

# Annual Technical Report 2014

Year Ended March 31, 2015

**OITDA**  
Optoelectronics Industry and Technology Development Association



INTERNATIONAL  
YEAR OF LIGHT  
2015

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Yasuhisa Odani  
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It is my pleasure to present to you an Annual Technical Report 2014, which outlines the result of our surveys, research and development activities in FY 2014.

According to the Optoelectronics Industry Trends Survey conducted every year by our association (OITDA), the domestic production of the optoelectronics industry has slightly increased in FY 2014 after significant increase of 18.0% in FY 2013, growing 1.5% to 8,591.6 billion yen. The total shipment, on the other hand, has decreased marginally from a substantial growth of 12.0% in FY 2013 to a decrease of 0.3% amounting to 16,874.2 billion yen in FY 2014. As a whole the optoelectronics industry remained flat in FY 2014. However, looking at the breakdown of shipments, it is revealed that the optoelectronics industry has been polarized into two groups: the laser processing field (total shipment growth of 17.7%), photovoltaic energy field (+7.7%), sensing/measuring field (+5.6%), and LED lighting field (+5.5%), which maintain high levels following the surge in FY 2013 due to the effects of Abenomics, etc., and the optical communication field, optical storage field, input/output equipment field, and display field, in which the total shipments have been decreasing because of structural factors. It is also notable that even in the fields with good performance, the photovoltaic energy and LED lighting fields have become sluggish in growth and the laser processing field also lags far behind Europe and the United States in terms of technology. The situation in the industry does not warrant optimism again.

On the other hand, optoelectronics technology includes many key technologies for accomplishing the growth strategy vigorously promoted by the government, such as image sensor and ultra high-resolution display used in medical/health care and robot technology, high-speed camera and user interface that contribute to automated driving systems for vehicles, sensors for disaster prevention to ensure a safe and secure life, biosensors, optical networks that contribute to the realization of ICT systems essential to the information society, and solar power generation and LED lighting that are key pillars of the energy policy. Thus a technology development strategy, commercialization strategy, and standardization strategy become increasingly necessary to all sectors of the optoelectronics industry to break through the current situation and develop the new emerging markets above.

OITDA has been engaged in the following priority issues in order to select an optoelectronics technologies with the potential to be developed into industry and to turn the potential into reality: (1) survey and research on the optoelectronics technology and industry; (2) promotion of technology development; (3) promotion of standardization; and (4) creation of new business and development of human resources. In FY 2014, we directed our efforts to these issues as in previous years and, based on the results of such efforts, also conducted dissemination and education, international exchange and cooperation and the provision of information on the optoelectronics technology and industry.

Details of the activities and the outcomes of individual issues are presented in the report. Here, I would like to introduce noteworthy events in FY 2014. First, we created a road map for the "optical communication" field, in the hope that it will be utilized as a guideline which contributes to the development of the optoelectronics industry. In the road map, we formulated a strategy on the new photonics switching architecture technology, with the aim of developing next-generation switching systems. We hope this will grow into a new technological development project. In the field of standardization, the IEC Tokyo meeting was held in November last year. As a core member of the meeting, OITDA conducted strategic international standardization activities related to optical communication devices and laser safety.

In order to support the growth of optoelectronics technology and industry, OITDA will strengthen and enhance our activities in accordance with needs, under the guidance of the Ministry of Economy, Trade and Industry and other governmental organizations, with the understanding and cooperation of our supporting members and many other people from the business world and the academic community who are our important partners. We look forward to your continued guidance, support and cooperation.

## 1. Introduction

The industrial economy of Japan has been buffeted by a harsh environment, with a global recession, a very strong yen, and prolonged deflation. Abenomics led to a weaker yen and higher stock prices, and the sentiment of companies and general consumers improved, and the increase in capital investment and consumer spending led to economic recovery. Amidst the steady improvement in economic conditions, the optoelectronics industrial sector, which has contributed greatly to Japan's economic growth by leading innovation and the industrializing of advanced technologies, needs to take a leap forward to become the driving force of the industry.

Since its foundation in 1980, thanks to a great deal of support and cooperation from the affiliated members and enterprises, OITDA has conducted its annual "Survey of Trends in the Optoelectronics Industry." The data accumulated continuously over more than 30 years is regarded highly as basic information on optoelectronics industry trends.

The purpose of this survey is to suggest the future direction of the optoelectronics industry through an analysis of its current status. In this fiscal year, as in the previous year, seven field-specific committees: optical communications, optical storage, I/O, displays/solid-state lighting, photovoltaic energy, laser processing, and sensing/measuring were established under the Optoelectronics Industry Trend Research Committee (parent committee) to survey and analyze the trends for each field and for the optoelectronics industry as a whole.

## 2. Domestic Production and Total Shipments for the Optoelectronics Industry

### 2.1 Survey of Domestic Production and Total Shipments for the Optoelectronics Industry

A survey on domestic production and total shipments for the optoelectronics industry was conducted as described below.

Questionnaire surveys were carried out on the domestic production value and total shipments including overseas production (questionnaires were sent to 313 enterprises in October 2014 and collected from December 2014 to February 2015) of domestic enterprises manufacturing optoelectronics-related products (optoelectronics equipment/systems and optical components) to determine actual performance in FY 2013, estimated production for FY 2014, and qualitative projections for FY 2015. Based on the results of the questionnaire, the data was analyzed and the industry trend was analyzed by the specific research committees for different product fields established under the Optoelectronics Industry Trend Research Committee. In addition, the validity of the data and analysis results was rechecked by the Optoelectronics Industry Trend Research Committee, and compiled as the domestic production value and total shipments for the entire Optoelectronics Industry in Japan.

In this survey, the optoelectronics industry is categorized into the following seven products fields and "Others," by combining optoelectronics equipment and components.

1. **Optical Communication:** Optical transmission equipment/system, optical fiber fusion splicing, light emitting device, photo detection device, optical transmission links, optical fiber, optical connector, optical passive component, etc.
2. **Optical Storage:** Optical disc equipment (read-only, recording and playing types), optical disc media, laser diodes, etc.
3. **Input/Output Equipment:** Optical printers, multifunction printers (MFP: optical and ink-jet), bar code readers, digital cameras (interchangeable lenses (single-lens reflex, mirrorless type (only the body without lens for both) and compact

type), digital video cameras, camera mobile phones, Tablet computer, etc.

4. **Displays and Solid-state Lighting:** Flat panel display, projector, large-scale LED display, solid-state lighting devices and equipment, LED (for lighting and displays), etc.
5. **Photovoltaic Energy:** Photovoltaic power systems, photovoltaic cells and modules
6. **Laser Processing:** Laser processing equipment, laser oscillator, i-line light processing equipment, additive manufacturing (3D printer), etc.
7. **Measuring and Sensing:** Optical measuring instruments, optical sensing equipment
8. **Others:** Hybrid optical equipment, etc.

- (Notes) Dotted underline: Items added to optoelectronics products since FY 2009 research.  
Single underline: Items added to the optoelectronics products since FY 2010 research.  
Double underline: Items added to optoelectronics products since FY 2012 research.  
Dashed line: Items added to optoelectronics products since FY 2013 research.  
wavy line: Items added to optoelectronics products since FY 2014 research

### 2.2 Survey of Domestic Production in FY 2013 and FY 2014, and a Qualitative Projection of Domestic Production for FY 2015

**Table 1** shows the actual domestic production in FY 2013, estimated domestic production for FY 2014 and a qualitative projection of the domestic production for FY 2015.

#### ● Actual production recorded in FY 2013: 8,467.2 billion yen, growth rate: 18%

All fields, except I/O showed positive growth, especially photovoltaic energy (growth rate: 71.4%) and laser processing (growth rate: 17.7%) increased significantly.

#### ● Estimated production for FY 2014: 8,591.6 billion yen, growth rate: 1.5%

It is expected that the laser processing, sensing/measuring, and displays/solid-state lighting fields will maintain positive growth. However, the photovoltaic energy field is expected to increase only by 1.9% in response to the large increase in the previous year. The optical communications and optical storage fields are expected to be negative.

#### ● A modest increase is likely in FY 2015 (qualitative projections)

Optical equipment/systems and optical component are expected to grow moderately. By field, the optical communications field is predicted to remain steady, a slight decrease is predicted in the optical storage field and a slight increase in the I/O field. The displays/solid-state lighting field is expected to increase. The photovoltaic energy field is predicted to be flat, and the laser processing and sensing/measuring fields to slightly increase.

### 2.3 Survey of Total Shipment Value for FY 2013 and FY 2014, and Projected Total Qualitative Shipment Values for FY 2015

**Table 2** shows total shipment values for FY 2013, estimated total shipment values for FY 2014 and projected total qualitative shipment values for FY 2015.

#### ● FY 2013 (actual): 16,931.1 billion yen, growth rate: 12.0%

Except for the optical storage and I/O fields, there was positive growth in the other fields, and especially the photovoltaic energy field (88.3% growth rate) and laser processing field (16.5%) showed substantial growth. The displays/solid-state lighting field finally turned to positive.

The optical communications field (5.4%) and sensing/measuring field (4.0%) also increased modestly.

● **FY 2014 (estimate): 16,874.2 billion yen, growth rate: -0.3%**

The photovoltaic energy field (7.7% growth rate), laser processing field (17.7%) and sensing/measuring (5.6%) will have positive growth. On the other hand, all the other fields are expected to be negative, and overall shipments will remain flat.

● **A modest increase is likely in FY 2015 (qualitative projections)**

The total shipment value for the optoelectronics industry in FY 2015 is expected to increase moderately. By field, the optical communications field is predicted to remain steady, a slight decrease is predicted in the optical storage field and a slight increase in the I/O field. The displays/solid-state lighting field is expected to increase. The photovoltaic energy field is predicted to be flat, and the laser processing and sensing/measuring fields to increase slightly.

## 2.4 Trends in Domestic Production for the Optoelectronics Industry

### (1) Changes in Domestic Production for the Optoelectronics Industry

Figure 1 shows the changes in domestic production and the rate of growth from the previous fiscal year (FY 2001 onwards) for the 35 years from FY 1980 to FY 2014. The nominal GDP and the domestic output of the electronics industry have been added as a reference for a comparison between domestic production for the optoelectronics industry and domestic production for the Japanese economy and other industries.

Output for the optoelectronics industry was around 80 billion yen in FY 1980 when the survey on the domestic production value started, and grew in the 80s along with Japan's economy. In 1991, it accounted for one-tenth of the domestic production value for the electronics industry, and consistently maintained positive growth, exceeding the 7 trillion yen level in FY 2000. Affected by the IT recession, the optoelectronics industry recorded negative growth in FY 2001 for the first time since the survey started. After a rapid recovery, it approached the 10 trillion yen level in FY 2003, and from there on has been greatly affected by

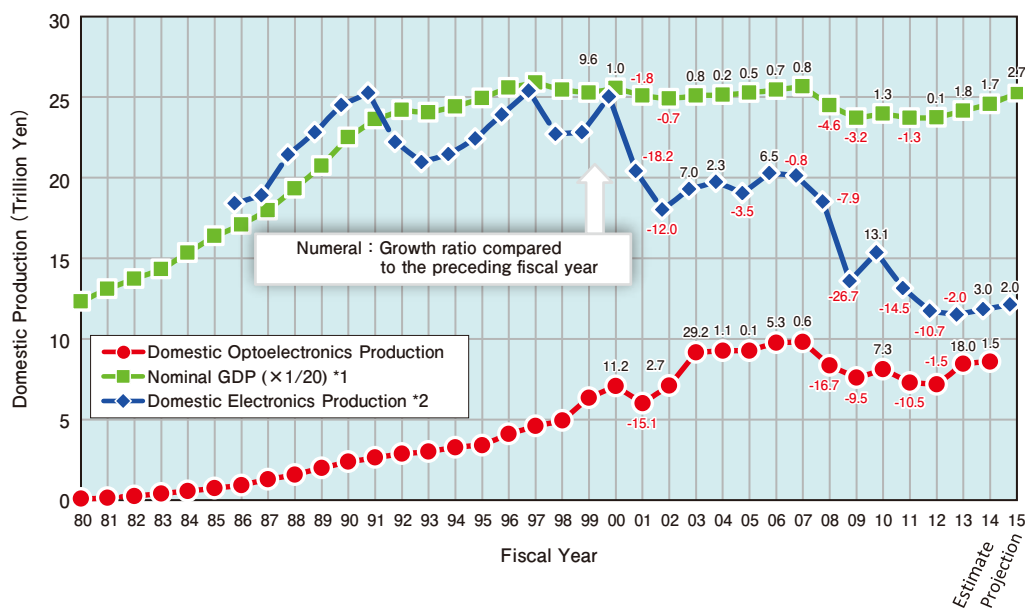
the macro economy, showing changes linked to GDP and the electronics industry. Until FY 2007 it grew slowly, but affected by the global financial recession from FY 2008 to FY 2009, it experienced two consecutive years of negative growth. The partial recovery trend seen in FY 2010 lost steam, and again has been negative in FY 2011 to FY 2012. However, in FY 2013, the economy recovered due to the effects of Abenomics, as indicated by the 1.8% nominal GDP growth forecast and the increase in capital investment and general consumption, and the domestic production value for the entire optoelectronics industry grew substantially (18.0%) for the first time in years. In FY 2014, strong and weak fields will be equally divided, with the output expected to increase by 1.5% compared to FY 2013 almost leveling off.

Figure 2 shows the changes in domestic production of optoelectronics products for each field over the 23 years from FY 1991 (actual results) until FY 2014 (estimate) (seven fields, excluding "Other").

During the 1990s, there was favorable growth in displays, input/output, optical communications, and optical storage fields, with domestic production for each increasing to over 1 trillion yen in the year 2000. In the laser processing, sensing/measuring, and photovoltaic energy fields, the production value was less than 500 billion yen in the year 2000, although they had performed favorably in the 1990s.

However, there were developments from significantly different aspects in each field after the IT bubble burst in 2001.

There was not much decline in the input/output field in FY 2001, and it also remained steady from FY 2002 onwards, but it started showing negative growth from FY 2008 onwards. In FY 2011, although it finally started showing signs of bottoming out, by FY 2012 and even in FY 2013 it followed a path of negative growth. In FY 2014, however, the trend stays almost flat. The displays/solid-state lighting field continued to grow favorably despite some fluctuations, peaked in FY 2010, and then nosedived. In particular, the domestic production value for flat panel display devices in the two years from FY 2011 decreased by almost 80%. However, in FY 2013 it is finally showing signs of bottoming out. In FY 2014, it is expected to revert to positive. On the other hand, the



\*1 FY2014 GDP data/FY2015 Economical Outlook (Feb. 2015)[Cabinet Decision]

\*2 Production Forecasts for the Global Electronics and Information Technology Industries, JEITA, Dec.154, 2014

Figure 1 Changes in Domestic Optoelectronics, Electronics Production, and Nominal GDP (1980-2015)



Table 1 Domestic Production of the Optoelectronics Industry (Summay)

Product Items		FY 2012 Production Actual		FY 2013 Production Actual		FY 2014 Production Estimate		FY 2015 Production Projection
		(in million yen)	Growth Rate(%)	(in million yen)	Growth Rate(%)	(in million yen)	Growth Rate(%)	
Optical Communications Field		478,335	-5.7	509,286	6.5	460,694	-9.5	Stable
Optical Equipment	Optical Transmission Equipment/System	235,384	-3.6	254,272	8.0	201,158	-20.9	Stable
	Trunk Line (incl. MUX)	58,887	1.9	77,797	32.1	63,009	-19.0	Stable
	Metro Line	79,517	68.6	86,466	8.7	57,030	-34.0	Stable
	Subscriber Line	54,113	-26.4	48,831	-9.8	41,381	-15.3	Little negative
	Router and Switch	26,136	23.5	24,928	-4.6	19,785	-20.6	Stable
	Video Transmission (CATV, etc)	3,104	-43.2	3,433	10.6	3,310	-3.6	Stable
	Optical Fiber Amplifier	9,627	-17.5	9,317	-3.2	12,943	38.9	Stable
	Others (ATM, Optical Wireless LAN, etc)	4,000	-85.4	3,500	-12.5	3,700	5.7	Little negative
Optical Components	Optical Fiber Fusion Splicer	17,631	4.9	18,327	3.9	19,768	7.9	Stable
	Light Emitting Device	28,271	26.1	32,076	13.5	37,976	18.4	Positive growth
	Photo Detection Device	8,041	23.2	7,664	-4.7	10,175	32.8	Stable
	Optical Transmission Link	37,133	-21.9	51,508	38.7	48,243	-6.3	Little negative
	Optical Fiber	86,952	-19.0	87,770	0.9	88,033	0.3	Positive growth
	Optical Connector	21,755	-0.6	19,810	-8.9	19,324	-2.5	Stable
	Optical Passive Component	21,194	-4.8	18,032	-14.9	14,880	-17.5	Stable
	Optical Circuit Component	13,662	28.5	14,312	4.8	15,587	8.9	Stable
Optical IC/Micro Optical Component, Others		8,312	10.2	5,515	-33.7	5,550	0.6	Stable
Optical Storage Field		230,584	-40.4	265,941	15.3	215,855	-18.8	Little negative
Optical Equipment	Optical Disk	220,066	-40.9	257,594	17.1	207,910	-19.3	Little negative
	Equipment	200,405	-42.9	240,703	20.1	192,317	-20.1	Little negative
	Read-only (CD, CD-ROM UNIT, DVD, BD)	164,719	-37.2	202,926	23.2	178,009	-12.3	Negative
	Recordable (MD, MO, CD, DVD, BD)	35,686	-59.9	37,777	5.9	14,308	-62.1	Little negative
	Media	19,661	-6.3	16,891	-14.1	15,593	-7.7	Little negative
Laser Diode		10,518	-30.3	8,347	-20.6	7,945	-4.8	Negative
Input/Output Field		1,458,517	-10.9	1,111,671	-23.8	1,084,410	-2.5	Positive growth
Optical Equipment	Optical I/O Equipment	1,175,753	-13.8	765,164	-34.9	695,289	-9.1	Positive growth
	Optical Printer	38,305	-19.0	28,451	-25.7	29,718	4.5	Positive growth
	MFP (FAX Machine, Copier, MFP)	85,448	-11.9	95,990	12.3	93,844	-2.2	Positive growth
	Bar Code Reader	18,846	18.6	13,224	-29.8	13,183	-0.3	Positive growth
	Image Scanner	9,250	15.2	9,812	6.1	11,181	14.0	Stable
	Digital Camera	510,572	2.2	306,845	-39.9	266,680	-13.1	Positive growth
	Digital Video Camera	46,527	-36.2	40,032	-14.0	34,868	-12.9	Little negative
	Camera Mobile Phone	466,805	-25.0	250,074	-46.4	208,395	-16.7	Little negative
	Tablet Computer	—	—	20,737	—	37,420	80.5	Stable
	Photo Detectors (Image Sensor)	282,764	3.5	346,507	22.5	389,121	12.3	Positive growth
Display and Solid-state Lighting Field		2,455,135	-10.4	2,562,661	4.4	2,669,252	4.2	Growth
Optical Equipment	Display Equipment	305,833	-56.0	292,708	-4.3	301,011	2.8	Growth
	Flat Panel Display	258,335	-59.2	256,802	-0.6	265,871	3.5	Growth
	Projector	44,343	-25.5	31,890	-28.1	32,629	2.3	Growth
	Large-scale LED Display	3,155	18.5	4,016	27.3	2,511	-37.5	Growth
Display Device		1,486,941	-3.3	1,613,582	8.5	1,730,751	7.3	Growth
LED		343,619	12.0	362,861	5.6	324,035	-10.7	Stable
Solid-state Lighting		318,742	58.6	293,510	—	313,455	6.8	Positive growth
LED Device (incl. OLED)		304,767	92.7	276,415	—	296,715	7.3	Positive growth
LED Lamp		13,975	-67.3	17,095	22.3	16,740	-2.1	Positive growth
Photovoltaic Energy Field		1,950,473	45.7	3,342,846	71.4	3,406,819	1.9	Stable
Photovoltaic Power System		1,309,832	72.4	2,673,858	104.1	2,890,483	8.1	Stable
Photovoltaic Cell/Module		640,641	10.6	668,988	4.4	516,336	-22.8	Stable
Laser Processing Field		373,314	-11.3	439,439	17.7	514,720	17.1	Positive growth
Equipment	Laser Processing Equipment	192,989	-26.6	229,976	19.2	262,028	13.9	Positive growth
	CO <sub>2</sub> Laser	55,653	-30.5	63,317	13.8	77,707	22.7	Positive growth
	Solid State Laser	26,194	-16.2	28,386	8.4	37,034	30.5	Positive growth
	Excimer Lasers	104,794	-29.1	125,942	20.2	114,335	-9.2	Little negative
	Fiber Laser-applied Production Equipment	3,991	36.3	9,922	148.6	30,115	203.5	Stable
	Semiconductor Laser Direct Processing Equipment	2,357	112.2	2,409	2.2	2,838	17.8	Positive growth
	i-line Lithography Equipment	126,500	32.5	151,300	19.6	182,000	20.3	Positive growth
	Additive Manufacturing (3D Printer)	—	—	561	—	3,013	437.1	Growth
Oscillators		53,825	-13.6	57,602	7.0	67,678	17.5	Stable
Sensing and Measuring Field		157,428	-16.7	162,028	2.9	164,902	1.8	Positive growth
Optical Measuring Instrument		12,672	-5.6	13,216	4.3	12,709	-3.8	Positive growth
Optical Sensing Equipment		144,756	-17.6	148,812	2.8	152,193	2.3	Positive growth
Others Field		74,494	6.1	73,348	-1.5	74,917	2.1	Positive growth
Product Items		FY 2012 Production Actual		FY 2013 Production Actual		FY 2014 Production Estimate		FY 2015 Production Projection
		(in million yen)	Growth Rate(%)	(in million yen)	Growth Rate(%)	(in million yen)	Growth Rate(%)	
Sub Total for Optoelectronics Equipment		4,046,183	-2.7	5,082,203	25.6	5,224,278	2.8	Positive growth
Sub Total for Optoelectronics Components		3,132,097	-0.0	3,385,017	8.1	3,367,291	-0.5	Positive growth
Total for Optoelectronics Products		7,178,280	-1.5	8,467,220	18.0	8,591,569	1.5	Positive growth

Table 2 Shipment Value of the Optoelectronics Industry (Summary)

Product Items		FY 2012 Production Actual		FY 2013 Production Actual		FY 2014 Production Estimate		FY 2015 Production Projection
		(in million yen)	Growth Rate(%)	(in million yen)	Growth Rate(%)	(in million yen)	Growth Rate(%)	
Optical Communications Field		540,640	- 7.2	569,856	5.4	531,509	-6.7	Stable
Optical Equipment	Optical Transmission Equipment/System	249,003	- 9.2	264,421	6.2	212,315	-19.7	Stable
	Trunk Line (incl. MUX)	61,519	2.2	78,544	27.7	63,272	-19.4	Stable
	Metro Line	79,490	26.0	86,416	8.7	56,980	-34.1	Stable
	Subscriber Line	62,844	- 14.5	52,019	-17.2	43,568	-16.2	Little negative
	Router and Switch	26,136	- 11.7	27,830	6.5	23,387	-16.0	Stable
	Video Transmission (CATV, etc)	3,328	- 39.1	3,785	13.7	3,670	-3.0	Stable
	Optical Fiber Amplifier	11,686	- 14.4	12,327	5.5	17,738	43.9	Positive growth
	Others (ATM, Optical Wireless LAN, etc)	4,000	—	3,500	-12.5	3,700	5.7	Positive growth
Optical Components	Optical Fiber Fusion Splicer	18,337	9.0	18,765	2.3	20,206	7.7	Stable
	Light Emitting Device	33,820	35.1	37,134	9.8	43,730	17.8	Stable
	Photo Detection Device	8,669	32.8	9,262	6.8	11,423	23.3	Positive growth
	Optical Transmission Link	58,740	- 1.7	70,415	19.9	72,879	3.5	Positive growth
	Optical Fiber	97,871	- 21.5	99,039	1.2	103,146	4.1	Positive growth
	Optical Connector	24,991	- 1.6	25,493	2.0	24,943	-2.2	Stable
	Optical Passive Component	23,272	- 27.3	19,129	-17.8	15,859	-17.1	Stable
	Optical Circuit Component	14,451	35.0	15,182	5.1	16,287	7.3	Stable
	Optical IC/Micro Optical Component, Others	11,486	52.3	11,016	-4.1	10,721	-2.7	Stable
Optical Storage Field		1,314,564	- 22.3	1,196,760	-9.0	1,084,790	-9.4	Little negative
Optical Equipment	Optical Disk	1,282,596	- 22.1	1,165,867	-9.1	1,056,397	-9.4	Little negative
	Equipment	1,142,146	- 20.7	1,055,349	-7.6	1,005,034	-4.8	Little negative
	Read-only (CD, CD-ROM UNIT, DVD, BD)	726,866	1.6	652,851	-10.2	638,044	-2.3	Stable
	Recordable (MD, MO, CD, DVD, BD)	415,280	- 42.7	402,498	-3.1	366,990	-8.8	Little negative
	Media	53,061	- 10.3	47,957	-9.6	42,941	-10.5	Stable
	Others (Optical Head)	87,389	- 40.8	62,561	-28.4	8,422	-86.5	Negative
Laser Diode		31,968	- 30.7	30,893	-3.4	28,393	-8.1	Little negative
Input/Output Field		4,061,657	- 6.4	3,765,866	-7.3	3,520,595	-6.5	Positive growth
Optical Equipment	Optical I/O Equipment	3,672,576	- 7.0	3,292,494	-10.3	2,983,439	-9.4	Positive growth
	Optical Printer	138,691	- 3.2	134,834	-2.8	135,900	0.8	Positive growth
	MFP (FAX Machine, Copier, MFP)	551,070	- 7.0	582,067	5.6	611,045	5.0	Stable
	Bar Code Reader	18,293	- 0.4	14,585	-20.3	14,883	2.0	Positive growth
	Image Scanner	62,194	10.6	41,985	-32.5	42,020	0.1	Stable
	Digital Camera	1,626,505	- 3.7	1,300,232	-20.1	1,022,600	-21.4	Positive growth
	Digital Video Camera	144,641	- 15.2	97,584	-32.5	90,324	-7.4	Stable
	Camera Mobile Phone	1,113,077	- 11.5	1,027,801	-7.7	968,508	-5.8	Little negative
	Tablet Computer	18,105	- 19.8	93,406	415.9	98,159	5.1	Stable
	Photo Detectors (Image Sensor)	389,081	0.6	473,371	21.7	537,157	13.5	Positive growth
Display and Solid-state Lighting Field		6,276,315	- 13.5	6,418,716	2.3	6,335,993	-1.3	Growth
Optical Equipment	Display Equipment	3,615,790	- 22.7	3,563,542	-1.4	3,417,821	-4.1	Growth
	Flat Panel Display	3,354,689	- 24.4	3,277,900	-2.3	3,117,097	-4.9	Growth
	Projector	213,125	8.6	232,541	9.1	250,079	7.5	Growth
	Large-scale LED Display	47,976	6.9	53,101	10.7	50,645	-4.6	Growth
LED	Display Device	1,876,508	- 6.3	1,942,859	3.5	2,008,024	3.4	Growth
	LED	375,134	23.0	403,269	7.5	373,023	-7.5	Growth
	Solid-state Lighting	408,883	54.2	509,046	24.5	537,125	5.5	Positive growth
	LED Device (incl. OLED)	309,591	95.7	413,696	33.6	444,125	7.4	Positive growth
LED Lamp		99,292	- 7.2	95,350	-4.0	93,000	-2.5	Little negative
Photovoltaic Energy Field		2,245,643	57.8	4,229,268	88.3	4,555,837	7.7	Stable
Photovoltaic	Photovoltaic Power System	1,260,440	58.0	2,693,247	113.7	3,073,717	14.1	Stable
	Photovoltaic Cell/Module	985,203	57.5	1,536,021	55.9	1,482,120	-3.5	Stable
Laser Processing Field		381,382	- 11.2	444,320	16.5	523,005	17.7	Positive growth
Equipment	Laser Processing Equipment	197,558	- 26.5	233,473	18.2	269,000	15.2	Positive growth
	CO <sub>2</sub> Laser	59,679	- 28.2	63,945	7.1	77,804	21.7	Positive growth
	Solid State Laser	28,552	- 10.7	31,594	10.7	41,196	30.4	Positive growth
	Excimer Lasers	102,676	- 31.2	125,338	22.1	116,658	-6.9	Little negative
	Fiber Laser-applied Production Equipment	4,276	39.9	10,196	138.4	30,567	199.8	Positive growth
	Semiconductor Laser Direct Processing Equipment	2,375	74.1	2,400	1.1	2,775	15.6	Stable
	i-line Lithography Equipment	126,500	32.5	151,300	19.6	182,000	20.3	Positive growth
	Additive Manufacturing (3D Printer)	—	—	568	—	3,022	432.0	Positive growth
Oscillators		57,324	- 12.0	58,979	2.9	68,983	17.0	Positive growth
Sensing and Measuring Field		211,807	- 3.1	220,303	4.0	232,565	5.6	Positive growth
Optical Measuring	Optical Measuring Instrument	12,638	- 7.2	14,238	12.7	13,940	-2.1	Positive growth
	Optical Sensing Equipment	199,169	- 2.8	206,065	3.5	218,625	6.1	Positive growth
Others Field		83,110	- 1.8	86,043	3.5	89,918	4.5	Positive growth
Product Items		FY 2012 Production Actual		FY 2013 Production Actual		FY 2014 Production Estimate		FY 2015 Production Projection
		(in million yen)	Growth Rate(%)	(in million yen)	Growth Rate(%)	(in million yen)	Growth Rate(%)	
Sub Total for Optoelectronics Equipment		10,944,198	- 9.6	12,017,677	9.8	11,894,607	-1.0	Positive growth
Sub Total for Optoelectronics Components		4,170,920	6.5	4,913,455	17.8	4,979,606	1.3	Positive growth
Total for Optoelectronics Products		15,115,118	-5.7	16,931,132	12.0	16,874,213	-0.3	Positive growth

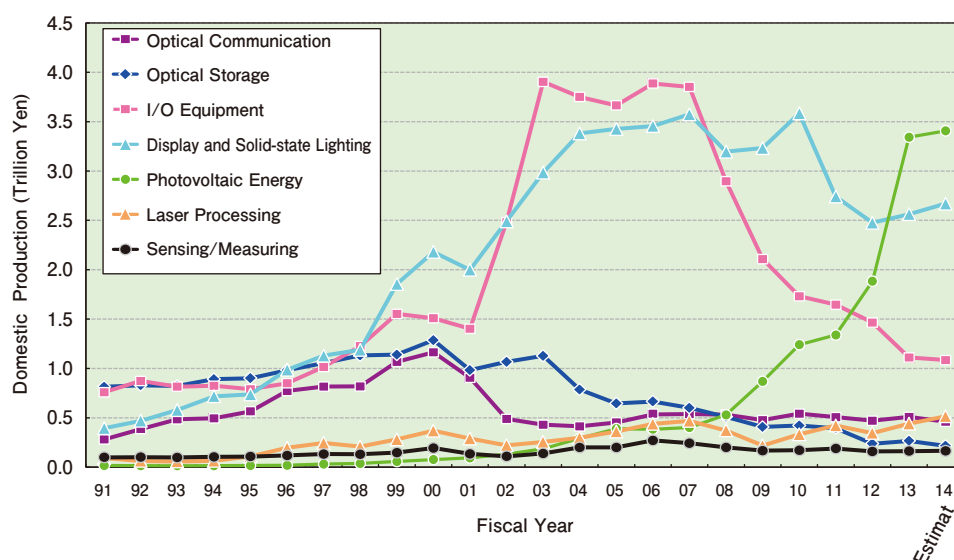


Figure 2 Changes in Domestic Optoelectronics Production by Each Field (1991-2014)

solid-state lighting field, which stands out in this field, attained three-digit growth in FY 2011 and double-digit growth in FY 2012. For FY 2013, although the values are not comparable with values from the previous year because of the changes in the aggregation method, production itself seems to be steadily increasing. Recently, the photovoltaic energy field has been leading growth in the optoelectronics field, and has been rising rapidly since FY 2008. In particular, since the introduction of Feed in Tariff (FIT) in July 2012, production for the power industry grew substantially, and this field showed the highest proportion of the domestic production value in FY 2013. (Customarily, the displays/solid-state lighting field has been the highest.) The optical storage field is continuing its prolonged decline. It fell below 250 billion yen in FY 2012 (-40.4%) but rebounded to increase by 15.3% in FY 2013. However, it is expected to reverse to a decline of -18.8% in FY 2014, and the downward trend is predicted to continue for some time. Optical communications, laser processing, and sensing/measuring, which

are mainly related to the domestic market, are easily influenced by domestic economic conditions and capital investments, are reflecting the trend in the economic conditions, and grew substantially in FY 2013. The laser processing and sensing/measuring fields are expected to record positive growth in FY 2014. However, optical communications had a negative growth of -9.5% in FY 2014 due to underperformance in trunk lines, and is predicted to remain flat in FY 2015.

## (2) Changes in the Proportions and Contribution Ratios for the Domestic Production Value by Field in the Optoelectronics Industry

Figure 3 shows the changes in the proportion of products for the fields comprising the domestic production value for the optoelectronics products over the four years from FY 2011 (actual results) until FY 2014 (estimate), while Figure 4 shows the changes in the contribution ratio for changes in the domestic production of Optoelectronics products for each field.

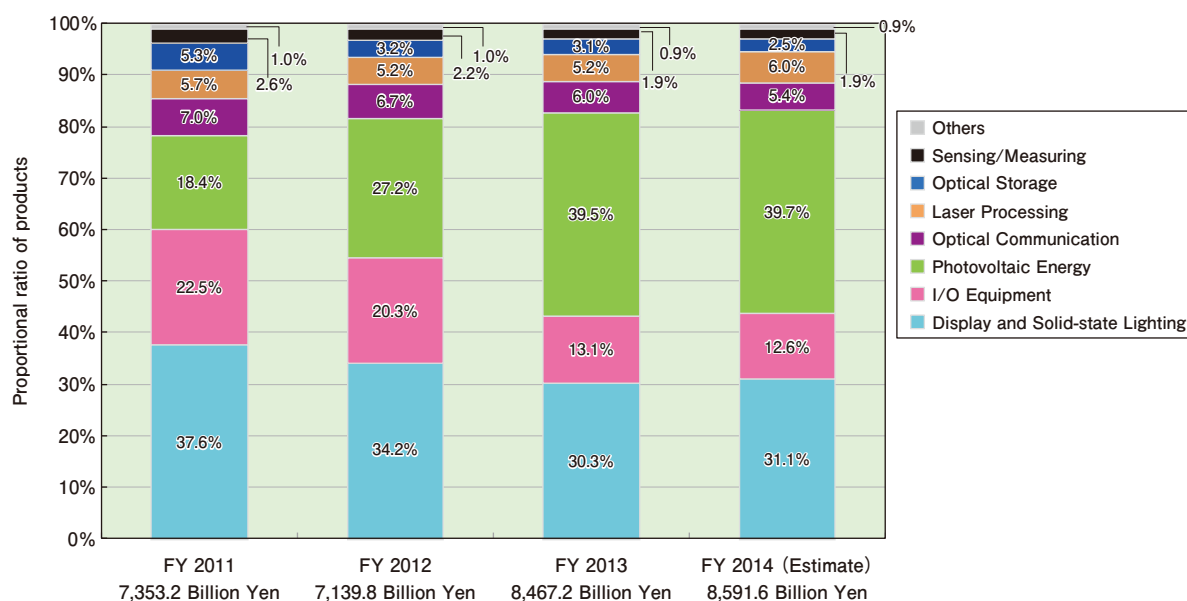


Figure 3 Changes in the Proportion of Optoelectronics Production by Each Field



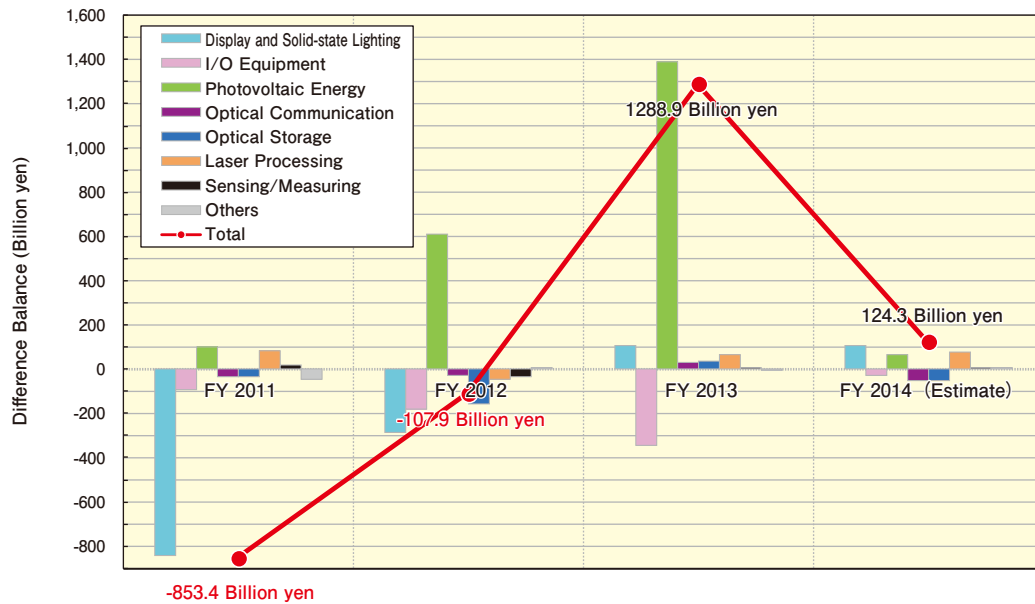


Figure 4 Changes in Contribution Ratio of Changes in Domestic Optoelectronics Production for Each Field

Looking at Figure 3 showing the proportion by field, three fields (displays/solid state lighting, I/O, and photovoltaic energy) account for approximately 80% of the whole, but due to the difference between the extents of recovery after the FY 2009 global recession, the proportions have been changing drastically. The photovoltaic energy field has continued to rise very rapidly due to FIT and the excess power purchase system, subsidies, etc.; it leapt to the top in FY 2013. In the displays/solid-state lighting field, due to the response to the vigorous demand before the complete transition to digital terrestrial broadcasting (DTB) in 2011, the stronger yen, as well as the shift towards overseas production due to continuously declining prices, the domestic production of flat display devices fell nearly 80% in two years. On the other hand, solid-state lighting has continued to grow rapidly due to the growing awareness

of energy conservation, but this did not fully compensate for the decline in the display field, and as a result, its composition ratio is expected to fall by 6.5 points from FY 2011 to FY 2014. The I/O field is estimated to decline by 9.9 points, due to the slump in the market for devices such as digital cameras and camera phones.

Regarding the contribution ratio for each field (Figure 4), the photovoltaic energy field showed a strong positive contribution in FY 2013. Only the input/output field was negative. By field, the displays/solid-state lighting field inverted to positive in FY 2013 and is expected to be positive in FY 2014, but the I/O field is expected to finally show signs of recovery. The optical storage field slightly rebounded to positive but is expected to slide into the negative again in FY 2014. Although the amount is small, the laser processing and sensing/measuring fields

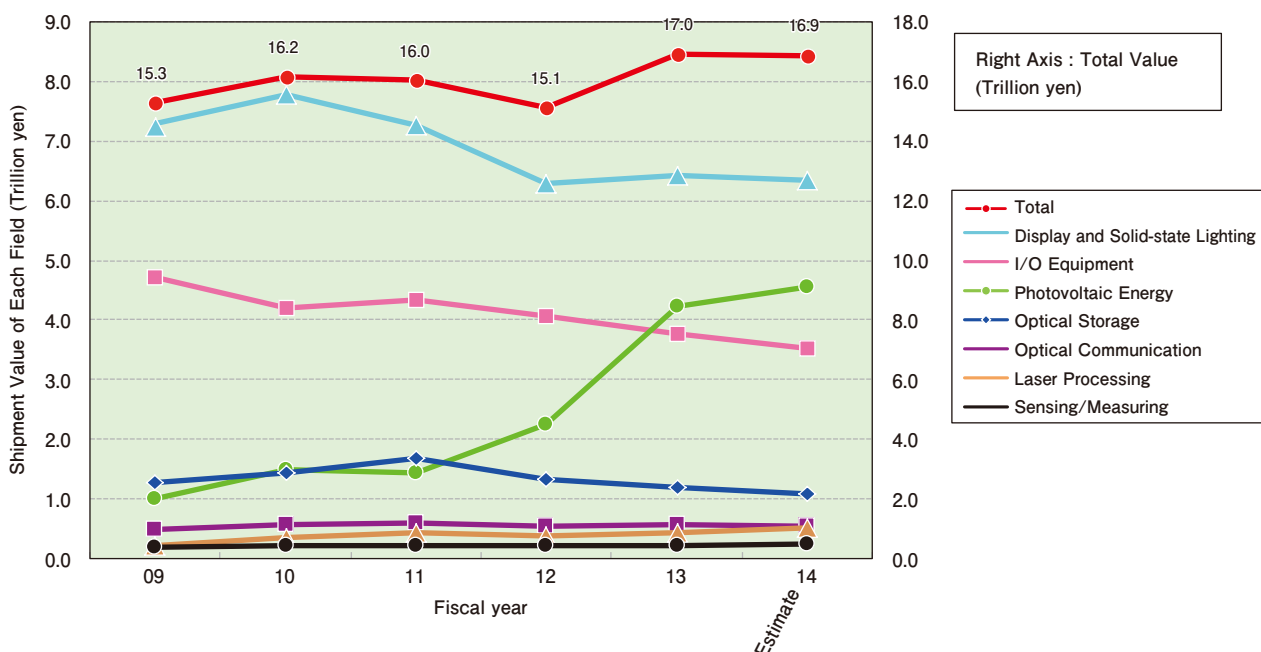


Figure 5 Changes in Total Shipment Value and Total Shipment Value by Each Field (FY 2009-2014)

are expected to increase steadily in FY 2014.

## 2.5 Trends in the Total Shipment Value for the Optoelectronics Industry

### (1) Changes in the Total Shipment Value for the Optoelectronics Industry, and the Total Shipment Value by Field

Figure 5 shows changes in the total shipment value and the total shipment value by field for six years from FY 2009 (actual results) to FY 2014 (estimate). Although it declined to 15.1 trillion yen in FY 2012, it recovered to 16.9 trillion yen in FY 2013, and is expected to remain flat in FY 2014.

By field, in FY 2013, the photovoltaic energy field increased greatly, still driven by its uses in the power business. The optical communications field also grew, because of the increase in the number of trunk lines and metro lines mainly at 100 Gb/s. The display devices performed well, and the entire displays/solid-state lighting field finally turned to positive. However, the I/O and optical storage fields continued to decline. In FY

2104, it is expected that the laser processing field will grow significantly, and the sensing/measuring field will continue to show a modest increase, thanks to the expansion of capital investment mainly in the automotive industry. The photovoltaic energy field is expected to maintain positive growth but slow down due to changes in the FIT system. On the other hand, the displays/solid-state lighting field is expected to decline by 1.3%, hindered by the decline in display devices. The optical communications field is also expected to decline by 6.7% due to the sluggish optical transmission equipment/systems market. The I/O field is expected to decrease slightly because of the stagnant overseas market for single-lens reflex digital cameras, despite the moderate increase in the printer field. The optical storage field has been in decline, and is expected to decrease by 10% from the previous fiscal year.

### (2) Changes in the Proportions and Contribution Ratios for the Total Shipment Value by Field in the Optoelectronics Industry

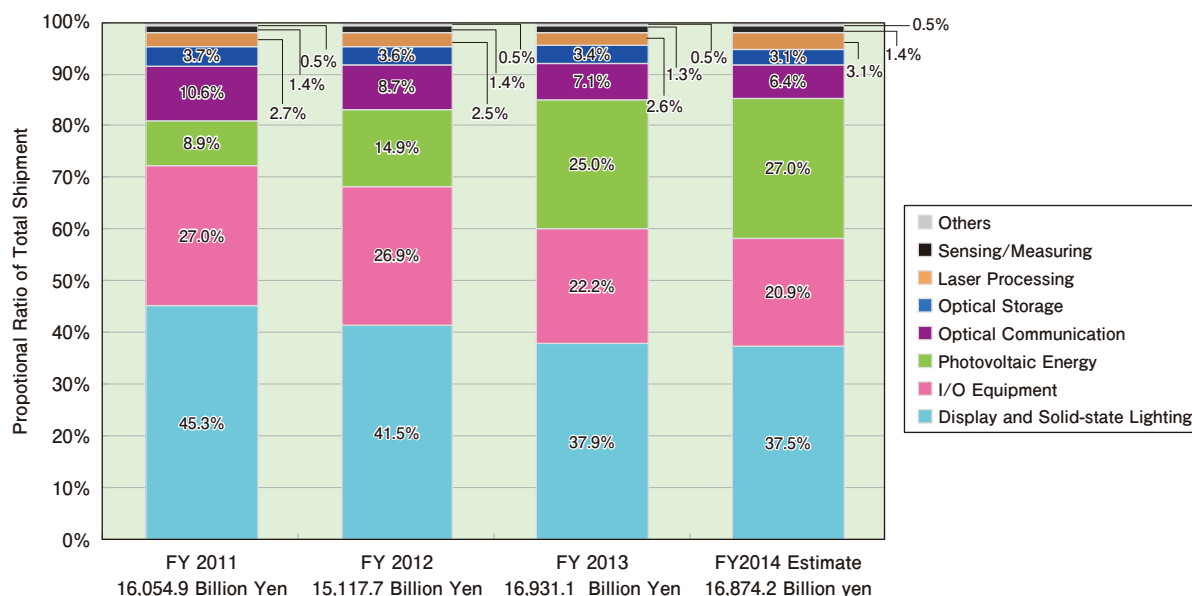


Figure 6 Changes in Proportion of Total Shipment Value by Each Field

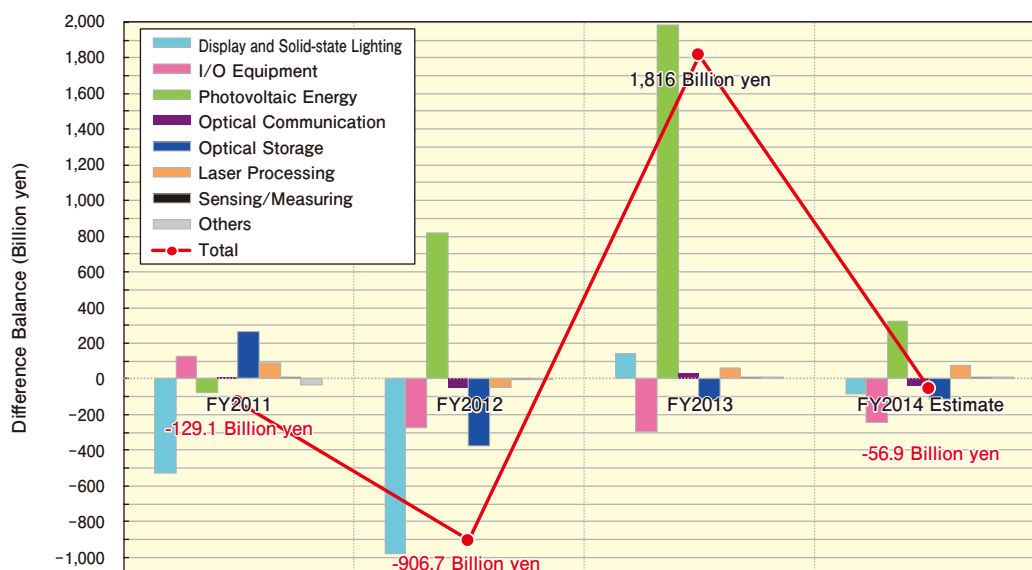


Figure 7 Changes in Contribution Ratio of Total Shipment Fluctuations in Optoelectronics Products for Each Field

Figure 6 shows the changes in the proportion of products for the fields comprising the total shipment value for optoelectronics products over the four years from FY 2011 (actual results) to FY 2014 (estimate), while Figure 7 shows the changes in the contribution ratio for total shipment fluctuations in Optoelectronics products for each field.

From the proportions by field (Figure 6), we can see that the photovoltaic energy field grew in FY 2012, whereas the displays/solid-state lighting field declined. In FY 2013, the photovoltaic energy field switched places with the I/O field in shares and leapt into second position, with a growth of 10.1 points.

The contribution ratio by field (Figure 7) shows that the photovoltaic energy field recorded large positive growth, and the displays/solid-state lighting, laser processing, sensing/measuring, and optical communications fields inverted to positive in FY 2013. The other two fields were negative. In FY 2014, the photovoltaic energy, laser processing, and sensing/measuring fields will maintain positive growth but the other four fields will slide into negative. In particular, growth is expected to be substantially inhibited in the photovoltaic energy field.

A detailed analysis of each field is given in Chapters 3-9.

### 3. Optical Communications Field

The domestic production value and total shipment value of the optical communications field in FY 2013 were approximately 509.3 and 569.9 billion yen respectively, which showed positive growth of 6.5% and 5.4% respectively compared to the previous fiscal year. However, in FY 2014, they will lower to 460.7 and 531.5 billion yen respectively, which indicate negative growth of 9.5% and 6.7% respectively from FY 2013, and 3.7% and 1.7% respectively from FY 2012. Since FY 2011, the production value and shipment value of the optical communications field as a whole have been flat, despite temporal increase in FY 2013.

This background is that it is difficult to expect significant growth in equipment renewal, etc. in response to increased traffic demand because the number of FTTH subscribers has been leveling off, and the growth of mobile network traffic due to the spread of 3.9G is slowing down. On the other hand, internet traffic is steadily increasing overseas, so that the demand for optical equipment/systems used for backbones is expected to increase even more in the next fiscal year and beyond. Demand for short range transmission equipment will also rise following the increase in capital investment in data centers in response to the growth of cloud services and big data businesses. Amid market trends such as sluggish growth in the domestic market and sustainable growth in overseas markets, significant differences in the growth rate between product fields can be caused.

#### 3.1 Optical Transmission Equipment/Systems

The actual domestic production value of optical transmission equipment/systems in FY 2013 was 254.3 billion yen (increase of 8.0% YoY), but is expected to decrease to 201.2 billion yen (decrease of 20.9% YoY) in FY 2014. In FY 2013, domestic production was driven by the investment in metro line equipment following commencement of the installation of 100G trunk lines using digital coherent technology by major domestic carriers. However, in FY 2014, since there will be only expansion of the transmission capacity for the existing 100G equipment, and no large investments as in FY 2013, the domestic production value is expected to shrink. The investment in subscriber lines has been declining because of the nationwide dissemination of FTTH.

This field mainly relates to the domestic market, and it tends to be influenced by capital investment by telecommunication carriers, so that it is difficult to estimate significant growth until the next upgrade. However, the traffic of communications networks has been steadily increasing, and to meet the traffic demand, investment for expanding network capacity will continue in the mid to long term. In addition, an

explosive increase in traffic will be required to support the mobile fifth generation (5G) after several years, and therefore, the production value of optical equipment/systems for mobile backhaul is expected to grow.

On the other hand, the actual production value of optical fiber amplifiers in FY 2013 was 9.3 billion yen (decrease of 3.2% YoY). However, it is expected to grow substantially to 12.9 billion yen (increase of 38.9% YoY) thanks to new orders for submarine cables.

#### 3.2 Optical Fiber Fusion Splicers

The actual total shipment value of optical fiber fusion splicers in FY 2013 was 18.8 billion yen (increase of 2.3% YoY), showing a consecutive increase from the previous year. The estimate for FY 2014 is 20.2 billion yen (increase of 7.7% YoY). Although Chinese and Korean optical fiber fusion splicers are increasing their sales in Asian markets mainly in China where there is a great demand, there is a strong demand for high-quality and high-reliability products from Japanese manufacturers, and the shipment value has been growing in recent years.

In the domestic market, the situation in which domestic manufacturers hold an almost 100% share has not changed. The high levels of technical skill that domestic manufacturers possess is a source of competitiveness. The Japanese manufacturers have strong brand power and hold large shares of the global market. Thanks to the recent depreciation of the yen, Japanese products have been gaining in price competitiveness, so that the domestic production value will continue to increase.

#### 3.3 Light Emitting/Photo Detection Devices for Communications

The actual domestic production value of light emitting devices for telecommunication in FY 2013 was 32.1 billion yen, showing an increase of 13.5% from the previous fiscal year. The production value in FY 2014 will be 38.0 billion yen (increase of 18.4% YoY) and continuous growth is expected.

In photo detection devices for telecommunication, the actual production value in FY 2013 was 7.7 billion yen, which showed a decrease of 4.7% from the previous fiscal year. In FY 2014, it is expected to grow to 10.2 billion yen (increase of 32.8% YoY).

Since high performance in terms of size, power consumption, detailed parameters, etc. is still required for light emitting and photo detection devices, performance improvements are being made day by day. For such devices in which the technologies make rapid progress, the high level of technical skill possessed by domestic manufacturers has a large advantage, and the growth in the production value and shipment value is expected to continue for some time. As these products with high growth rates are intermediate materials, large volumes are shipped overseas, and they are expected to obtain the effects of the recent depreciation of the yen.

#### 3.4 Optical Transmission Links

The domestic production value and total shipment value of optical transmission links in FY 2013 increased significantly to 51.5 billion yen (increase of 38.7% YoY) and 70.4 billion yen (increase of 19.9% YoY). This is driven by the investment in trunk line systems such as building backbones in response to an increase in traffic and disaster prevention measures, but one reason for this seems to be the substantial increase (increase of 357.4% YoY) in the demand for over 100 Gb/s optical transmission links with high-speed and high unit cost following the progress in network speeds.

On the other hand, in FY 2014, the domestic production value is expected to be 48.2 billion yen (decrease of 6.3% YoY), but the shipment value is expected to slightly increase to 72.9 billion yen (increase of 3.5% YoY). According to the surveys of each speed category, the production and shipment values in FY 2014 for over 100 Gb/s optical transmission links which become the mainstream for links will continue

to grow. Therefore, it is considered that the ratio of overseas production for low-speed optical links and the volume of overseas shipments will be raised.

### 3.5 Optical Fiber

The domestic production value of optical fibers was 87.8 billion yen in FY 2013 (increase of 0.9% YoY) and will be 88.0 billion yen in FY 2014 (increase of 0.3% YoY), remaining flat. It is considered that the stagnation in the production value has been continuing due to the sluggish domestic demand and price decline caused by the ceiling in the number of FTTH subscribers and the pause in the expansion of the LTE mobile base station area.

On the other hand, the total shipment value grew to 99.0 billion yen in FY 2013 (increase of 1.2% YoY) and 103.1 billion yen in FY 2014 (increase of 4.1% YoY), indicating production growth in overseas manufacturing bases and capturing of demand in Asia and South America where broadband environments are being developed.

### 3.6 Optical Passive Components and Optical Circuit Components

The actual domestic production value of optical passive components such as optical isolators and optical attenuators in FY 2013 was 18.0 billion yen, showing a decrease of 14.9% from FY 2012. In FY 2014, it is expected to decrease further to 14.9 billion yen (decrease of 17.5% YoY).

The shipment value recorded significant consecutive negative growth compared to the previous fiscal year. This seems to be due to a decline in price and share caused by intensifying competition with manufacturers in emerging countries. In addition, it is considered that commoditization of optical passive components is in progress due to the lack of requirement for high performance.

## 4. Optical Storage Field

### 4.1 Read-Only Equipment

The read-only equipment category covers CD players (music CD players, CD-ROM units), DVD players (videos, games, PCs, car navigation) and BD players. The total shipment value of read-only equipment decreased by 10% from an actual value of 726.9 billion yen in FY 2012 to 652.9 billion yen in FY 2013. This is because of the significant decline in BD players of 36.9% between FY 2012 and FY 2013. In FY 2014, the total shipment value for the entire read-only equipment field is expected to decline only slightly by 2.3% from the previous fiscal year because the shipment value of BD players is expected to recover and DVD-ROM equipment for games and video is decreasing. The trend in DVD equipment accounting for more than 50% or more in a breakdown in the total shipments has not changed this year also. The domestic production value is rising and falling: a 37.2% decrease YoY in FY 2012, a 23.2% increase YoY in FY 2013, and a 12.3% decrease YoY in FY 2014 (estimated). The factors in the violent fluctuations could be the increase in onboard equipment because of the expansion of the auto industry following the economic recovery, and the rush in demand ahead of the consumption tax hike and the reaction to, as well as the saturation in the shift of domestic production to overseas plants. Most BD players have been produced overseas from the beginning, and the domestic production value is very small and unchanged. It may be difficult to return to domestic production in the future.

### 4.2 Recording and Playing Equipment

In the recording and playing equipment category, DVD/BD drives used in PCs and BD recorders are surveyed. The actual total shipment value of this category amounted to 402.5 billion yen in FY 2013, and the estimate for FY 2014 is 367.0 billion yen, showing a decrease of 8.8% from the previous fiscal year. The actual domestic production

value in FY 2013 was 37.8 billion yen, and in FY 2014, it is estimated to decline by 62.1% compared to the previous fiscal year to 14.3 billion yen. BD related devices accounted for 60% or more of the actual total shipment value. Some models of the latest BD recorders can transfer recorded programs to a smartphone on the go beyond the boundaries of the home wireless network. Recording BD drives for PCs include those installed in high-performance desktop PCs and notebook PCs, and slim USB bus power driving compact external BD drives. These drives have a major market in Japan where a BD recording function is preferred. All production of DVD recording/playing equipment for PCs has been shifted to overseas. Unlike recording BD drives, these drives target PCs in the global market. However, due to slimmer PCs in response to the emergence of large-screen smartphones and tablets, higher-speed IP networks, and expansion of cloud services, PCs with no optical disc device installed will continue to increase.

### 4.3 Optical Disk Media

In the optical disk media category, the domestic production value of CD-Rs, DVD  $\pm$  Rs and BD-Rs, which are write-once optical disk media, in FY 2013 was approximately 8.7 billion yen, showing a decrease of 20.8% from the previous fiscal year. In FY 2014, the figure is estimated to decrease by 6.2% to approximately 8.2 billion yen. On the other hand, the total shipment value of these media in FY 2013 was 30.5 billion yen, showing a decline of 15.5%, which is equivalent to approximately 3.5 times the domestic production value in the same fiscal year, indicating that a significant proportion of the production was shifted to overseas (including outsourced production). It is thought that domestic manufacturers will procure inexpensive media mainly from overseas, and shift domestic production to higher value-added professional-use media and multi-layer media. The domestic production value of MDs and MOS, which are rewritable optical disks, in FY 2013 was approximately 800 million yen with a decline of 21.9% compared to the previous fiscal year, and the total shipment value was also approximately 800 million yen. Most products are produced in Japan and it is expected that the demand will continue to decrease. The domestic production value of rewritable DVDs (including CD-RWs) in recent years has been on a downward trend. Domestic manufacturers have been shifting production to BDs that are technically difficult to produce and high-priced. The domestic production value of BD-REs in FY 2013 decreased by 5.9% from the previous fiscal year to 3.1 billion yen and is expected to decline further by 6.3% in FY 2014. On the other hand, the total shipment value of BD-REs in FY 2013 was 8 billion yen, showing a decrease of 2.4% compared to the previous fiscal year, and in FY 2014, is expected to decrease by 10.0% to 7.2 billion yen. With BD-REs, it is also thought that domestic manufacturers will shift their production to higher value-added professional-use media and multi-layer media. For professional-use write-once optical disks, both the domestic production value and the total shipment value in FY 2013 increased by nearly 300% from the previous fiscal year, and are also expected to grow in FY 2014. For professional-use rewritable optical disks, the domestic production value in FY 2013 was approximately 3.2 billion yen, and in FY 2014 it is expected to decrease by 5.0%. The total shipment value in FY 2013 was approximately 3.9 billion yen, with an increase of 20.0% compared to the previous fiscal year. In FY 2014, it is expected to decrease by 5.0% to approximately 3.7 billion yen. Since there is little difference between the domestic production value and total shipment value of professional-use optical disks, most professional-use optical disks that require high reliability are manufactured in Japan. Since optical disks are superior in environmental resistance such as dustproofness and waterproofness, they have a long life in addition to compatibility between different generations of format being guaranteed, and so the market for archival purposes is expected to grow.



#### 4.4 Noteworthy Trends

The standardization of optical disks and archiving were picked up as noteworthy trends this fiscal year. Regarding the standardization of optical disks, with the explosive growth of information, the standards for long-term storage on optical disk have been actively published in and outside Japan. In FY 2013, the physical standards for various BDs such as ISO/IEC 30190, and the operational standard for long-term storage on optical disks, JIS Z 6017 were published. In FY 2014, BDs were added to the "Test method for the estimation of the lifetime of optical media for long-term data storage" (ISO/IEC 16963), its translation (JIS X 6256) was published, and "Selection of digital storage media for long term preservation" (ISO/TR 17797) was developed.

Museums, libraries, and archives (hereafter, "MLA") need to store digitized references, audio, and video stably over long periods. In response to social demands on the selection of media to reduce as much as possible the risk of deletion or modification during data storage, and operational procedures for fulfilling accountability to third parties, the Japan Image and Information Management Association (JIIMA) has started a certification system to certify the quality of archival optical disk products in this fiscal year. This is an appropriate mechanism for users who need to store information for long periods and to show reasonable criteria for the selection of media. It is expected to spread in the years ahead.

### 5. Input/Output (I/O) Field

#### 5.1 Industry Trends for the Entire Optical I/O Equipment Field

The domestic production value of the entire optical I/O equipment field recorded a significant reduction of 25% and above in FY 2008 and FY 2009, due to the impact of the recession stemming from the Lehman shock, and has continued to move downward after that. The domestic production value in FY 2013 was about 1,100 billion yen, showing a decrease to approximately 30% of the production value before the Lehman shock. The estimate for FY 2014 finally indicates signs of bottoming out but a tough situation persists. Reasons could be the shift of production to overseas, and the price decline due to intensifying competition, as well as the recession. In addition, smartphones have emerged, and replaced the role of conventional I/O equipment such as digital cameras and video cameras. Another reason is that domestic companies do not hold sufficient shares of the smartphones market.

On the other hand, as with the domestic production value, the total shipment value is also moving downward, but its decline is smaller compared to the domestic production value, which suggests that the domestic production value decreased more than the total shipment value because of the shift of production to overseas. However, according to the estimate for FY 2014, with the depreciation of the yen under Abenomics, it is predicted that some production will be returned to Japan. It is still necessary to pay close attention to the trends.

#### 5.2 Trends for Major Products

##### (1) Optical Printers and Multifunction Printers (MFPs)

The decreasing trend for optical printers and multifunction printers (MFPs) has finally changed and some upward trend can be seen. For MFPs in particular, both the domestic production value and the total shipment value in FY 2013 (actual) and FY 2014 (estimated) remained flat or upward compared to the previous fiscal year. The domestic production value of optical printers in FY 2014 is also expected to increase by 4.5%, which can also be interpreted as a sign of returning some production to Japan. On the other hand, the new business inkjet segment has been expanding as a rival for optical printers, and it is still necessary to pay close attention to the trends. One of the characteristics of printers and MFPs is regionality, and each region has different requirements for the products. Therefore, it will be even more necessary

to develop products that meet the needs of each individual region.

##### (2) Digital Cameras and Digital Video Cameras

Both the domestic production value and the total shipment value for digital cameras and digital video cameras are generally on the decline. This is due to the influence of the significant decline in the demand for low-priced digital cameras and digital video cameras following the emergence of smartphones. On the other hand, some products, such as action cameras (wearable cameras), are growing in this category. From now on, it will be important to publicize their special appeal that cannot be duplicated by smartphones to stimulate demand.

##### (3) Camera mobile phones and tablet terminals

For camera mobile phones including smartphones that have captured the demand for low-priced digital cameras and digital video cameras, both the domestic production value and the total shipment value have been decreasing. Eventually, a situation in which not only the direct market for camera mobile phones but also the indirect market for digital cameras and digital video cameras has been captured by overseas companies will be seen. For tablet terminals, fully-fledged dissemination started in FY 2013 and this has been steadily increasing in FY 2014 despite the end of rapid growth. From now on, it is expected that their application will expand in the corporate segment in which they are not widely used, to contribute to bringing efficiency to companies and create added value.

#### 5.3 Noteworthy Trends for This Fiscal Year

The introduction of Managed Print Systems (MPS), a print management system, is becoming widespread in Europe and the United States. High-performance A4 color MFPs have been released one after the other by each manufacturer. A4 color MFPs seem to be polarized into high-performance models as above and printer-based low-priced models.

Shipments of action cameras, which are recently gaining attention, have been steadily growing every year. As they allow videos to be shot easily from many angles, something that is not available with conventional digital video cameras, and come with a wide range of accessories for attaching the camera to various places, they are used for various purposes such as shooting sports videos, as onboard cameras, underwater filming, and cameras carried by personalities in variety programs.

In camera mobile phones, thanks to fully-fledged dissemination of an LTE-Advanced communications service, higher-speed and greater capacity communications services are available, which enables more lively communication. Therefore, the installation rate for camera functions will remain high, and the number of pixels will increase. Moreover, as the development of 5th generation mobile communications technology gets into full swing toward 2020, the revolution in the technology surrounding the camera function of mobile phones is predicted to progress every year.

### 6. Displays and Solid-state Lighting Field

The total domestic production value in the field of displays /solid-state lighting in FY 2013 was 2,562.7 billion yen (4.4% increase YoY), turning to an increase for the first time since FY 2010. The projected value for FY 2014 is 2,669.3 billion yen (4.2% increase YoY), maintaining an increase similar to FY 2013. In particular, all fields are on an upward trend: display equipment (2.8% increase), display devices (7.3% increase), and solid-state lighting devices/equipment (6.8% increase). This increase is likely associated with the increase in TV unit prices in line with the introduction of larger-screen, higher-resolution, and higher-function TVs, and continuous expansion of the market for small/medium-sized high-resolution liquid crystal panels for smartphones and tablets. Furthermore, the upturn in the economy so far has also probably made



some contribution. Growth in the solid-state lighting market has slowed, but the market continues to expand in terms of value as a result of offsetting price declines by an increase in sales quantity, and the shift to high-priced products thanks to the progress of control technology, including dimming and color toning.

On the other hand, the total shipment value in this field in FY 2014 is expected to decrease by 4.9% due to the decline in sales following the reaction to the rush demand ahead of the consumption tax hike. However, an increase and steady growth are expected for display devices (3.4% increase) and solid-state lighting devices/equipment (5.5% increase), as in FY 2013. The projection for FY 2015 is positive, and an increase or slight increase is predicted, including display devices.

## 6.1 Industrial Trends in the Display Field

The survey of the display field is conducted separately for commercial display systems that are close to consumers, and display devices that serve as a basis for industry.

### (1) Display Equipment

For flat panel display TVs, negative factors such as the decline in product unit prices due to continuous fierce competition were concerning. However, in FY 2013, total shipments and domestic production resulted in 3,133.2 billion yen (3.0% decrease YoY) and 189.3 billion yen (11.1% decrease YoY) respectively due to the rush in demand ahead of the consumption tax increase and the lessening of the significant declining trend. In FY 2014, despite the introduction of new technology such as larger-screen, higher-resolution TVs, a modest decline is expected with a total shipment value of 2,948.3 billion yen (5.9% decrease YoY) and a total production value of 177.4 billion yen (6.3% decrease YoY) due to the price decline, and in Japan, due to the rise in the consumption tax. It is thought that domestic manufacturers will further optimize their business structure including restructuring of manufacturing facilities to benefit the advantages of a weaker yen, in addition to exploring high value added product markets and designing products with reduced costs. The TV manufacturing industry is expected to get back on a path to growth, powered by stepping up efforts to differentiate itself from other companies following the fully-fledged introduction of smart TVs, in addition to the transition from test 4K broadcasting, which started in June 2014, to full-scale broadcasting.

The domestic production value of organic EL has generally been flat for the past several years. The production value for FY 2014 is projected at 7.9 billion yen, almost identical to the 8.0 billion yen results for FY 2013. In the global market for organic ELs, with the displays for large-screen TVs, tablets, and smartphones led by Korean manufacturers, the organic EL display panel development divisions of Sony Corporation and Panasonic Corporation were integrated, and JOLED Inc. was established on January 5, 2015, which is expected to accelerate mass production of organic EL display panels and to achieve prompt commercialization.

The market for large-scale LED displays is expanding, but while the total shipment results in FY 2013 was 53.1 billion yen (10.7% increase YoY), the projection for FY 2014 temporarily stagnates to 50.6 billion yen (4.6% decrease YoY). Going forward, the market is expected to grow again thanks to expanding demand and expanding investment in various public sectors in preparation for the 2020 Tokyo Olympic and Paralympic Games. In contrast, it is also desirable to achieve stable growth of the market by developing applications for commercial use other than at public facilities and sport facilities.

The total shipment value of projectors was 232.5 billion yen (9.1% increase YoY) in FY2013 and 250.1 billion yen (7.5% increase YoY) is expected in FY 2014 thanks to the expansion in educational use. Recovery from the downturn after the Lehman shock continues in spite of the effects of the continuing fall in unit prices and the slump in the

European market. The domestic production value, which had been decreasing, was 31.9 billion yen (28.1% decrease YoY) in FY 2013 and 32.6 billion yen (2.3% increase YoY) in FY 2014, and is thought to have bottomed. The shift from domestic to overseas production bases has been in progress. However, attention should be focused on whether the weak yen will return production to Japan. With new applications, several thousand lumen class models using solid-state devices such as LEDs and lasers as the light sources have been released by various companies, and attention is turning to future trends.

### (2) Flat Panel Display Devices

The total shipment value of flat panel display devices inverted to an increase to 1,918.1 billion yen in FY 2013 (3.3% increase YoY). In FY 2014, thanks to the expansion of the market for smartphones and tablet terminals that make use of high-definition small/medium-sized LCD panels in which domestic manufacturers have strength, it is expected that total shipments will continue to increase to 1,982.5 billion yen (3.4% increase YoY). The domestic production value also grew to 1,605.6 billion yen (8.6% increase YoY) in FY 2013, and is expected to continue increasing to 1,722.8 billion yen (7.3% increase) in FY 2014.

It is expected that demand will expand in 2015 and beyond with the small/medium-sized LCD panel business as a core, and growth will continue against the backdrop of market expansion on the back of smartphones and tablet terminals with sophisticated functions. In terms of technology, demand expansion is expected around high-value-added products for which domestic manufacturers have advantages, thanks to the progress in high-resolution panels capable of displaying large volumes of data, wide color gamut reproduction using new quantum dot materials, and in-cell housing of touch panels.

## 6.2 Industrial Trends in the Solid-state Lighting Field

The solid-state lighting devices/equipment has grown dramatically, and total shipments were 509.0 billion yen (24.5% increase YoY) in FY 2013, which was still a significant increase. In FY 2014, it is expected to expand relatively moderately to 537.1 billion yen (5.5% increase YoY). Among these, the total shipment value of LED lighting devices for general lighting was 411.2 billion yen results (34.9% increase YoY) in FY 2013 and expected to be 441.6 billion yen (7.4% increase YoY) in FY 2014. In terms of technology, progress in control technology, including dimming and color toning, is expected in the future.

The growth in the shipment volume and value of LED lighting devices in the domestic market has become apparent since 2009. It grew steadily compared to the previous year, but in FY 2014, growth is expected to decline significantly to 7.4% below the norm. When looking at the ratio of shipment volumes of LED lighting devices to shipment volumes of all lighting devices (shipment volume of LED lighting devices / shipment volume of all lighting devices) and the ratio of the shipment value of LED lighting devices to the shipment value of all lighting devices (shipment value of LED lighting devices / shipment value of all lighting devices), in FY 2013 the ratio reached 61% in volume and 62% in value, and in FY 2014 the ratios for both volume and value are projected to exceed 70%.

## 7. Photovoltaic Energy Field

### 7.1 Industry Trends in Photovoltaic Energy

#### 7.1.1 Photovoltaic Power Systems

Figure 8 shows changes in the domestic production value of photovoltaic systems, which indicate the size of the photovoltaic industry. For photovoltaic systems, both the domestic production value and total shipments (which include the overseas production value) have been growing year by year, due to the various introductory projects for new energy by the Japanese government. In particular, due to the revival of subsidies to residential solar power systems and the launching of the

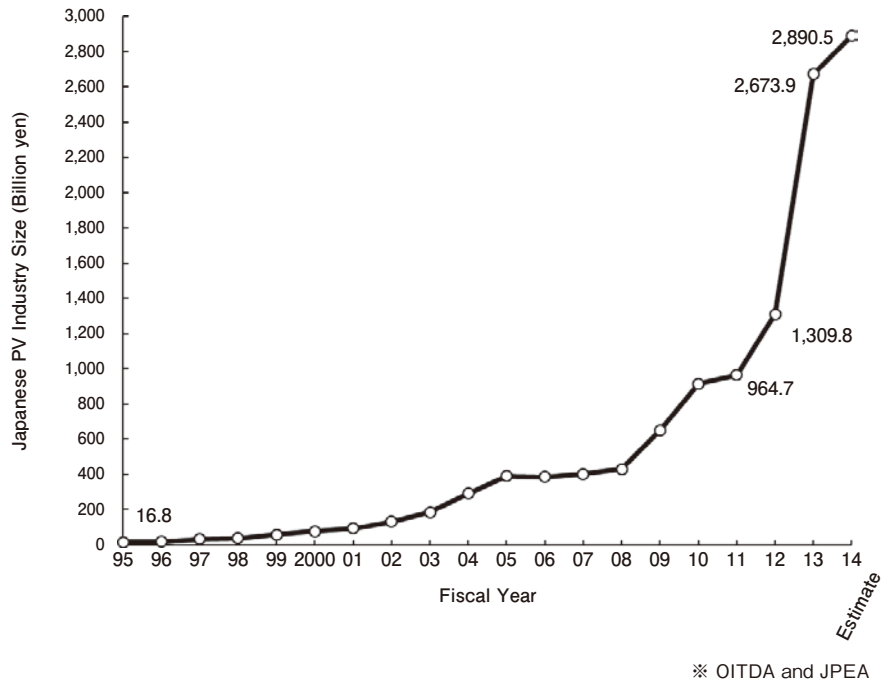


Figure 8 Changes in Japanese PV Industry Size

system of surplus power purchases at preferential prices in FY 2009, the size of the photovoltaic industry regained its expanding trend, and the production value expanded to 914.3 billion yen in FY 2010 and 964.7 billion yen in FY 2011. Furthermore, due to the start of Feed-in Tariff (FIT) in FY 2012, non-residential markets were also coming into the picture along with residential markets. As a result, the size of the photovoltaic industry rapidly increased to 1,309.8 billion yen (36% increase YoY), growing to the 1 trillion yen range. The boom in the nonresidential market and further reductions in solar power system prices have led to progress in expansion of the photovoltaic industry, and it recorded a doubling increase to 2,673.9 billion yen in FY 2013. In FY 2014, following the trend in FY 2013, and with progress in the introduction of authorized photovoltaic facilities, the size of the photovoltaic industry is expected to reach 2,890.5 billion yen (8.1% increase YoY).

### 7.1.2 Photovoltaic Cells/Modules

In FY 2013, the domestic production value of photovoltaic cells/modules reached 669.0 billion yen (4.4% increase YoY), but in FY 2014, the domestic production value is expected to significantly decline to 516.3 billion yen (22.8% decrease YoY), because of the price fall in cell modules and the subsequent overseas production shift, in spite of the increase in photovoltaic systems thanks to the strong domestic market.

In FY 2013, Total shipments of photovoltaic cells/modules increased significantly to 1,536.0 billion yen (55.9% increase YoY), thanks to large growth in the domestic market, but in 2014, total shipments of photovoltaic cells/modules are expected to 1,482.1 billion yen (3.5% decrease YoY), due to the price fall in cell modules.

### 7.2 Detailed Analysis of the FY 2013 Shipment Volume

As shown in Table 3, in FY 2013, the total shipment volume of solar cells in Japan was 8,625 MW (97.3% increase YoY), which overtook the past record. It is attributed to the fully-fledged expansion of the domestic market, thanks to the second year of the FIT, which started in July 2012. The conventional photovoltaic system popularization support project by the Japanese government focused on the residential market.

However, after the transition to FIT, it has extended to government and industry, and the electrical business market as well. Moreover, the drop in photovoltaic energy system prices has placed it on a fully-fledged path to growth for the domestic market.

Looking at each material individually, the consumer field is 0.1 MW, which is very small increase similar to last year. The electrical business field is 7,927 MW, with an increase of 3,673 MW from the last fiscal year, a quantum leap into the 8GW range. The research and other fields (including private generation) increased from 117 MW last year to 699 MW.

Looking at each material individually, as shown in Table 4, the shipment quantity increased greatly for all material types, including monocrystalline Si, polycrystalline Si, a-Si, etc. In FY 2011, polycrystalline Si and monocrystalline Si were at similar levels, but since FY 2012, polycrystalline Si has been rising to surpass monocrystalline Si by far. Polycrystalline Si increased to 4,741 MW (135.5% increase YoY), a doubling increase in two consecutive years after negative growth in 2011, getting close to 5GW. Polycrystalline Si is the main type of photovoltaic energy used in government and industry and the electrical business field, so its shipment quantity increased greatly due to the growth in domestic demand. On the other hand, the monocrystalline Si type increased to 2,986 MW (92.0% increase YoY), showing a significant expansion similar to polycrystalline Si. The a-Si/monocrystalline Si, a heterojunction type of monocrystalline Si type photovoltaic cells and back-contact type monocrystalline Si photovoltaic cells, have become the focus in monocrystalline Si photovoltaic cells, and these types of photovoltaic cells have been displaying a continuous underlying upward trend focused on the residential market because of their high energy conversion efficiency. On the other hand, the a-Si type and others have shown steady expansion every year, especially CIS thin film photovoltaic cells, and the shipment volume in FY 2013 was 898 MW (11.9% increase YoY), almost reaching the 1-GW level. Only Japan has been successful in the large-scale commercial production of CIS photovoltaic cells, and it is gaining global attention for its GW level production.

Table 3 Shipment of PV cells by use in FY2011 to 2013

usage	FY2011		FY2012		FY2013		growth amount (MW)	growth rate (%)
	shipment (MW)	share (%)	shipment (MW)	share (%)	shipment (MW)	share (%)		
consumer	0.3	0.0	0.3	0.0	0.1	0.0	-0.2	-66.7
power generation	2,684.7	100.0	4,254.3	100.0	7,926.8	91.9	3,672.5	86.3
for research and others	0.6	0.0	116.7	0.0	698.5	8.1	581.8	498.5
total	2,685.6	100.0	4,371.3	100.0	8,625.4	100.0	4,254.1	97.3

Table 4 Shipment of PV cells by material type in FY2011 to 2013

materials	FY2011		FY2012		FY2013		growth amount (MW)	growth rate (%)
	shipment (MW)	share (%)	shipment (MW)	share (%)	shipment (MW)	share (%)		
monocrystalline Si	1,028.0	38.3	1,555.3	35.6	2,986.3	34.6	1,431.0	92.0
polycrystalline Si	1,021.1	38.0	2,013.3	46.1	4,741.0	55.0	2,727.7	135.5
a-Si others	626.4	23.7	802.6	18.4	898.0	10.4	95.4	11.9
total	2,675.5	100.0	4,371.2	100.0	8,625.3	100.0	4,254.1	97.3

## 8. Laser Processing Field

### 8.1 Industry Trends for the Entire Laser Processing Field

The laser processing field covers a wide range of areas from the welding/cutting of thick steel plates in the automobile, shipbuilding, and other industries, to micro processing purposes such as micro drilling, scribing, marking, and lithography in the electronics and optoelectronics industries. The lasers used overlap and are complicated. However, to facilitate an understanding of industry trends for the survey, they are classified into carbon dioxide gas lasers, solid-state lasers, excimer lasers, fiber lasers, and semiconductor lasers for analysis. Since the last fiscal year, lamp lithography equipment using g-line (436nm), h-line (405nm), and i-line (365nm) have been added as other optical processing equipment. In addition, additive manufacturing (AM): 3D printing, which is recently drawing attention, has been also added as a new target of the survey.

The production values that saw a large drop due to the Year 2000 slump on the IT industry started showing a clear recovery trend from FY 2003 and eventually production grew strongly. However, due to the global recession that originated from the U.S. in the latter half of FY 2008, the trend reversed to show a large decline and in addition, its effects are estimated to have grown, and showed a further large decline in FY 2009. On the other hand, signs of an economic recovery in the semiconductor and LCD industries can be seen since the second half of FY 2009, and in FY 2010, they showed a V-shaped recovery with 53.3% growth, and in FY 2011 this declined with a reduction of 3.9%. This could have been because of the deterioration in export conditions following the stronger yen, and the influence of the EU economic recession. In FY 2012, this trend accelerated and led to a further huge drop of 26.6%. On the other hand, in FY 2013, the Japanese economy moved towards recovery due to the effect of Abenomics coupled with correction of the strong yen, and a 19.2% rise was achieved. This healthy condition continued through FY 2014 as well, with projections of a 13.9% increase, and in FY 2015, a gradual rise is predicted.

### 8.2 Remarkable Trends for This Fiscal Year

Since this fiscal year, Other Optical Processing Equipment (lamp lithography equipment) and AM have been added to the survey targets. Other Optical Processing Equipment took the largest share of 40.7% in the estimates for FY 2014. This is because i-line lithography equipment is still widely used for all but high-end applications, and in addition to i-line, h-line and g-line are used for LCD lithography, and the equipment cost per unit is very high. The share of AMs is 1% or smaller. On the other hand, comparing only the carbon dioxide gas laser, solid laser,

excimer laser, and other laser-applied production equipment, which has been conventionally surveyed, the excimer laser significantly lost its share from 54.8% in FY 2013 to 43.6% in FY 2014. Conversely, other laser-applied production equipment greatly increased its share from 2.9% to 12.6%. This increase was driven by fiber lasers and semiconductor lasers. Solid-state lasers also gained in share from 11.7% to 14.1%. Carbon dioxide lasers are at 29.7%, which changed little from last year.

Trends in major products are discussed below.

### 8.3 Trends in Major Products

#### (1) CO<sub>2</sub> laser

CO<sub>2</sub> lasers increased by 13.8% in FY 2013, thanks to the effects of Abenomics. In FY 2014, this is expected to grow by a further 22.7%. Cutting and drilling applications represented a share of 96.8%. However, cutting, which has been sluggish, is used in a wide range of fields including automobiles, electric equipment, and steel materials, and increased by 28.2%. Printed circuit board drilling machines, which indicated a 30% or higher growth in FY 2013, grew only 12.6%. In the cutting, welding, and connection fields, replacement with fiber lasers is steadily in progress. Following the economic recovery in FY 2014, CO<sub>2</sub> laser production equipment also rose in scale. Concerns such as the Greek crisis still remain, but continuous growth from the effects of Abenomics is hoped for again in FY 2015.

#### (2) Solid state lasers

The domestic production value of solid-state laser-applied production equipment shows a recovery from a flat/slight decline in FY 2013, and a significant increase of 30.5% is expected. The reason for this could be that the increase in production thanks to the boom in the automobile industry together with the improvement in the economy drove an expansion in the cutting and drilling of onboard parts. In particular, the onboard parts (relays, sensors, etc.) field is steady, and cutting/drilling shows a significant increase of 81.0%. The application of picosecond lasers for production purposes seems to have started.

#### (3) Excimer lasers

The production value of excimer laser-applied production equipment has expanded steadily since FY 2003, and recorded an all-time high in 2007. However, due to the influence of the worldwide recession starting with the subprime loan problems, it slid into a decline in FY 2008, and decreased significantly in FY 2009 by 39.7% from the previous fiscal year. In FY 2010, it showed a V-shaped recovery with 52.8% growth compared to the previous fiscal year, following the growth of the Asian economy, and economic recovery in Japan and the United States.

However, in FY 2011 and FY 2012, it inverted to show decreases of 7.3% and 29.1% respectively due to the suppression of capital investment by semiconductor manufacturers. In FY 2013, semiconductor investment recovered, and investment in high-resolution small/middle LCD panels is steadily increasing, and investment in large panels has been gradually recovering since the 2nd half of the fiscal year to increase by 20.2% from the previous year, partly because of the rebound to investment suppression in the previous year. In FY 2014, the demand for semiconductors continued to recover, but the investment in small/middle LCD panels completed, and production is expected to decline by 9.2% from the previous fiscal year. A slight decrease is also predicted for FY 2015. Lithography equipment contributed most to the changes in the production value of excimer laser-applied production equipment. In FY 2014, excimer laser annealing (ELA) equipment changed significantly but its effects are limited. In FY 2014, slower growth can be seen in some rising countries. In Japan, the effects of the weaker yen and Abenomics are steadily yielding fruit, and the markets in Europe and the United States, China, Korea, and Taiwan steadily grew. However, due to a declining share, the domestic production value is expected to slightly decrease. In FY 2015, the demand for memory and image sensors is steady. Following the expansion of panel demand for 4K TVs, the domestic production value is expected to be flat.

#### (4) Fiber laser-applied production equipment

The production value of fiber laser-applied production equipment grew by 30% every year, but a significant growth of about 200% is expected for FY 2014. This is because of the acceleration of its replacement by fiber lasers in the metal processing field, in which carbon oxide gas lasers have mainly been used, as well as the expansion of the laser-applied processing equipment market following domestic economic recovery. However, the market size is smaller than for carbon oxide gas lasers, and there is no sign of a reduction in the carbon oxide gas laser processing equipment market. In FY 2015, the production of fiber laser-applied production equipment is expected to be flat, but the replacement of carbon dioxide lasers will progress in the future. The domestic production value of fiber laser oscillators increased by 48% in FY 2013, and is expected to grow by 31% in 2014. Compared to other laser oscillators, this indicates a large expansion. However, it is smaller than for fiber laser-applied production equipment, which suggests an increase in imports of fiber laser oscillators.

#### (5) Semiconductor laser direct processing equipment

Semiconductor laser direct processing equipment is mainly used for laser hardening, laser annealing, laser welding, laser brazing, laser soldering, and laser marking (resin). With the development of high-intensity semiconductor lasers, it has started to be used for applications conventionally covered by carbon dioxide gas lasers and fiber lasers. The growth in FY 2013 was a small 1 to 2%, but in FY 2014 a 15% or higher growth is expected. The projection for FY 2015 is a slight increase, but there is a possibility that direct processing equipment with high-intensity semiconductor lasers will grow substantially.

#### (6) i-line lithography equipment

i-line lithography equipment has been added to the survey targets since last year and both the domestic production value and shipment value increased by around 20% from the previous fiscal year in both FY 2013 and FY 2014. In FY 2015, they are also expected to increase moderately.

#### (7) Additive Manufacturing (3D Printers)

Although the production value is small, AM indicated a remarkable growth of 437.0% in FY 2014 compared to FY 2013. In Japan, small-lot industries such as aircraft, space, and weapons industries, where AM technology is used on products, are small in scale, and mass production industries such as automobiles, home electronic appliances, and electronics can only use AM technology for prototyping. However,

recently, composite processing equipment that combines powder bed fusion equipment and directed energy deposition equipment with cutting equipment have been released one after another. It is thought that even in Japan, the design will progress so that it can exploit the advantages of AM technology, and it will be more efficient to directly manufacture many products and parts using AM technology for production costs and delivery deadlines in the future. With the promotion of projects with industry-government-academia partnerships and the revival of capital investment following the return of production to factories in Japan due to the weaker yen, the market is expected to grow significantly.

## 9. Sensing and Measuring Field

### 9.1 Optical measuring instruments

Optical measuring instruments is basically used to measure optical characteristics in the research/development/production of optical devices/optical modules/optical communications systems that use wavelengths from the visible range to the near infrared range, and in the installation/maintenance of optical fibers. This survey targets optical spectrum analyzers (including wavelength meters), measuring instrument light sources, OTDRs, power measurement systems, optical fiber identifiers, and medical optical measurement instruments. The domestic production value in FY 2012 decreased slightly by 5.6% from the previous fiscal year to 12,672 million yen, but in FY 2013 increased from the previous fiscal year by 4.3% to 13,216 million yen, showing a slight increase. Domestic production in FY 2014 is estimated to decrease by 3.8% compared to the previous fiscal year. As with production values, the total shipment value in FY 2013 increased by 12.7%, but a slight decline of 2.1% is expected for FY 2014. It is estimated that the following factors exist in the optical communications field in which these instruments are used as a backdrop.

In Japan, FTTH has been spreading steadily since the start of the service in 2001. However, with the emergence of smartphones, 3G/LTE mobile networks have recently proliferated explosively, and in place of the conventional fixed wired networks, mobile wireless networks are leading broadband services. In other countries, mobile access mainly supports broadband as in Japan. And this trend will continue in future. With the rapid growth of mobile traffic, there will be continuing demand for optical measuring instruments used in the manufacture of transmission equipment and optical devices to support the traffic. However, production and shipment tend to fluctuate according to the upgrading of trunk and metropolitan systems instruments. In addition, for low-cost field-use optical measuring instruments, low-priced products from overseas manufacturers are expanding the market, which does not lead to any substantial increase in the domestic production value.

### 9.2 Optical Sensing Equipment

The domestic production value of optical sensing equipment in FY 2012 decreased by 17.6% from the previous fiscal year to 144,756 million yen, and the result for FY 2013 was 148,812 million yen with a 2.8% increase, and an increase of 2.3% is expected for FY 2014. As with production values, total shipment values have been increasing. Optical sensing equipment uses sensors that use light at wavelengths mainly from the visible range to the infrared range. As many of them are used in industrial sectors, the demand largely depends on investment in production facilities. The attitude to strengthen overseas production persists. However, with the economy on its way to recovery, and the effects of recent sharp depreciation of the yen, returning production to Japan is making a contribution.

Looking at the breakdown in the domestic production value results for FY 2013, motion sensors increased by 13.2% from the previous fiscal year, infrared cameras and their application equipment increased by 23.1% and security equipment increased by 33.1%. The product



groups used for security show significant increases. For others, temperature sensors/radiation thermometers increased by 18.5%. The product groups including motion sensors, that can be used to save energy, indicate a growth of more than 10%.

In the security fields, with a recent rise in awareness of crime prevention by companies and individuals, the domestic markets for security devices such as motion sensors and infrared cameras has been experiencing massive growth. Moreover, motion sensors are finding applications in energy saving fields, and they are spreading to control the operation of many devices such as air conditioners, electric fans, TV sets, electric toilet seats, and vending machines, as well as automated lighting in bathrooms and corridors where there are existing markets.

On the other hand, for devices such as photoelectric sensors, rotary encoders/linear scales, displacement/length-measuring sensors, speed sensors, surface inspection systems, component analyzers, and environmental sensors and equipment that are affected by capital investment in manufacturing industries, some products are slightly increasing and others are slightly decreasing. With the trend for production to return to Japan in the manufacturing industries, optical sensing equipment as a whole shows a tendency to improve, but some fields indicate no sign of recovery. There is remarkable growth in optical sensing equipment that responds to social needs, and this trend will continue in the future.

## 10. Resources for the Optoelectronics Industry

### 10.1 Introduction

The number of full-time employees, the number of researchers engaged in R&D in optoelectronics-related companies, and the amount of investment in R&D are surveyed.

With the survey contents being the same as the preceding fiscal year, a quantitative questionnaire survey to obtain the figures for estimates for FY 2014 was conducted. For the estimates for FY 2014 and projections for FY 2015, a quantitative questionnaire survey was performed to determine whether they “increased,” “decreased,” or “stayed the same” compared to the previous year. For reference purposes, the total domestic production for the optoelectronics industry has also been included in the survey. In this fiscal year, we obtained responses from 62 companies, which is 11 companies more than the previous fiscal year, and are reporting the summarized results.

### 10.2 Resources for the Optoelectronics Industry for FY 2014 (Estimate)

#### (1) Number of full-time employees and number of researchers

Regarding human resources, the 62 companies included companies with from 5 up to 20,000 full-time employees, and the median number was between 100 and 149. The number of researchers was from 2 up to 3,000, the median number was between 40 and 49. Comparing the same cumulative number of companies, it is thought that about 1/5 to 1/2 of full-time employees are R&D workers.

#### (2) Amount invested in research & development and domestic production (reference)

Looking at funding, the 62 companies include companies with 500 thousand yen to under 100 billion yen invested in research and development, and the median was from 200 up to 500 million yen.

Looking at domestic production values, 17 companies responded that their domestic production value increased in FY 2014 compared to the previous fiscal year (2013), 36 responded that the value stayed the same, and 9 reported a decrease. Twenty-one companies intend to increase production in FY 2015 from this fiscal year (2014), 28 intend to maintain the same level, and 13 companies intend to reduce it.

### 10.3 Increase/Decrease from the Previous Fiscal Year (Estimate for FY 2014, Projection for FY 2015)

#### (1) Number of full-time employees

Ten companies responded that the number of fulltime employees increased in FY 2014 compared to the previous fiscal year (2013), 46 responded that the number stayed the same, and 6 reported a decrease. Ten companies intend to increase their personnel in FY 2015 from this year (2014), 35 intend to maintain the same level, and 17 companies intend to reduce it.

Changes in the top three responses are (FY 2014 → FY 2015): (1) Same → Same (29 companies), (2) Same → Decrease (12 companies), (3) Increase → Increase and Same → Increase (5 companies)

#### (2) Number of researchers

Eight companies responded that the number of researchers increased in FY 2014 compared to the previous fiscal year (2013), 50 responded that it stayed the same, and 4 reported a decrease. Ten companies intend to increase the number of researchers in FY 2015 from this year (2014), 41 intend to maintain the same level, and 11 companies intend to reduce it.

Changes in the top three responses are (FY 2014 → FY 2015): (1) Same → Same (32 companies), (2) Same → Decrease (8 companies), (3) Same → Increase (4 companies)

#### (3) Amount of R&D investment

Twenty-two companies responded that they increased investment in FY 2014 compared to the previous fiscal year (2013), 29 responded that it stayed the same, and 11 reported a decrease. Twenty-four companies intend to increase R&D investment in FY 2015 from this year (2014), 18 intend to maintain the same level, and 20 companies intend to decrease it.

Changes in the top three responses are (FY 2014 → FY 2015): (1) Same → Same and Increase → Increase (11 companies), (2) Same → Increase (10 companies), (3) Same → Decrease (8 companies)

#### (4) Domestic production (Reference)

Seventeen companies responded that domestic production increased in FY 2014 compared to the previous fiscal year (2013), 36 responded that it stayed the same, and 9 reported a decrease. Twenty-one companies expect production to increase in FY 2015 from this year (2014), 28 expect it to maintain the same level, and 13 companies expect a decrease.

Changes in the top three responses are (FY 2014 → FY 2015): (1) Same → Same (23 companies), (2) Same → Increase (10 companies), (3) Increase → Increase (9 companies)

## 11. International Trends Observed at the IOA Meeting

### 11.1 Introduction

The Optical Industry and Technology Development Association (hereafter, OITDA) was established in Japan in 1980 for the promotion of the optical industry, the first such organization in the world. Subsequently many similar organizations came to be established in many parts of the world starting in the 1990s. In July 1996, OITDA served as a host organization, and worked with OIDA (Optoelectronics Industry Development Association, U.S.), PIDA (Photonics Industry and Technology Development Association, Taiwan), and SOA (Scottish Optoelectronics Association, Scotland), which had already been established at that time, to hold an international meeting of the group of four organizations. Since then, meetings have been held every year. Since FY 2007, the group has been called the International Optoelectronics Association (IOA; the number of participating organizations has increased since the year 2000 and at present it has nine member organizations.

The 8th meeting (19 in all) after it became IOA was held in Washington, D.C. in November this year (FY 2014), with OIDA (U.S.) as the host organization. Here we have briefly explained trends in the



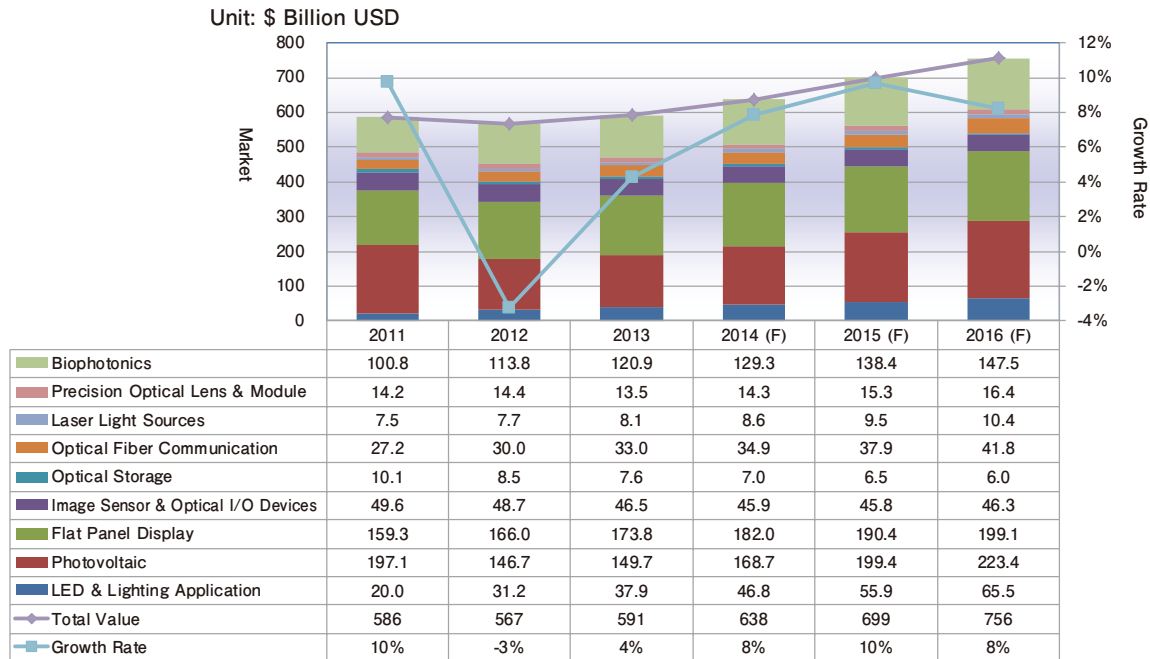


Figure 9 Changes in the Global Market of Optoelectronics Industry (PIDA)

optoelectronics industry on a global scale and in the major countries, based on the materials published by this conference. However, although each organization's definitions of the categories of their optoelectronics industries are generally based on OITDA's categorizations, this can vary between organizations, so in the strict sense they are not comparable with Japan.

## 11.2 Global Optoelectronics Industry Trends

### 11.2.1 Overall Global Optoelectronics Industry Trends

Each year PIDA (Taiwan) reports the trends in the global optoelectronics industry as well as in Taiwan. This year, as shown in Figure 9, the report gives results and prediction for the global market from 2011 to 2016. The global optoelectronics market declined by 3% in 2012, but since 2013 has steadily recovered and is expected to increase by 4% in 2013 and by 8% in 2014. An increase of approximately 10% is predicted for 2015 and 2016. The global optoelectronics industry is growing steadily.

### 11.2.2 Optoelectronics Industry Trends in Each Country

The following gives an overview of the optoelectronics industry in each country:

#### (1) Taiwan (PIDA report)

According to PIDA, the optoelectronics industry in Taiwan exhibited negative growth in 2012 and 2013, but a slight growth of 5% is expected for 2014. The market is driven by flat panel displays, which remain almost constant, and the optical storage field is on a downward trend.

#### (2) The U.S. (OIDA report)

In the U.S., the photovoltaic cell field accounts for a large share, followed by the optical communications field, and LED and imaging fields.

#### (3) Scotland (SOA report)

In Scotland, the defense and imaging/sensing fields are steadily growing. However, the other fields are showing a slight downward trend.

#### (4) Switzerland (Swiss Photonics report)

The total revenues for the optoelectronics industry in Switzerland dropped sharply in 2009 and gradually recovered, but in 2012, experienced a decline of nearly 20%. The reason for the decline was a sudden decrease in the photovoltaic cell field. On the other hand, the laser processing field and image processing field are leading the industry. The photovoltaic cell field still has an approximately 10% share, but it was reported that this share will gradually decrease in the future.

## 1. Introduction

OITDA has been conducting research studies every year on optoelectronics technology trends in order to explore new movements in the optoelectronics technology and to provide guidelines for the future. This fiscal year, seven fields including inorganic optical materials and devices, optical communication networks, information processing photonics, laser processing and optical measurement, light energy, organic optical materials and devices, and optical user interfaces were surveyed. The results for each field are being published in 19 articles in "Technology Trends" on OITDA's web news, OptoNews, and will also be presented in the Optoelectronics Technology Trend Seminar at the InterOpto 2015 exhibition scheduled on October 14 to 16, 2015.

## 2. Inorganic Optical Materials and Devices

### 2.1 Terahertz/Mid-Infrared Ranges

Since diverse materials including gases and bio-molecules show characteristic spectra in the terahertz range, terahertz technology is expected to find applications in various safety and security devices. Developing an easy-to-handle high-output light source and a high-sensitive detector is a challenge for practical applications.

In detectors, a pixel pitch of 12  $\mu\text{m}$  has been achieved in an uncooled infrared image sensor using the resistance bolometer method based on MEMS technology. As infrared image sensors have potential applications for thermography, night vision, etc., there are growing expectations for further miniaturization and cost reduction. On the other hand, with high-precision detection using an InAs/GaSb Type II superlattice infrared detector, a 10% or higher quantum efficiency has been achieved at a cut-off wavelength of 6  $\mu\text{m}$ . Expectations are expanding for longer cut-off wavelengths and higher performance.

In light sources, efforts to achieve operations of a quantum cascade laser (QCL) using conventional GaAs materials at higher temperatures and at lower frequencies are drawing attention. With the introduction of an indirect injection mechanism, 1.89 THz oscillation was attained at a temperature of 160 K, which demonstrated the efficacy of the mechanism. Development using GaN materials has been directed to achieving laser oscillation at a frequency range of 5 to 12 THz, that has not been attained with GaAs materials. There has been success in generating the world's first laser oscillation with a GaN QCL at frequencies up to 5.5 THz. There are expectations for achieving oscillation in a higher frequency band at high temperatures and high output.

### 2.2 Near-infrared Range (Wavelength range for optical communications systems)

The development of near-infrared range semiconductor lasers has been conducted mainly in the optical communications system field. However, since it is difficult to achieve a large-area emission and high-quality oscillation beam at the same time, high output could not be achieved easily, which has hindered an expansion of the application areas. With the advent of a Photonic Crystal Surface-Emitting Laser (PCSEL), it is now possible to generate high-output and high beam quality laser oscillation. Single-wavelength oscillation with a maximum output of 1.5 W or higher, an oscillation wavelength of 941.5 nm, a wavelength width of 0.02 nm or shorter, and a side-mode suppression ratio of 60 dB or higher has been achieved, which has raised expectations for applications in various fields. GaAsBi lasers are receiving attention as a means of reducing the temperature dependence of the oscillation wavelengths. Although they are still in the prototyping stages due to difficulties with crystal growth, laser oscillation has been achieved with a temperature dependence of oscillation frequencies of down to 45% of GaAs lasers.

Looking at optoelectronics technology, research and development of

silicon photonics has gained momentum. For passive devices, the use of a Silicon on Insulator (SOI) substrate improves in-plane uniformity and flexibility in structural design, which enables the development of devices having not only light transmission, but also a variety of functions. Regarding uniformity, a 300-mm wafer process for Arrayed Waveguide Grating (AWG) devices has achieved a wavelength variation of 3 nm or smaller. In addition, polarization-transformation at selected wavelengths and polarization-independent wavelength filters using a polarization rotation Bragg grating have been realized to accomplish the polarization diversity and polarization multiplexing transmission in a waveguide. For light sources, the use of III-V-group semiconductors is indispensable, and these require heterogeneous substrate bonding technology to form a III-V-group semiconductor on an Si platform. Many laboratories are developing direct bonding technology and resin bonding technology, and practical applications are expected. On the other hand, regarding the integration on an InP substrate, the scale has expanded from a light source and modulator, to a multi-mode interferometer and Mach-Zehnder modulator, and a photosensor. This is because of the switch from the conventional intensity modulation system to a phase modulation system for large capacity transmission. A small-sized coherent receiver, which can be installed in a CFP/CFP2 (C Form-factor Pluggable) transceiver, has achieved 128 Gbit/s DP-QPSK demodulation. There are two methods of implementing a light source on an optical module: active alignment and passive alignment. Active alignment has been the mainstream in implementations that require accurate alignment. However, with improvements in the accuracy of implementation in the passive method, an accuracy of 0.41  $\mu\text{m}$  ( $3\sigma$ ) can be achieved. Passive alignment has become a promising technology for mass production in the silicon photonics field.

### 2.3 Visible/Ultraviolet Ranges

With projectors using high-luminance lasers, application of the technology for visible-range light sources is expanding into the high-value-added cinema market.

For increasing the output of LEDs for lighting, it has been confirmed that the use of an m-plane GaN substrate improves efficiency in the violet wavelength ranges.

Ultraviolet light sources have been drawing attention as an alternative to mercury lamps that have a high environmental impact. Using an AlGaN system semi-polar-surface substrate, uniform crystal growth has been achieved by optimizing crystal growth conditions, which increases the speed of the radiative recombination process, identifying the possibility of efficiency improvements. Devices using a SiC photonic crystal are receiving attention as a breakthrough to the limit of Si photonic crystal devices in terms of strong optical input resistance and ultra-wide-band operation. In fact, multi-photon absorption reduction effects, wide-band operation, and thermal stability have been confirmed.

The technology for systematically supplying safe and secure high-quality organic food is being developed. This applies LEDs that can emit light of selected wavelengths to the fields of production at plant factories and agricultural pest control. In production at plant factories, it is possible to control texture as well as ingredients and growth rate, which enhances the merchantability of high-value-added vegetables. Invasion of insects mixed in cargos from overseas and carrying communicable diseases due to the global movement of people is a recent topic. The development of multi-wavelength LEDs has promoted a better understanding of insect attraction and control using light of various wavelengths and intensity. The development of the technology for collecting and controlling pests and spawn regulation is in progress.

## 3. Optical Communications

The FY 2014 Optoelectronics Technology Trend Survey of optical

communications was conducted as part of developing a roadmap of optical communications up to the 2030s by the Optical Communication Technology Joint Committee established under the Optoelectronics Technology Trend Research Committee and the Technological Strategy Development Committee. Application areas of optical communications generally include metro/core networks and access networks. However, it is also thought to cover the mobile area because optical access networks carry mobile traffic these days. In new services represented by cloud computing services, traffic tends to concentrate at data centers. It is expected that the traffic inside and outside data centers, and between data centers will be increasing. This is why a technology trend survey was carried on three areas: data centers, metro/core, and access/mobile.

### 3.1 Trends in the Data Center Area

A survey was conducted on technological trends in data center networks in terms of flexibility improvements/software linkage of the network, data center technology, transmission technology, large-scale/high-speed optical switches, optical fibers, optical integration technology, and silicon photonics.

Software-Defined Networking (SDN), which centrally controls the settings of network resources in a virtual environment by means of software, enables flexible control of any traffic without considering the detailed configuration of the data center network, which is expected to achieve a reduction in service preparation time and operating costs for the data center, and creation of new services that link applications with the network. In recent years, field trials have been carried not only on establishing connections within a data center, but also on configuring a large-area cloud by connecting several data centers via ultra-high-speed optical networks using SDN.

Since the traffic flowing between servers increases with the number of servers in a data center, the performance of the network connecting the servers significantly affects the processing capacity of the data center. To increase the speed of networks, enable flexible architectures, and reduce power consumption, the development of MMF transmission, 100 GbE/400 GbE SMF transmission, and optical switches are in progress. Moreover, at IEEE, in addition to the 100 Gb Ethernet, for which standardization has already started, standardization of a 400 Gb Ethernet is being considered.

To reduce space and expand the capacity of data centers, optical fibers with high wiring densities are required. The development of high-density cable technology and Multi-Core Fibers (MCFs) is in progress. There have been few reports on short-distance transmission experiments using Few-Mode Fibers (FMFs). However, there are potential applications following the progress of signal processing technology including MIMO.

For optical interfaces, application of silicon photonics is being considered. It is suitable for SMF transmission in the 1,550/1,310 nm bands, which will contribute to long-distance transmission due to the increase in the scale of data centers, as well as to higher speeds, lower power consumption, and reduced costs.

### 3.2 Trends in the Metro/Core Area

In the metro/core area, technological trends were surveyed in terms of higher reliability/simpler maintenance of the network, flexibility improvements/software linkage of the network, transmission system/node/optical transceiver technology, optical fibers, and optical integration technology.

As a metro/core network consists of many pieces of equipment and several networks, it requires complicated operation and management, which is one of the reasons for the increase in costs. Development is underway in which an SDN collectively manages those elements by handling the network as a large-capacity resource pool providing high-speed connections to increase flexibility in resource allocation. Unitary

control of a multi-layer network reduces maintenance tasks by simplifying operations.

For long-distance/large-capacity transmission, progress in digital signal processing technology is expected. A large amount of research has been conducted on ultra-high-density multiplexing by reducing crosstalk between wavelengths and reductions in the degradation of transmission quality induced by non-linear effects inside a fiber. Alongside the research into higher performance, reduction in size, cost, and power consumption are being vigorously studied from the viewpoints of optical transceivers and optical node control.

The transmission capacity of the currently available single optical fiber is limited to around 100 Tbps. The development of Few-Mode Fibers (FMFs), which can increase transmission capacity by the number of modes, Multi-Core Fibers (MCFs), which realize spatial multiplexing by placing several cores in a clad, and optical amplification technology for FMF/MCF is in progress. Increasing the speed of the digital signal processing circuit, downsizing, and to achieve these, raising the level of circuit integration are being considered.

### 3.3 Trends in the Access/Mobile Area

In the access/mobile area, a survey was conducted on the technological trends of silicon photonics in terms of optical access networks, and downsizing and a reduction in the power consumption of terminals.

In the access area, research and development are in progress on next-generation large-capacity optical access systems that will be used to provide homes and offices with high-definition video distribution and cloud computing services. Technological discussions on 10 Gigabit Ethernet Passive Optical Networks (10G-EPONs) and 10 Gigabit PONs (XG-PONs) are approaching their conclusion. Currently, standardization of the Next Generation PON phase 2 (NG-PON 2), which is a next generation optical access system exceeding 40 Gbps, is in progress at the ITU-T/FSAN. In NG-PON 2, Time and Wavelength Division Multiplexing-PON (TWDM-PON), which is based on four-wave multiplexing at 10 Gbps for download and 2.5 Gbps for upload, has been standardized. Standardization of the physical layer was completed in December 2014. As new trends, discussions on the management of optical access networks with an SDN have started. On the other hand, in the mobile field, discussions are underway on various Radio on Fiber (RoF) technologies to support wide-band mobile traffic and efficient accommodation of wireless base stations.

Silicon photonics is required not only for the downsizing of terminals including current Optical Network Units (ONUs) but also compact integration of optical transceivers to support TWDM-PON, which uses several wavelengths. The development of wavelength filters, optical modulators, optical receivers, and optical I/O is underway.

## 4. Information Processing Photonics

In information processing photonics, a survey was conducted on technological trends in three fields: optical memory, optical interconnection, and optical computing. With the ongoing sophistication of digital technology, dramatic progress especially in computers, mobile devices, and wireless/wired communications technology have led to explosive growth in the amount of information we handle. Looking at the advancements in science and technology, in computer science, which processes a large amount of data at high speed, and in computational science, which is called the third science, the technological development of petaFLOPS computing including super computers, and beyond—i.e. exaFLOPS computing—is important. In information processing photonics, a trend survey was carried out on optoelectronics technology concerning next-generation large-capacity information processing as discussed above.

#### 4.1 Optical Memory

According to the FY 2014 Information and Communications White Paper by the Ministry of Internal Affairs and Communications (MIC), the total amount of data around the world was approximately 1.8 ZB (1.8 trillion GB) in 2011 and will reach approximately 40 ZB (40 trillion GB) in 2020. Such a huge amount exceeds the total recording capacity of all the recording media in the world. Therefore, it is indispensable to further expand their recording capacity.

Looking at the trends in the research and development of optical memory over the past few years, archival applications are expanding at an increased rate. A trial calculation indicates that optical disc memory is 1.8 to 4.8 times superior to magnetic hard disks and magnetic tape in terms of the total cost over 20 years or longer data storage times. There are also reports describing that optical discs are robust against flood hazards. The notion that optical memory should be used for long-time storage is becoming common. However, the recording capacity of the current BD-based optical memory is around 128 GB. To catch up with the competing technologies, it is important to create a roadmap of increasing recording capacities and data transfer speeds, and to conduct basic research on recording methods, materials, and signal processing technologies.

In addition, development is ongoing to apply the technologies cultivated in the development of optical memory to other fields such as using optical disc technology for biotechnology and phase-change materials for devices.

#### 4.2 Optical Interconnect

The amount of information processed at data centers and with supercomputers will continue to increase dramatically, and the rate of increase is expected to exceed the growth in the performance of a single processor or memory by far. In principle, the only way to fill the gap between the growth in device performance and the expansion of the amount of information that needs to be processed is to increase the number of devices and process the information in parallel. Parallelism of IT resources is in progress in various layers of IT systems from many cores in an LSI chip to clustering in data centers and supercomputers. Therefore, the performance of the interconnect between parallel devices will have greater effects on the performance, cost, and power consumption of the entire system.

Optical interconnect is expected to be a means of solving the problems with interconnect. However, its application is currently limited to Active Optical Cables (AOCs) for interconnection between the racks and boards of supercomputers and at data centers where transmission distances are relatively long. In the future, electrical-optical conversion will be required near or even inside an LSI module in place of conventional electrical-optical conversion at the edge of a board. Therefore, the logical approach to interconnect will be silicon photonics that pursues integration of optical interposers that perform electrical-optical conversion inside an LSI module, and ultimately monolithic integration of LSI electronic circuits and optical circuits.

The market for this field is expected to expand to several hundred million dollars by 2020. Many players have proposed various methods and been struggling for leadership by promoting standardization and alliances. As this field has high demands for cost effectiveness, numerous proposals have been made on packaging technologies and connector technologies to in particular reduce assembly and inspection costs in preparation for commercialization.

#### 4.3 Optical Computing

Optical computing has a vast and diverse range of applications from image formation on a microscope to holography and Fourier optics. Optical computing is based on ultra-parallel and ultra-high-speed high-

resolution spatial signal control, which serves as information media. To realize an optical computing system, it is necessary to combine elemental technologies crossing fields from basic sciences to industrial technologies according to the purpose of creating an optical computing system with new functions.

Possible applications of optical computing include applications in fields where it is difficult to further increase speeds and reduce power with current electronic circuits, and sensing systems where it is advantageous at the current status of technology to process only optical information without embedding electronic devices.

In recent years, extensive research is conducted into a field of computational imaging that achieves deep depth-of-field and super resolution processing by combining an optical system and computer processing. Hot topics include single pixel imaging (imaging with a point detector) and an expansion of depth-of-field using a light field (ray information).

Digital holography has been expanded from conventional visible light and near infrared light to the X-ray and terahertz bands, and new methods have been proposed including multi-wavelength and use of an incoherent light source. Moreover, various new technologies have been suggested such as a hybrid system that combines digital holography with fluorescence microscopy, optical trapping, and a confocal system.

In research into nano-photonics, which targets photophysical phenomena that occur in an area sufficiently smaller than the diffraction limit of light, proposals have been made to properly autonomously control various fluctuations in the nano range with near-field optical interactions, and utilize the resulting characteristic optical functions.

For photon correlation technology, which handles analog information by using the parallelism of light, various technologies and application systems based on different photon correlation principles have been proposed.

Optical computing technology can be built into basic issues including optical memory, optical measurement, optical interconnect, optical communications, and telecommunication science. Optical computing has a large potential for applications in many other fields.

### 5. Laser Processing and Optical Measurement

In the field of laser processing and optical measurement, “trends in domestic fiber lasers” and “high-output pulse CO<sub>2</sub> lasers” in light source technology, “3D printing and MID fabrication process using laser resin surface modification and selective plating methods” in processing technology, “low-noise and high time-resolved CMOS image sensors” and “laser ultrasonic visualizing technology” in measurement technology, and “Raman spectral imaging” in medical-related technology are being investigated this year.

#### 5.1 Light Source Technology

For fiber lasers, the trends in domestic and overseas development have been surveyed every other year. In this fiscal year, a survey was conducted mainly on domestic trends. Regarding high-output lasers, 2 to 4 kW models have started to be marketed in Japan. Their output power is much smaller than overseas 100 kW models, but the product lineup has been expanded in the volume zone in the market. These fiber lasers are installed in laser processing machines for cutting and additive manufacturing. Alongside high-output continuous wave (CW) lasers, the technological development of pulse fiber lasers is underway.

On the other hand, it should be noted that CO<sub>2</sub> lasers have found a new application, and have started to be used in 20 nm or smaller micromachining. Instead of using light with a wavelength of 10 μm from a CO<sub>2</sub> laser directly, the laser is used as a driver (excitation source) for generating extreme ultraviolet light. Although the development of a light source with a wavelength of 13.5 nm for semiconductor lithography is



underway, it is impossible to generate light with such a wavelength from existing laser media. Consequently, plasma emission is used to do it. As the main drivers, pulse CO<sub>2</sub> lasers of 20 to 40 kW have been developed, although some techniques are required to generate the desired light with a wavelength of 13.5 nm efficiently.

## 5.2 Processing Technology

Powder molding technologies using CO<sub>2</sub> lasers and fiber lasers are investigated as the latest technological trends in Additive Manufacturing (AM, 3D printing) for which technologies and the market are rapidly evolving and expanding. In general, apparatus for AM with plastics is equipped with a CO<sub>2</sub> laser and apparatus for AM with metals is equipped with a fiber laser. High cost performance light sources are adopted as heat sources in both kinds of apparatus. Technological development is being conducted actively in China, as well as in Europe, the United States, and Japan.

A molded interconnect device (MID) fabrication process using lasers was surveyed as a new laser processing technology. An MID is a component having both mechanical and electrical functions that is manufactured by forming metal electrical circuit patterns on the surface of a three-dimensional resin molding. It is used in various electronic/communications equipment. High value-added components are created by micromachining the surface of the resin molding with a laser during the plating or etching process in the production process. Moreover, it is possible to generate light that is absorbed by wider types of resin materials using an ultrashort pulse laser. Since an ultrashort pulse laser suppresses quality degradation of the target resin, the application of an ultrashort pulse laser to the MID process has been attempted.

## 5.3 Measurement Technology

Recent CMOS image sensors have evolved into “computational camera systems” utilizing digital technology rather than as alternatives to camera film. It is now possible to obtain more information by spatially/temporally modulating of an optical input signal and signal processing of the resulting image. A low-noise/high time-resolved CMOS sensor has been built using a newly developed lateral electric field controlled charge modulator.

Laser ultrasonic visualization technology is being developed, which uses ultrasound generated by pulse laser irradiation into a structure to detect internal defects. Ultrasound is created by scanning the surface of an object with an excitation laser and its propagating signals are received with a fixed probe. It is possible to investigate the internal state of the test specimen by signal-processing the ultrasonic echoes from the internal defects and superimposing them on the camera image.

## 5.4 Medical-related Technology

Raman microscopes, which consist of the optical system of a microscope and a Raman spectrum spectroscopy, are widely used inside and outside Japan. Although Raman spectroscopy can analyze the chemical composition and molecular structure of a substance non-destructively, the spontaneous Raman scattering light is extremely weak. Technological development to enable fast imaging using the weak Raman light is underway. In addition, non-linear Raman spectroscopy imaging technology is receiving attention in the medical/biology fields as a means to analyze the localization and movements of biomolecules in a cell or tissue without staining or fluorescence-labeling.

## 6. Light Energy

In fiscal 2012, the total capacity of the solar power generation systems deployed worldwide was approximately 30 GW, almost on a par with fiscal 2011. In fiscal 2013, although there was a sudden decrease in system deployment in Germany, which had a large share, the total amount

turned into an increase again at 38.4 GW. This is because of significant increases mainly in Asia including Japan and China, and in the United States. The introduction of solar power generation systems appears to be shifting from Europe, which is an environmentally advanced area, to Asia and the United States.

With technological development, the energy conversion efficiency of various types of solar cells has been improving. In some important solar cells, including HIT (heterojunction type) solar cells by Panasonic, Cu (InGa) Se<sub>2</sub> solar cells by Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW, Germany), and CdTe solar cells and perovskite type solar cells by First Solar (U.S.), upgrades to the energy conversion efficiency have been reported one after another. On the other hand, the growth of conversion efficiency of amorphous Si solar cells, dye-sensitized solar cells, and organic thin-film solar cells is slowing or remains at the 10% mark. Since tandem-type amorphous Si solar cells are relatively easy to manufacture, a combination with artificial photosynthesis is being considered. As dye-sensitized solar cells and organic thin-film solar cells are efficient under indoor lighting, multiplying applications are being sought including installation in electronic devices such as indoor-use sensors.

In fiscal 2014, there have been various changes in the environment surrounding solar power generation systems in Japan, including the transformation of the Feed in Tariff system (FIT). When considering the trends in the future introduction of solar power generation systems, it is necessary to watch the trends in the social environments that surround solar power generation system, as well as the technological trends in their energy conversion efficiency.

### 6.1 Crystalline Type Silicon Photovoltaic Cells

This fiscal year was a year of dramatic advances, where solar cells that surpassed a conversion efficiency of 25%, the long-time world record in crystalline silicon solar cells achieved by Professor M. Green, have been announced by Panasonic (25.6%), Sharp (25.1%), and SunPower (25.0%). On the other hand, the effects of the high-priced FIT system have surfaced in Japan. It is time to start realistic discussions without inflated expectations or enthusiasm. Political support including deregulation is, of course, necessary. However, ideally, it should promote the introduction of solar power generation based on economic rationality. It goes without saying that a reduction in the power generation costs is the royal road to promoting their introduction. Therefore, for crystalline silicon solar cells, technological development to reduce production costs and improve the conversion efficiency of mass-produced modules is the trend for the time being.

### 6.2 Compound Thin Film Photovoltaic Cells

Topics in Copper-Indium-Selenium (CIS) thin film solar cell technology include the achievement of an efficiency of 21.7% by Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg (ZSW, Germany) with the three-stage method, which surpassed the conventionally highest efficiency of 20.8% and achievement of the highest efficiency of 20.9% by Solar Frontier with “sulfurization after selenization.” These results have demonstrated that it is possible to attain a conversion efficiency of higher than 20% using the method for forming a different p-type CIS light absorption layer. For CdTe solar cell technology, First Solar (U.S.) has achieved a module efficiency of 17.0%, which is the world’s highest. This indicates that CdTe solar cells are truly competitive against p-type single crystal Si solar cells in terms of performance. As far as there is no substantial falling of the wafer price, CdTe solar cell of First Solar company seems to become more low-price than p-type single crystal Si solar cells module.



### 6.3 Dye-Sensitized/Perovskite Type Photovoltaic Cells

For dye-sensitized solar cells, there has been no update in conversion efficiency for cells measured by public institutions. However, a 24.19 cm<sup>2</sup> mini module achieved an efficiency update of 10.4%. Taking advantage of low illumination, high efficiency, and high visible light transmission, indoor devices and window solar cells are being considered. However, with the shift of research from dye-sensitized solar cells to perovskite solar cells, the number of researchers tends to be declining.

On the other hand, perovskite solar cells are gaining attention. The conversion efficiency of a small-area cell exceeds 20%. The efficiency of a flexible cell is also higher than 10%. Research on perovskite materials free from Pb is underway. Research and development is being conducted all over the world. We must keep an eye on future technological trends in perovskite cells.

### 6.4 Organic Thin Film Photovoltaic Cells

The conversion efficiency of Organic Thin Film Photovoltaic (OPV) cells has been improving every year. In early 2013, a current highest of 12% was reported. Research and development on OPV cells is currently driven by companies. However, reports on analyses of high-efficiency mechanisms and the degradation mechanism by universities and public institutions have tended to increase recently. Analytical studies of the internal structure of a bulk heterojunction, discussions on molecular orientation, layer-separated structures, and the theoretical limits of efficiency are also active topics.

### 6.5 Super High-Efficiency Solar Cells

In the field of multi-junction type solar cells, research and development of wafer bonding technology is being conducted vigorously. A group at Fraunhofer ISE is creating concentrator solar cell modules using four-junction and five-junction solar cells. They reported a conversion efficiency of 35.0% under the Concentrator Standard Operation Condition (CSOC) and 36.7% under the Concentrator Standard Test Condition (CSTC). Daido Steel has developed a concentrator solar cell module using Lattice-Matched (LM) three-junction type solar cells and a Fresnel-Köhler optical system, and reported a conversion efficiency of 32.3% under the CSTC. Since the conversion efficiency of crystalline Si solar cells has almost reached the theoretical value by Shockley-Queisser, Research on intermediate band quantum dot solar cells with high efficiency and price reductions can be anticipated. A research and development group at Tokyo University has developed the world's first concentrator module equipped with quantum dot solar cells. At a concentration of 105 times, a quantum dot cell concentrator module recorded 15.3% and a single-junction GaAs cell module 19.0%. They reported that increasing the in-plane density and the number of layers to add the total number of quantum dots is an issue for the time being.

### 6.6 Evaluation Technology

Standards for cells and modules have been mainly defined by the IEC. At meetings at Busan and Ann Arbor in June and October, discussions on many new and revised standards were held at TC 82/WG 2. With JIS, discussions are underway at the Solar Power Generation Cell/Module Subcommittee of the Japan Electrical Manufacturers' Association (JEMA).

Estimation of power generation in a wide area is a technology of increasing importance. Fraunhofer ISE has compared the estimated values and actual measurements of power generation for PV systems at 26 locations. They reported that they succeeded in reducing the difference between the estimated values and actual measurements (to approximately 5%) by using an estimation based on satellite data. According to a report from the National Institute of Advanced Industrial Science and Technology (AIST) in Japan, the difference between the estimated values

and actual measurements can be reduced to within approximately 3% using the current method by estimating power generation based on high-precision indoor measurements and using measured sunlight and temperature data.

### 6.7 Module Materials

Exposing crystalline silicon solar modules to the outdoors for long periods causes degradation. The reason for the degradation has been considered to be water vapor penetrating the module. However, recently, it has been revealed that Ethylene-Vinyl Acetate (EVA) copolymer used as a sealant on hydrolysis with water vapor yields acetic acid, which corrodes the finger electrodes of the cell (chemical corrosive degradation). Therefore, it is now important to develop sealants that do not generate acid.

### 6.8 Smart Grid

The purpose of a smart grid is to give active role to a component of a lot of distribution network and countless electricity demand equipment. This can adjust power variation of renewable energy, and building of a flexible power system is achieved. To introduce renewable energy to the power system, output regulation (control) needs to be available for the renewable energy generation system. For stable operation, it is also necessary to consider the facility configuration of the entire power system including to what degree fluctuations will increase in each power system by establishing systems for exploiting smart grid system technology and introducing renewable energy.

### 6.9 Mega Solar Technology

In Japan, solar power generation systems have been introduced mainly to houses. In July 2012 when the FIT went into effect, fully-fledged introduction and dissemination of large-scale solar power generation, which had been delayed, started. Power stations were divided into three types: low-voltage interconnection (lower than 50 kW), high-voltage interconnection (50 kW up to 2 MW), and special high-voltage interconnection (2 MW and higher). Most current mega solar systems are high-voltage interconnection systems that can be easily connected to a high-voltage system of 6.6 kV, which is the main voltage. The racks loaded with solar cell modules are usually made of Fiber Reinforced Plastics (FRP) with light weight and high durability and great flexibility in shape for weather resistance and a long life, or wood that makes effective use of domestic thinned wood.

### 6.10 Energy Storage

For solar energy to serve as a really practical energy source, it is important to store energy so that it can be used on cloudy and rainy days, and at night, as well as converting optical energy into usable energy such as electricity.

There are two technologies for storing energy: (1) converting optical energy into hydrogen by water electrolysis and storing hydrogen, and (2) reducing carbon dioxide by light energy and finally making a hydrocarbon-based combination, and storing energy. The former method draws attention as the next generation of energy storage, and cost reduction and higher energy conversion efficiency are being pursued. There are two technologies for optical energy storage technology using heat: (3) changing optical energy into thermal energy and storing the thermal energy, and (4) creating a high-temperature state with optical energy, and initiating chemical reactions with that temperature and storing energy. Thermochemical hydrogen production using the latter method, although still in the research and development stage, is thought to be a technology that will play an important role in the next generation of energy systems because of its high theoretical efficiency and the ability it provides to build a large-scale chemical plant.

## 7. Organic Optical Materials and Devices

In this fiscal year, a survey to investigate the technological trends in organic optical materials and devices was conducted on organic luminescent materials, organic semiconducting materials, transparent conductive materials, optical functional materials and devices, artificial photosynthesis (material conversion), and methods for evaluating optical organic devices.

### 7.1 Organic Luminescent Materials

Thermally Activated Delayed Fluorescence (TADF) material, which is receiving attention as the “third-generation” organic luminescent material following fluorescence and phosphorescence molecules, was surveyed.

In recent years, a method for increasing the exciton generation probability of a singlet-excited state (S1) by reverse intersystem crossing of triplet excitons that are generated by current excitation with a probability of 75% to S1 has been proposed as a new mechanism for extracting triplet-excited state (T1) energy. Using this mechanism, it is possible to extract energy as TADF after reverse intersystem crossing of triplet excitons to S1 ( $T1 \rightarrow S1$ ), which in principle, enables use of all excitons generated by current excitation as “singlet-excited energy.” In addition, since it is not necessary to use spin-orbit coupling of heavy atoms, rare metals such as iridium and platinum, which are required for phosphorescence materials, do not have to be contained, which is expected to significantly improve flexibility in molecular design. TADF materials have a great potential as future organic luminescent materials.

### 7.2 Organic Semiconductor Materials

Conventional development of organic semiconductor materials focused research on 1) high mobility, 2) chemical stability so that it is possible to manufacture devices in air, and 3) solubility that enables an application process. However, when aiming for practical applications of organic electronics, the development of new semiconductor materials oriented to durability to withstand thermal, environmental and bias stress, and large-area application is urgent. Especially for the thermal durability of devices, 150°C or higher is required in the current electrode patterning and sealing processes, and for some purposes, durability at even higher temperatures is required. For durable low molecular weight organic semiconductor materials, vapor deposition heat-resistant organic semiconductor materials represented by pentacene are receiving attention.

### 7.3 Transparent Conductive Materials

Printed Electronics (PE), which manufactures electronic components and devices efficiently, significantly simplifies the manufacturing process, reduces delivery lead times, cuts down on costs including equipment costs, saves resources and reduces environmental impact, and can support small-lot high-mix production, compared to conventional manufacturing methods including photolithography. Research into applications is underway. In recent years, a production process that uses PE technology not only for forming wiring, but also for almost all processes in forming semiconductors and insulators, is being considered for Radio Frequency Identifier (RFID) tags, OLEDs, and organic semiconductor devices. To develop such a production process, it is necessary to establish three technologies: development of materials including conductive ink, printing technology, and baking technology.

For conductive ink, there have been many reports on silver nano-ink. However, because of concerns over disconnection with Electro Migration (EM) of silver wiring and costs, conductive copper nano-ink with superior EM resistance and low raw material costs is drawing attention. Conductive copper nano-ink is applicable to various printing methods, and it can form copper circuits with a volume resistivity of  $4 \mu\Omega \cdot \text{cm}$  on a wide variety of substrates including polyimide, glass, and ceramic.

Even on low-thermal resistance substrates such as PET and PEN, which are receiving attention as substrates for touch panels, RFIDs, and organic semiconductors, it has been reported that low-resistance (of the order of  $10^{-6} \Omega \cdot \text{cm}$ ) copper films could be obtained. Applications in various fields, including printing and a photo sintering process, are expected with an eye towards a roll-to-roll process.

### 7.4 Optical Functional Materials and Devices

The survey this fiscal year picked up Soft Contact Lens (SCL) sensors, for which a technology near to practical application has emerged. An SCL biosensor has been developed by combining biocompatible high polymer materials and MEMS technology. This sensor was attached to an eyeball of a Japanese white rabbit and oral glucose was administered. It was possible to measure the tear sugar and monitor changes in its concentration. Comparison with blood sugar levels revealed that tear sugar concentration follows the blood sugar level with a delay of several minutes, and there is a correlation between tear sugar concentration and blood sugar levels that suggests the possibility of the non-invasive evaluation of blood sugar levels through tear sugar. Cavity sensor (a sensor that can be attached to a cavity) technology including SCL sensors, which are superior in safety, will be applied to daily monitoring devices targeting various biological components including tear components in the near future.

### 7.5 Artificial Photosynthesis

For artificial photosynthesis, trends in material conversion systems were surveyed following the research on hydrogen generation catalysts in the previous fiscal year.

Single electron reduction of  $\text{CO}_2$  requires high energy with an equilibrium potential of -1.9 V (against the standard hydrogen electrode). In multi-electron reduction of  $\text{CO}_2$ , the required potential can be drastically decreased. Therefore, to perform  $\text{CO}_2$  reduction using solar energy, it is important to achieve multi-electron reduction. However, in principle, in a normal photoreaction, only one electron can be moved when a molecule absorbs a single photon. Moreover, the frequency with which the same molecule reabsorbs light under sunlight is estimated to be once per 0.1 to 1 second. Therefore, it is extremely difficult to progress multi-electron movement under sunlight using a single molecule. To cope with this, a catalyst using mesoporous organic silica and a rhenium complex has been developed and confirmed to be applicable to material conversion with multi-electron reduction.

### 7.6 Optical Organic Devices

Targeting organic electroluminescence (organic light emitting diodes) and organic thin film solar cells as representatives of optical organic devices, the necessity of interface control, which is a common issue for these devices, and their evaluation technologies were surveyed. The results indicate that ultraviolet photoelectron spectroscopy/photoelectron yield spectroscopy and inverse photoelectron spectroscopy are effective and the future development of these technologies should be monitored.

## 8. Optical User Interfaces

The Internet infrastructure has progressed, and it is now possible to obtain nearly infinite amounts of information at any time, anywhere. With the method for processing big data being established, user interfaces for judging the importance of and relationships between large amounts of mixed information and processing them is a technology which is increasingly becoming more important. This subcommittee surveyed the technological trends in terms of both applications using optical user interfaces and basic technologies including displays, sensor devices, and image processing. It also conducted a study into wearable computing technology, which is a recent important technology that is located in the

border with applications.

### 8.1 Medical/Health Care

To extend healthy life expectancy, sophistication of medical care at each step including daily health monitoring, diagnosing/therapy, and the technology for an interface that connects the doctor and patient is important.

In this application area, diagnostic technology with an emphasis on endoscopes, therapy technology with an emphasis on robot-assisted surgery, and health care technology for preventive medicine are drawing attention. In diagnostic technology, efforts are underway to develop an 8K endoscope and use it for actual applications and to provide doctors with value-added visual information using optical technology. Regarding therapy technology, implementation of robot and interface technologies for assisting endoscopic surgery is in progress. In healthcare technology, health monitoring services that link wearable sensors with a high-speed and large-capacity IT infrastructure for processing data is expanding.

### 8.2 Communication/Education

With the rapid spread of smartphones and tablet terminals, personal and close communication, in particular communication using short texts, and icons/pictograms/photos in social networking services have been disseminated. Along with the appearance of a head-mounted display that presents a dynamic wide view, various application developments are progressing. Also, video communication applications with high definition and high realistic sensation have begun to spread in order to realize a highly realistic communication by connecting a plurality of spaces in remote locations.

The fully-fledged use of ICT in education has just begun with educational support and ICT-applied support systems. At universities, prep schools, and private schools, the use of real-time remote lectures by distributing lecture videos like teleconferencing and Video On Demand (VoD) distribution is active.

### 8.3 Wearable Computing

With the spread and evolution of mobile phones, mobile computing has become a common way of using computers. In addition to the technological background including the miniaturization and performance sophistication of computers and the dissemination of wireless communications networks, with a rise in the social acceptance of “always carrying a computer,” wearable computing is seizing the opportunity for new business.

Smartglasses are drawing attention in terms of their combination with augmented reality technology for industrial purposes, as well as applications in healthcare. In Japan, field tests have been conducted for assisted warehouse picking, machine maintenance, and preventive maintenance at a water purification plant, and efforts to locate fully-fledged practical application are drawing attention. Wristwatch-like wearable devices have been commercialized rapidly. Following the emergence of a new product equipped with an Operating System (OS) for wristwatch-type information display devices (Android Wear) in 2014, Apple Watch, which is scheduled to appear on the market in 2015, is receiving attention.

### 8.4 4K/8K Broadcasting

The “4K/8K Roadmap” published by the Ministry of Internal Affairs and Communications in September 2014 specifies that the preparations for the 2020 Tokyo Olympic and Paralympic Games will be front-loaded, 4K test broadcasting (up to three channels) and 8K test broadcasting (one channel) on BS will start in 2016 (with 4K and 8K broadcasted in time division), and 4K and 8K practical broadcasting on BS will start in 2018 (as early as possible in 2018).

There have been remarkable technological advancements concerning 4K/8K. The domestic shipment volume of 4K TV sets has increased from 2013 to 2014, and 4K displays, cameras, and smartphones are also spreading. For 8K, research and development of equipment including displays and cameras is ongoing, and performance improvement, miniaturization and cost reduction are in progress. Test broadcasting on “Channel 4K” started in June 2014, and efforts have been made to maintain stable operation, extend the broadcast time, and enrich the contents.

### 8.5 Display Devices

There are still great expectations for the evolution of display technology. In addition to conventional performance improvements including higher resolution, the creation of new value is demanded. The axes of values in the development of display devices include “enhanced image quality,” “multiple functions,” and “augmented reality.” For “enhanced image quality,” the trend is toward higher-resolution, larger screens, and a broader color gamut, and research into creating more realistic images is underway. In the field of “multiple functions,” the advent of smartphones has enabled merging of the touch input function. In the future, it is expected that the degree of freedom in the placement of displays will increase with flexibility and looked-for shapes, and the development of basic technology to achieve flexibility is in progress. For “augmented reality,” there are proposals for new display devices and technological development for implementation.

### 8.6 3D Displays

The methods for 3D display include a two-view three-dimensional display method that shows two different images to the right and left eyes of the viewer, a multi-view three-dimensional display method that displays images shot from several directions and provides the viewer with a 3D image according to movement in the perspective, and a spatial image reproduction three-dimensional display method that reproduces an optical image of the object in space by generating light identical to the light from the object. Spatial image reproduction is said to be able to provide natural 3D display. To improve the quality of the reproduced images, it is necessary to develop high-resolution devices for recording and playing back vast amounts of information. For practical application, it is important to clarify the resolution required for 3D display and the range of reproduction depth before developing devices and building a system.

### 8.7 VR/AR Technology

Virtual Reality (VR) technology enables various simulated experiences in an artificial world that is “synthesized” by a computer. Augmented Reality (AR) technology provides various informational supports in the real world augmented with a computer by “modulating (adding, deleting, emphasizing, or attenuating) sensory information” that is not in fact available in the real world. It is one of the elemental technologies that compose the user interface of application systems in each industrial field.

Using these features, application to various fields including medicine, sightseeing, education, maintenance, construction, the arts, entertainment, and military has been attempted. Development of business models using environmental representation that is feasible with the current technological level is drawing attention. There are also increasing demands for technology that includes measurement accuracy and robustness, and presentation quality. This field is expected to experience ongoing expansion.

### 8.8 Computer Vision

Computer vision technology “understands” the scenes taken to obtain



geometric information of the scenes and to detect the existence of an object that has been learned in advance by entering the images taken by a camera into a computer and processing them. It is an extremely important elemental technology in the construction of a human-optical user interface. For the evolution of the elemental technology for computer vision, speeding up conventional technology with hardware and enriching the development environment to make this technology easily available are the keys in research trends. In the field of image recognition that recognizes an object in a scene, a method using a neural network is drawing attention again as a more general learning algorithm.

In the field of computer vision, a great paradigm shift has occurred in recent years, which is bringing rapid performance improvements. The evolution of this field is a key to the future of optical user interfaces.

## 8.9 Optical Sensing

Camera technology is a core elemental technology for I/O equipment with optical user interfaces. With high image quality and higher resolution CMOS/CCD image sensors, digital cameras and mobile devices with cameras have proliferated explosively in recent years. With the strong need for improvements in image quality, which is basic to the performance of a camera, and miniaturization, the pixel pitch of image sensors has been reduced year by year with the progress in fine processing technology, and has reached submicron levels approaching the diffraction limit. However, there are still high demands for high-resolution images with a superior sense of realism. Therefore, the technological evolution of image sensors with higher sensitivity, lower noise, etc., which will respond to demands, is expected to continue.

Contrary to color image capture, spectroscopic imaging obtains information on a subject that is not visible or not easily visible by narrowing the band of wavelengths entering the pixels and acquiring the intensity information for specific wavelengths. It is one of several very promising technologies, and is expected to lead to great progress in the camera imaging and sensing fields.

## 9. Patent Application Trend Survey

### 9.1 Survey of Patent Trends Related to Optoelectronics Technology

As in the previous fiscal year, each working group separately conducted fixed-point observation and analysis of patent application trends in the past 10 years in the four fields of optical communication networks, optical memories, displays, and solar energy in order to investigate the trend in patent applications in optoelectronics technology. In this fiscal year, five topics: "optical cables," "PV racks," "optical amplifiers," "laser processing," and "LED lighting" were selected, and a detailed patent trend analysis was carried out including a survey on each technological keyword. The results of fixed-point observation are summarized below.

#### (1) Optical communication network industry

In the optical communication network field, the transition in the number of published patents (FY 2005 to FY 2014), nationalities of patent applicants, and trends by technological field were surveyed for patent applications in three areas: Japan, the United States, and Europe. The number of published patents in Japan has been decreasing since 2005 with repeated rises and falls, and in 2014, it has reduced to almost half of the peak (in 2005). The number of published patents in the United States once decreased between 2005 and 2011, but has been on an increasing trend from 2012 to 2014. In Europe, the decline in the number of published patents has begun to slow since 2008 or seems to be recovering. By nationality, in the United States and Europe, the number of applications by Chinese has been significantly increasing, which indicates that Chinese companies recognize that the American and European markets are promising in the optical communication network field.

Comparing a breakdown of patents published in 2014 in the top 10 technological categories, Japanese patents are on a decreasing trend in almost all of the 10 categories. On the other hand, American patents are increasing in most categories. They are increasing especially in "protocols" and "transmission control methods."

In response to overseas business development and the global strategies of competitors, conducting strategic applications such as promoting continuous applications in differentiated technologies, as well as understanding patent trends overseas more fully than ever is becoming more important.

#### (2) Optical memory industry

In the optical memory field, a survey was conducted on the transition in the number of published patents (FY 2005 to FY 2014), nationalities of patent applicants, and trends by company for patent applications in Japan, the United States, Europe, and China. Compared to FY 2013, the number of patents published in all countries is still on a declining trend with a 37% decrease in Japan, a 16% decrease in the U.S., a 34% decrease in Europe, and a 25% decrease in China. The comparisons of nationalities and companies indicate a decrease in the number of patents published by major applicants. With an increase in capacity and decrease in prices of HDDs and semiconductor memory, dissemination of network technology, and high-speed transmission technology, conventional markets for optical memory are being replaced by other systems, which may lead to careful selection of the themes for technological development and patent applications.

#### (3) Display industry

In the display field, the transition in the number of patents published (FY 2004 to FY 2014) and the nationalities of patent applicants were surveyed for patent applications in Japan, the United States, Europe, and China, and a similar survey was conducted on PCT applications. In this field, the number of published patents in Japan, the United States, and Europe has been decreasing from the peak in 2005 and 2006. The number of applications in China has been flat or slightly increasing since 2006, and reached its highest in 2014. The number of PCT applications has been increasing since 2009. The number of Chinese applicants has been growing significantly since 2013 in particular, which suggests that intellectual property activities using PCT applications by Chinese applicants have been gaining momentum with an eye on overseas markets.

Regarding patents published in Japan, looking at the nationalities of the applicants, in spite of the major decline in the number of Japanese applications since 2009, the number of applications by overseas applicants including Koreans has also been decreasing. In the United States, although the number of published patents has been decreasing, the number of registered patents has been increasing continuously since 2011, which has been attributed to the compressing of backlogs by the United States Patent and Trademark Office (USPTO).

The transition in the number of published patents suggests that the conventional display markets and technology have reached maturity. However, with new market revitalization with HMD, etc. and development of new markets in emerging countries, the number of patent applications in the display industry is expected to go upward. Therefore, it is necessary to keep an eye on patent application trends in India and Brazil, as well as in Japan, the United States, Europe, and China.

#### (4) Solar energy industry

A survey was conducted on the transition in the number of published patents in the solar energy field (FY 2005 to FY 2014) and the nationalities of the patent applicants for patent applications in Japan, the United States, Europe, and China. The number of patents published in Japan continued to increase from 2008 to 2013, but slightly decreased in 2014. In the United States, it started to decline in 2012. In Europe and China, the number decreased in 2014.

Looking at the nationalities of the applicants, applications from Japanese companies were the highest. For the number of published patents accumulated over 10 years in Japan and Europe, Sharp was in first place. First place in the United States went to Sanyo Electric. Japanese companies have high shares. They occupied the top 20 in the number of published patents in Japan, five out of the top 20 places in the United States, and 16 out of the top 20 in Europe. Japan is still leading the world in research and development in this field, and the trend will continue.

#### 9.2 Informal Meeting with the Japan Patent Office (December 12, 2014)

Eight members of the Japan Patent Office attended the meeting, including Mr. Katsuhisa Segawa, Director of the Optical Devices Division, First Patent Examination Department, and nine members attended from the Patent Application Trend Survey Committee, including Dr. Kodama, Committee Chairperson. Dr. Kodama gave a speech entitled "Patent Application Trends in the Optical Technology Industry and Requests to the JPO" to introduce the activities of the Patent Application Trend Survey Committee and gave a summary of the survey results.

Mr. Segawa from the Japan Patent Office gave a talk entitled "Key Policies on Patent Examination for the Future." Then the members had a lively exchange of opinion based on the contents of these presentations.

#### 9.3 Patent Forum (March 6, 2015)

The committee held the OITDA Patent Forum at Gakushi Kaikan (Chiyoda City, Tokyo) to report on the results of the patent trend survey in FY 2014 and offer a special lecture. There were more than 90 participants, including OITDA's supporting members and non-members combined.

As speaker for the special lecture for FY 2014, the committee invited Mr. Toshiaki Iimura, an attorney who was formerly Chief Judge of the Intellectual Property High Court and presently a partner in YUASA and HARA (law and patent firm). Mr. Iimura gave a lecture on "Technology Standardization and the FRAND Declaration, and Exercising the Rights of a Standardization Patent – Apple vs. Samsung, (iPhone) Decision by the Intellectual Property High Court," describing in detail the results of an invitation for public comments on the limitation to the right to demand an injunction on an essential patent after the FRAND declaration, the reasons behind the decision, and calculation of the damages by introducing an actual court case that garnered attention, and he also explained the present status of intellectual property trials. With various decisions made in each country on exercising the rights of a standardization patent, there were active questions from participants, showing strong interest.



## 1. Introduction

Since 1996, OITDA has undertaken "Optoelectronics Technology Roadmap Development" activities, with the aim of ascertaining the future growth of the optoelectronics industry, and seeking a direction for optoelectronics technology R&D. These activities have become one of the platforms for launching many national projects in the fields of optical communication, optical storage, displays, light energy and laser processing, and have contributed extensively to the development of the Optoelectronics industry and technology. Starting in FY 2011, OITDA also began to develop the "Optoelectronics Technology Roadmap towards the 2030s." The five fields selected for prospective future development are: Information-processing photonics, Safety and security photonics, Optical user interface, Optical communications and Optical processing/measurement. A five-year plan was created to develop a roadmap for each field each year. Instead of simply listing technologies, a vision for the society of the future is first created to understand the issues, and then is expanded to include the technologies needed for solutions. Thus this technique takes social needs as the starting point.

In preparation for the Optical Communications Technology Roadmap for FY 2014, its fourth year, the Optical Communication Technology Joint Committee composing nine technological experts from industry and academia was established under the Technological Strategy Development Committee and the Optoelectronics Technology Trend Research Committee. To construct a valuable, safe and reliable society by solving social problems such as aging, global warming, and the information explosion that will emerge in the future, optical communications technology with high speed/large capacity for transmitting amounts of information 1,000 times greater than currently with a power consumption of 1/1,000 of the current is required by 2030, and these are indicated as needs on the Roadmap.

The Roadmap covers three areas: data centers, metro/core, and access/mobile, and each member of the Joint Committee is in charge of higher reliability/simpler maintenance of the network, flexibility improvements/software linkage of the network, data centers, optical access, transmission systems, optical nodes, optical fibers, optical switches, optical integration, and silicon photonics, and the Roadmap is completed by presenting the needs of the society of the future, and the technology and R&D periods required to implement these.

## 2. Optoelectronics Technology Roadmaps

The current information-oriented society has been constructed by developing numerous innovative optoelectronics technologies to respond economically to growing traffic demands. The global optical communication networks connect the world and overcome distances on a global scale. As the information-oriented society develops, with an increase in the variety and number of personal terminals, the amount of traffic sent from terminals will expand, and various bandwidths and various types of traffic such as the Internet of Things (IoT) and Machine to Machine (M2M) is expected to be generated by various devices. When optical communications technology responds to these demands, a sustainable approach that can contribute to preventing global warming is essential. In addition, solutions with an eye on the arrival of the aging society, decline in the working population, and implementation of an infrastructure resistant to disasters will also be required.

Telephone services have mainly connected one person with another over a distance. In the future, new values and services will be created by linking objects other than persons, such as computers with communication. The important elements for users of optical communications include increasing speeds for transferring the ever-growing traffic, extending the application areas of optical communication from core/metro/access to data centers and mobile, improving the ease of use of communications services and the reliability of services. On

the other hand, for optical communications providers, it is important to reduce power consumption and to drive downsizing to contribute to global warming countermeasures, to simplify the maintenance and operation of social infrastructures so that they can be maintained with a smaller workforce in response to the aging population and declining birth rate, and to construct a reliable network as part of the social infrastructure. In preparing the Optical Communications Technology Roadmap for FY 2014, the needs of "optical communications users" and "optical communications providers" were clarified, and the required optical technologies and needs were correlated through the technology trend surveys in the related fields.

The conventional application areas of optical communications generally include core/metro networks and access networks. However, recently they also include the mobile field as optical access networks for accommodating mobile traffic. Since in new cloud services traffic tends to concentrate at data centers, the current Roadmap treats data centers as a single field.

The Roadmap for each field, data centers, metro/core, and access/mobile is summarized below.

### 2.1 Data Center Area

One of the features of the data center area is a tendency to adopt cost-competitive, standardized and widely used economical technologies, rather than leading-edge high-speed optical transmission technology. Therefore, a technology roadmap was prepared based on the needs for low power, downsizing, and high speeds.

Low power is essential for processing the growing amounts of data without increasing the power. As of 2015, a power of approximately 10 mW/Gbps is required. With the evolution of optical integration technology/silicon photonics technology, power reduction will reach approximately 1/10 by around 2020, and 1/1,000 by around 2030. Downsizing is compulsory to accommodate the growing amounts of data with the same footprint. As with low power, with significant developments in optical integration technology/silicon photonics technology, high-density mounting will be achieved from the current 100 pcs/chip to 300 pcs/chip by around 2020 and 3,000 pcs/chip by around 2030. For high speed, it is generally assumed that standardized technologies will be introduced in sequence; in 2020, a 400 Gbps Ethernet will be widely introduced, and in 2030, fully-fledged installation of a 1 Tbps Ethernet will start.

In addition, to simplify maintenance and operation of data centers, with the evolution of management and integration technology, the range of operations available for a single person will dramatically expand. In 2030, a data center will be able to manage and operate itself without human intervention, and failures will be self-repaired. Optical fibers connecting these networks will become easy to handle, which will reduce the burden on operations. With optical spatial communications technology, it will be possible to connect equipment in a data center to each other without optical fibers.

### 2.2 Metro/Core Area

In the metro/core area, with the assumption of an increase in large-capacity contents such as high-resolution video, a target of a 1,000 times capacity expansion per fiber has been set for 2030 with a baseline of 2015. In addition to the progress in access/mobile technology, seamless connection from users from anywhere to the cloud, or a data center that distributes large-capacity contents will enable high-value services such as various applications using big data. Moreover, since the linkage between the network and applications will be accelerated with software technology including Software-Defined Networking (SDN), an application itself will be able to set up a large-capacity line in cooperation with the network, and new service development can also be expected.

There are various combinations for a 1,000 times capacity expansion. For example, by increasing the speed per channel by 10 times from 100 Gbps to 1 Tbps, and keeping the number of wavelengths multiplexed as it is, increasing the number of modes for optical fiber transmission from 1 to 6, and the number of optical fiber cores from 1 to 19, a current capacity of 10 Tbps can be expanded to 10 Pbps. On the other hand, similar levels of power reduction are also important. A target has been set, which reduces the current power consumption of approximately 400 mW/Gbps to 1/1,000 for relatively short-distance metro and 1/100 for long-distance core. Since an increase in metro traffic is expected in the future, the average power consumption of the entire metro/core will be reduced to 1/1000 by the progress in optical switch technology and reductions in fiber losses.

For a reliable network infrastructure, progress in the use of optical spatial communication technology to avoid network failures coming from disaster and degradation monitoring by appropriately estimating/monitoring infrastructure life is assumed. For simplified maintenance and operations in response to the population decline and the aging society, with unmanned maintenance and operations using the next-generation redundant deployment design technology and failure monitoring technology, and failure prediction with the next generation of monitoring technology using IoT and M2M, operational efficiency is expected to improve.

### 2.3 Access/Mobile Area

To enable connections to a data center at any time from anywhere without being aware of terminal types and bandwidth limitations, to enjoy various applications and services, it is necessary to construct a world that combines the conventional Fiber to the Home (FTTH) and mobile wireless. In mobile wireless, as represented by 5G, technology development for a capacity expansion of approximately 1,000 times is

accelerating. These are mainly wireless technologies. As wide-band optical access will also be in demand to accommodate high-speed wireless access by 2030, traffic is assumed to expand to approximately 1,000 times the current level.

In the access/mobile area, as the transmission distance is relatively short, the optical access bandwidth will be expanded from the current 1 Gbps to 1 Tbps. Power reduction is also important. A target has been set to reduce the current power consumption of approximately 400 mW/Gbps to 1/1,000 or 400  $\mu$ W/Gbps. An interface card with a 1,000 times faster speed and 1/1,000 the power consumption will be available. And downsizing will enable its use in various terminals. It is also necessary to implement an interface card with a broadband that can connect to any type of interfaces by merging wireless functions.

Offloading technology between heterogeneous networks and roaming technology, and connecting M2M networks and the cloud are also important, and it is required to expand bandwidth, improve connectivity, and raise reliability by using these heterogeneous access technologies simultaneously. Moreover, it is preferable to build a network that optimizes Quality of Experience (QoE) in collaboration with the technology for monitoring experienced performance/ user satisfaction.

To achieve a valuable, safe and reliable society by 2030, further development of an information-oriented society is essential. No one will deny the fact that it is necessary to have high-speed/large capacity communications with optical communications technology. Evolving optical communications, which forms the infrastructure for the society of the future, contributes to the development of the optical industry. The presentation of the Optical Communications Technology Roadmap has significant meaning. It is expected that this Roadmap will be used as guidelines for research and development of optical technology towards 2030.

# Creation of New Business

## 1. Introduction

In order to support and promote the creation and fostering of new business in the optoelectronics industry, OITDA carried out the following two activities in FY 2014.

### • Technical Advisory Institution

OITDA has been operating the Technical Advisory Institution in which technical experts give technical guidance and advice in response to requests for consultation and questions from companies related to the optoelectronics industry.

### • Support for the Creation of New Business

To assist venture companies and small to medium companies in the optoelectronics field, OITDA supported nine companies in exhibiting their technologies/products at InterOpto 2014 and provided eight companies with opportunities to make presentations in the Notable Optoelectronics Technology Seminar at InterOpto 2014.

## 2. Technical Advisory Institution

This institution has been operating with the aim of supporting the establishment of new businesses related to optoelectronics technologies and has introduced technical experts to handle consultations and answers to questions from various companies related to optoelectronics. The areas covered by this institution are not limited to the creation of new businesses but also include technical advice for new product development and marketing.

When accepting a consultation or a question, OITDA judges if it matches the intent of this institution. Once it is determined that the institution can be of assistance, the most suitable technical expert is assigned to give advice and guidance.

The total number of consultations in FY 2014 was 17, as indicated in [Table 1](#). There were many cases concerning laser safety, in particular, inquiries on classification and the safe design of equipment. There are also cases concerning safety and standards for products imported and exported from/to overseas. "Safety of Laser Products, JIS C 6802," which is a domestic standard on laser safety, was revised on September 22 from the 2011 version to the 2014 version with IEC 60825-1, which

Table 1 List of technical consultation in 2014

1	Question for safety standards of laser products JIS C6802
2	FDA, IEC60825-1:2007, For safety of laser products
3	For calculation of laser permissible output
4	For safety measure of laser equipment, JIS C6802
5	Classification of laser safety at 1550nm
6	Classification of linear light source LD unit
7	Safety standards of laser pointer products
8	Classification of linear light source laser product
9	Classification of scanning linear light source laser product
10	Judgment for labeling on safety standards of laser products
11	Commentary for items in JIS C6802
12	For safeguard of metal 3D printers
13	Inquiry for classification of laser safety (1)
14	For time base of multi wavelength emission laser products
15	Inquiry for classification of laser safety (2)
16	Inquiry for classification of laser safety (3)
17	For laser shield plate

is an international standard.

OITDA is trying to diffuse the laser safety standards by providing guidance on safety measures for laser equipment, criteria and methods of classification based on this institution, with the intention of increasing the levels of laser safety by promoting participation in the laser safety school.

## 3. Support for the Creation of New Business

To assist small to medium companies and venture companies (including university-originated ventures) related to the research, development, production and sales of devices, equipment or systems using optoelectronics technology, OITDA provided support for exhibitions at InterOpto 2014 and lectures in the Notable Optoelectronics Technology Seminar as shown in [Table 2](#).

Table 2 Support Theme of InterOpto2014

Company	Exhibition	Seminar
Nikkiso Giken Co., Ltd.	Deep UV LED devices	Latest Trends in Deep UV LED Development
Arai Med-Photon Research Laboratories Corporation	Novel PD Ablation <sup>®</sup> catheter and PD Ablation <sup>®</sup> device for arrhythmia ablation therapy using photodynamic therapy technology	PD Ablation <sup>®</sup> : Development of an Innovative Arrhythmia Therapy Device Originating from a University Venture
C&I Co., Ltd.	Small sized waveguide-mode sensor for solution measurement applicable to, for example, early stage diagnosis of virus infections	Development of a Waveguide-Mode Sensor for Mobile Use
System JD CO.,LTD	Portable photovoltaic array tester "SOKODES": Device and Technology for detecting a faulty module in a photovoltaic system	Introduction to Photovoltaic Array Tester "SOKODES"
SYNERGY OPTOSYSTEMS CO., LTD.	Optical measurement system and technology for optical interconnection and optical communication	Trend in Optical Characteristic Measurement and Evaluation Technology in the Optical Interconnection Field
Four Technos Inc.	High precision/high speed full automatic die bonder	Markets for and Applications of High Precision Bonders
QD Laser, Inc.	High-performance and high-quality semiconductor lasers for industrial and communication applications. Technologies for epitaxial growth and grating fabrication on GaAs substrates	Novel GaAs-based Semiconductor Lasers for Communication and Industrial Applications
TAKION CO., LTD.	New Triac IC for LED drive circuits enabling improved power factor and reduced flicker	—
Cyber Laser Inc.	Ultrafast pulse laser IFRIT-TD20	Ultrafast Pulse Laser for High Throughput Nano-Micro-Processing

## 1. Introduction

Standardization has been one of OITDA's major activities since its establishment, and has been promoted broadly across the optoelectronics industry. OITDA standardization efforts are mainly focused on the optical transmission field, but they also include several fiber optics application fields and lasers. Besides working for domestic standardization, OITDA also works on international standardization in these fields, with standards such as IEC and ISO. The field specific meetings are actively considering policies for standardization in order to respond quickly to the fast changing industrial structure. Figure 1 shows the present organization of OITDA's standardization.

In FY 2014, OITDA received a contract from the Ministry of Economy, Trade and Industry (METI) for the "International standardization/dissemination of large-diameter multi-mode optical fiber connectors and their communications performance," a new project that is part of the international standardization joint research and development/dissemination project for energy saving, following on from the "Standardization of test methods for optical transmission subsystems of high-speed automotive LANs," which was completed last fiscal year. OITDA also received contracts from the Mitsubishi Research Institute (MRI) for "International standard development for energy saving: International standardization for the safety of projectors with new light sources and fiber lasers," part of the international standardization/

dissemination project for energy saving, and "International standardization activities concerning social needs (safety/security)/production of international leaders: Internationalization of optical compatibility for optical fiber mutual connection connectors" and "International standardization activities concerning government strategic fields: International standardization of the evaluation method for high-durability laser guards" as part of the strategic international standardization accelerating project, and contracts from the Japan Standards Association (JSA) for "High-function JIS development: Development of a JIS for evaluation criteria for high-quality archive grades that enable digital data to be saved to optical disc for long periods" and many other projects. In addition, continuing from the previous fiscal year, OITDA received a contract from JKA to carry out "Survey research on the safety and security of laser equipment" as a supplementary project. As in previous years, OITDA prepared many proposals for JIS projects to be submitted to the JSA.

With great help from related organizations, 26 JIS proposals drafted by the members of this meeting were enacted or revised this fiscal year. Table 1 lists the JIS standards that were drafted by various standardization meetings at OITDA and enacted up to the current fiscal year, and Table 2 lists OITDA Standards and technical papers (TPs). The activities of the standardization meetings are reported below.

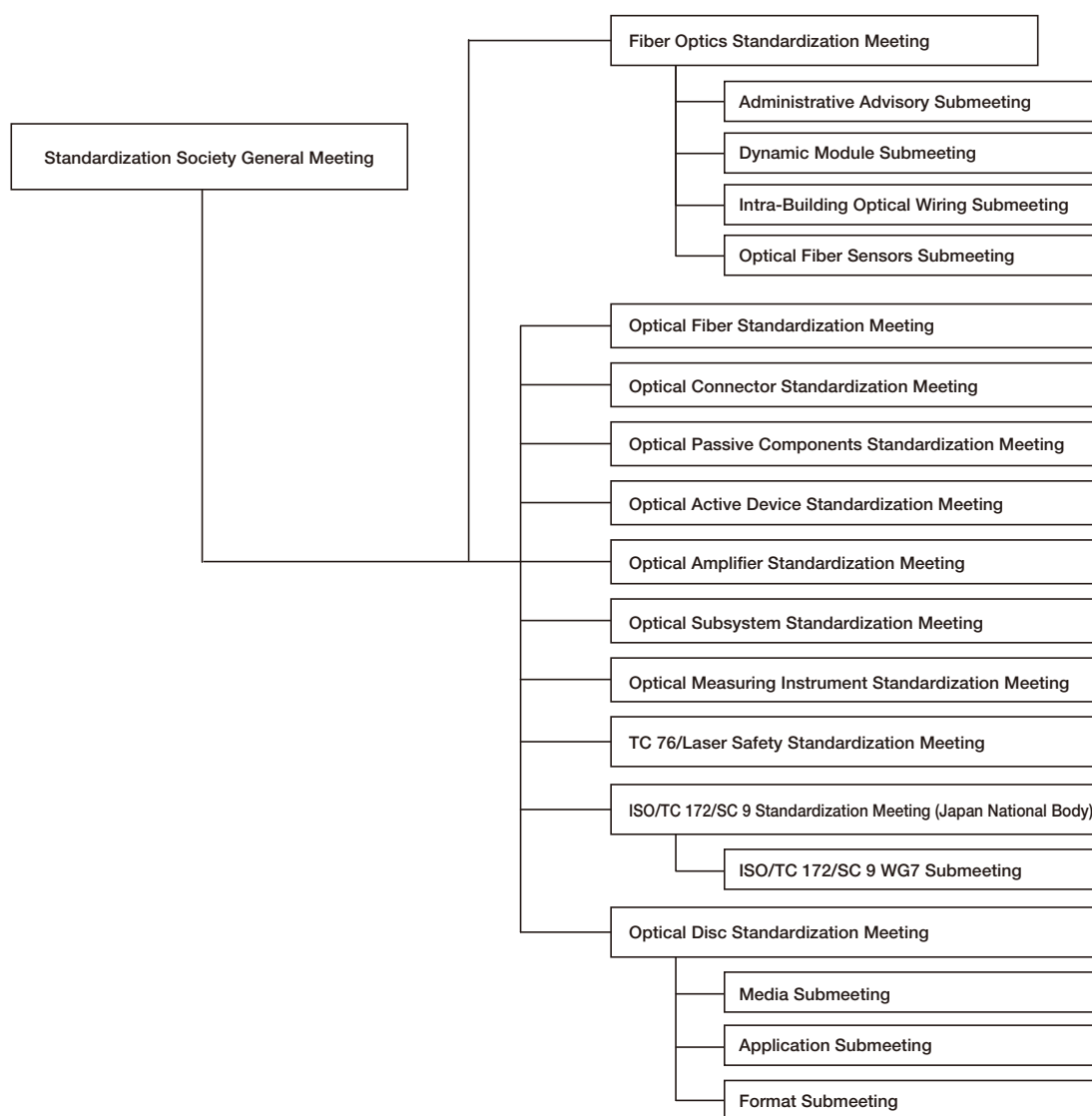


Figure 1 Organization of OITDA Standardization (2014FY)



Table 1 JIS List in Optoelectronics

(As of Mar. 31, 2015)

Standardization Meeting		Titles of standards	JIS No.	Establishment date
Optical Fibers	1	General rules of optical fibers	JIS C 6820	Revised Dec.21,2009
	2	Test methods for mechanical characteristics of optical fibers	JIS C 6821	Revised Jul.20,1999
	3	Test methods for structural parameters of optical fibers—Dimensional characteristics	JIS C 6822	Revised Dec.21,2009
	4	Measuring methods for attenuation of optical fibers	JIS C 6823	Revised Mar.23,2010
	5	Test methods for bandwidth of multimode optical fibers	JIS C 6824	Revised Dec.21,2009
	6	Test methods for structural parameters of optical fibers—Optical characteristics	JIS C 6825	Revised Dec.21,2009
	7	Test methods for chromatic dispersion of optical fibers	JIS C 6827	Revised Mar.20,2015
	8	Optical fiber cords	JIS C 6830	Revised Feb.20,1998
	9	Jacketed optical fibers	JIS C 6831	Revised Aug.20,2001
	10	Silica glass multimode optical fibers	JIS C 6832	Revised Mar.20,2009
	11	Multicomponent glass multimode optical fibers	JIS C 6833	Revised Feb.20,1999
	12	Plastic cladding multimode optical fibers	JIS C 6834	Revised Feb.20,1999
	13	Silica glass single-mode optical fibers	JIS C 6835	Revised Jan.20,2012
	14	All plastic multimode optical fiber cords	JIS C 6836	Revised Apr.20,1999
	15	All plastic multimode optical fibers	JIS C 6837	Revised Mar.20,2015
	16	Fiber ribbons	JIS C 6838	Revised Mar.20,2001
	17	Indoor optical fiber ribbon cables	JIS C 6839	Revised Jan.20,2008
	18	Polarization crosstalk measurement of optical fiber	JIS C 6840	Mar.25,2006
	19	Optical fiber fusion splicing method	JIS C 6841	Revised Jul.20,1999
	20	Measurement methods and test procedures—Polarization mode dispersion of optical fibers	JIS C 6842	May.21,2012
	21	General rules of optical fiber cables	JIS C 6850	Revised Jan.20,2006
	22	Optical fiber cable test procedures	JIS C 6851	Revised Jan.20,2006
	23	Test methods for mechanical characteristics of all plastic multimode optical fibers and cords	JIS C 6861	Revised Apr.20,1999
	24	Measurement methods and test procedures—Differential mode delay of multimode optical fibers	JIS C 6864	Jan.20,2008
	25	Indoor optical fiber cables—Part 2 : Sectional specification	JIS C 6870-2	Nov.20,2006
	26	Optical fiber cables—Part2-10 : Indoor cables—Family specification for simplex and duplex cables	JIS C 6870-2-10	Jan.20,2008
	27	Optical fiber cables—Part 2-11 : Indoor cables—Detailed specification for simplex and duplex indoor optical fiber cables for use in premises cabling	JIS C 6870-2-11	Dec.21,2009
	28	Optical fiber cables—Part 2-20 : Indoor cables—Family specification for multi-fiber optical distribution cables	JIS C 6870-2-20	Jan.20,2008
	29	Optical fiber cables—Part 2-21 : Indoor cables—Detailed specification for multi-fiber indoor optical distribution cables for use in premises cabling	JIS C 6870-2-21	Dec.21,2009
	30	Optical fiber cables—Part 2-31 : Indoor cables—Detailed specification for optical fiber ribbon cables for use in premises cabling	JIS C 6870-2-31	Dec.21,2009
	31	Outdoor optical fiber cables—Part 3 : Sectional Specification	JIS C 6870-3	Nov.20,2006
	32	Outdoor optical fiber cables—Part 3-10: Outdoor cables—Family specification for duct, directly buried and lashed aerial optical telecommunication cables	JIS C 6870-3-10	Jan.20,2011
	33	Outdoor optical fiber cables—Part 3-20: Outdoor cables—Family specification for self-supporting aerial telecommunication cables	JIS C 6870-3-20	Jan.20,2011
	34	Test methods for structural parameters of polarization-maintaining optical fibers	JIS C 6871	Oct.20,2008
	35	Beat length measurement of polarization-maintaining optical fibers	JIS C 6872	Oct.20,2008
	36	Polarization-maintaining optical fiber	JIS C 6873	Dec.21,2009
Optical Connectors	1	General rules of connectors for optical fiber cables	JIS C 5962	Revised Mar.20,2001
	2	Test methods of connectors for optical fiber cables	JIS C 5961	Revised Feb.20,1998
		Test methods of connectors for optical fiber cables (Amendment 1)	JIS C 5961	Revised Jul.20,2009
	3	General rules of connectors with optical fiber cables	JIS C 5963	Mar.20,2001
	4	Fiber optic connector interfaces—Part 4: Type SC connector family (F04 Type)	JIS C 5964-4	Mar.20,2014
	5	Fiber optic connector interfaces—Part 4-1: Type SC connector family—Simplified receptacle SC-PC connector interfaces (F16 Type)	JIS C 5964-4-1	Jun.20,2014
	6	Fiber optic connector interfaces—Part 5: Type MT connector family (F12 type)	JIS C 5964-5	May.21,2012
	7	Fiber optic connector interfaces—Part 6: Type MU connector family (F14 Type)	JIS C 5964-6	Mar.20,2014
	8	Fiber optic connector interfaces—Part 6-1: Type MU connector family—Simplified receptacle MU-PC connector interfaces (F17 type)	JIS C 5964-6-1	Mar.20,2014
	9	Fiber optic connector interfaces—Part 7: Type MPO connector family (F13)	JIS C 5964-7	Mar.23,2010
	10	Fiber optic connector interfaces—Part 13: Type FC-PC connector family (F01 Type)	JIS C 5964-13	Mar.20,2015
	11	Fiber optic connector interfaces—Part 13: Type MT-RJ connector family (F19 Type)	JIS C 5964-18	Jun.20,2014
	12	Fiber optic connector interfaces—Part 20: Type LC connector family	JIS C 5964-20	Mar.20,2015
	13	Fiber optic connector optical interfaces—Part 1: Optical interfaces for single mode non-dispersion shifted fibers—General and guidance	JIS C 5965-1	Jul.20,2009
	14	Fiber optic connector optical interfaces—Part 2-1: Optical interface standard single mode non-angled physically contacting fibers	JIS C 5965-2-1	Oct.20,2011
	15	Fiber optic connector optical interfaces—Part 2-2: Optical interface standard single mode angled physically contacting fibers	JIS C 5965-2-2	Oct.20,2011
	16	Fiber optic connector optical interfaces—Part 3-1: Optical interface, 2.5 mm and 1.25 mm diameter cylindrical full zirconia PC ferrule, single mode fiber	JIS C 5965-3-1	Oct.20,2011
	17	Fiber optic connector optical interfaces—Part 3-2: Optical interface, 2.5 mm and 1.25 mm diameter cylindrical full zirconia ferrules for 8 degrees angled-PC single mode fibers	JIS C 5965-3-2	Oct.20,2011
	18	F01 Type connectors for optical fiber cables (Type FC connector)	JIS C 5970	Revised Mar.20,2015
	19	F02 Type connectors for optical fiber cables	JIS C 5971	Revised May.20,1998
	20	F03 Type connectors for optical fiber cables	JIS C 5972	Revised May.20,1998
	21	F04 Type connectors for optical fiber cables (Type SC connector)	JIS C 5973	Revised Mar.20,2014
	22	F05 Type connectors for optical fiber cables	JIS C 5974	Revised May.20,1998
	23	F06 Type connectors for optical fiber cables	JIS C 5975	Revised May.20,1998
	24	F07 Type connectors for optical fiber cables	JIS C 5976	Revised Mar.20,2001
	25	F08 Type connectors for optical fiber cables	JIS C 5977	Revised May.20,1998
	26	F09 Type connectors for optical fiber cables	JIS C 5978	Revised May.20,1998
	27	F10 Type connectors for optical fiber cables	JIS C 5979	Revised May.20,1998
	28	F11 Type connectors for optical fiber cables	JIS C 5980	Revised May.20,1998
	29	F12 Type connectors for optical fiber ribbons (MT connectors)	JIS C 5981	Revised May.21,2012
	30	F13 Type connectors for optical fiber ribbons	JIS C 5982	Revised Mar.23,2010
	31	F14 Type connectors for optical fiber cables (Type MU connector)	JIS C 5983	Revised Mar.20,2014
	32	F15 Type connectors for optical fiber cables	JIS C 5984	Mar.20,2001

Standardization Meeting		Titles of standards	JIS No.	Establishment date
	33	F16 Type connectors for optical fiber cables (Type SC-SR connector)	JIS C 5985	Revised Jun.20,2014
	34	F17 Type connectors for optical fiber cables (Type MU-SR connector)	JIS C 5986	Revised Mar.20,2014
	35	F18 Type connectors for optical fiber cables	JIS C 5987	Dec.20,2005
	36	F19 Type connectors for optical fiber cables	JIS C 5988	Revised Jun.20,2014
	37	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-2: Tests—Mating durability	JIS C 61300-2-2	Mar.22,2011
	38	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-4: Strength of optical fiber to device interface (Cable retention)	JIS C 61300-2-4	Mar.20,2015
	39	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-5: Tests—Strength of optical fiber to device interface (Torsion)	JIS C 61300-2-5	Mar.21,2013
	40	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-6: Tests—Tensile strength of coupling mechanism	JIS C 61300-2-6	Mar.20,2014
	41	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-7: Strength of coupling mechanism (Bending moment)	JIS C 61300-2-7	Mar.20,2015
	42	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-11: Strength of optical fiber to device interface (Axial compression)	JIS C 61300-2-11	Mar.20,2015
	43	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-15: Tests—Torque strength of coupling mechanism	JIS C 61300-2-15	May.21,2012
	44	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-27: Tests—Dust—Laminar flow	JIS C 61300-2-27	Mar.20,2014
	45	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-1: Examinations and measurements—Visual and mechanical examination	JIS C 61300-3-1	Nov.20,2013
	46	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-4: Examinations and measurements—Attenuation	JIS C 61300-3-4	Mar.22,2011
	47	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-11: Examinations and measurements—Engagement and separation forces	JIS C 61300-3-11	Mar.21,2013
	48	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-15: Examinations and measurements—Dome eccentricity of a convex polished ferrule endface	JIS C 61300-3-15	May.21,2012
	49	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-16: Endface radius of spherically polished ferrules	JIS C 61300-3-16	May.21,2012
	50	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-17: Examinations and measurements—Endface angle of angle-polished ferrules	JIS C 61300-3-17	Nov.20,2013
	51	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-22: Ferrule compression force	JIS C 61300-3-22	Mar.20,2014
	52	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-23: Examinations and measurements—Fiber position relative to ferrule endface	JIS C 61300-3-23	Nov.20,2013
	53	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-24: Keying accuracy of optical connectors for polarization maintaining fiber	JIS C 61300-3-24	Nov.20,2012
	54	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-25: Concentricity of ferrules and non-angled PC polished ferrules with optical fiber installed	JIS C 61300-3-25	Dec.22,2014
	55	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-26: Examinations and measurements—Measurement of the angular misalignment between fiber and ferrule axes	JIS C 61300-3-26	Mar.22,2011
	56	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-27: Measurement method for the hole location of a multiway connector plug	JIS C 61300-3-27	May.21,2012
	57	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-30: Examinations and measurements—Polish angle and fiber position on single ferrule multifiber connectors	JIS C 61300-3-30	May.20,2010
	58	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-33: Withdrawal force of a split sleeve using pin gauges	JIS C 61300-3-33	Dec.22,2014
	59	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-34: Examinations and measurements—Attenuation of random mated connectors	JIS C 61300-3-34	Nov.20,2012
	60	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-36: Measurement methods for the inside and outside diameters of fiber optic connector ferrules	JIS C 61300-3-36	May.21,2012
	61	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-40: Examinations and measurements—Polarization extinction ratio of an optical connector plug with polarization maintaining fiber	JIS C 61300-3-40	Dec.22,2014
Optical Devices (passive)	1	General rules of passive devices for light beam transmission	JIS C 5860	Revised Nov.20,2012
	2	General rules of interference filters	JIS C 5870	Revised Mar.20,2009
	3	Test methods of interference filters	JIS C 5871	Revised Jan.20,2011
	4	General specifications of retarder	JIS C 5876-1	Mar.20,2009
	5	Polarizer—Part 1: General rule	JIS C 5877-1	Revised Mar.20,2015
	6	Test methods of polarizer	JIS C 5877-2	Jan.20,2012
	7	General rules of passive devices for fiber optic transmission	JIS C 5900	Revised Mar.21,2013
	8	Test methods of passive devices for fiber optic transmission	JIS C 5901	Revised Mar.20,2001
		Test methods of passive devices for fiber optic transmission (Amendment 1)	JIS C 5901	Revised Jul.20,2009
	9	Non-wavelength-selective fiber optic branching devices—Part 1: Generic specification	JIS C 5910-1	Revised Mar.20,2014
	10	Non-wavelength-selective fiber optic branching devices—Part 3: Non-connectorised single-mode 1xN and 2xN non-wavelength-selective branching devices	JIS C 5910-3	Mar.20,2015
	11	General rules of wavelength switches	JIS C 5912	Mar.25,2006
	12	General rules of optical circulator	JIS C 5914	Revised Mar.21,2013
	13	Single-mode fiber, pigtailed-style optical circulators	JIS C 5915	Dec.21,2009
	14	General rules of dispersion compensators for fiber optic transmission	JIS C 5916	Revised May.21,2012
	15	Fiber optic chromatic dispersion compensator using single-mode dispersion compensating fiber	JIS C 5916-3	Mar.20,2014
	16	General rules of optical attenuators	JIS C 5920	Revised Dec.20,2005
	17	Single-mode fiber, pigtailed-style fixed optical attenuators	JIS C 5921	Dec.21,2009
	18	Fiber optic WDM devices—Generic specification	JIS C 5925-1	Oct.20,2011
	19	Non-connectorized single-mode fiber optic C-band/L-band WDM devices	JIS C 5925-3	Jan.20,2011
	20	Non-connectorized single-mode fiber optic 980/1 550 nm WDM devices	JIS C 5925-4	Jan.20,2011
	21	Non-connectorized single-mode fibre optics middle-scale 1xN DWDM devices	JIS C 5925-5	Nov.20,2013
	22	Fiber optic filters—Part 1: Generic specification	JIS C 5926-1	Mar.20,2014
	23	General rules of optical switches	JIS C 5930	Revised Dec.20,2005
	24	Test methods for optical switches	JIS C 5931	Nov.1,1988
	25	General rules of optical isolators	JIS C 5932	Revised May.21,2012
	26	Test methods of optical isolators for fiber optic transmission	JIS C 5933	Oct.1,1993

Standardization Meeting		Titles of standards	JIS No.	Establishment date
	27	General rules of lenses for fiber optic transmission	JIS C 5934	Jul.20,1999
	28	Measurement methods of lenses for optic transmission	JIS C 5935	Jan.20,2005
	29	Single-mode fiber, pigtailed-style optical isolators	JIS C 5936-3	Jan.20,2011
	30	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 1: General and guidance	JIS C 61300-1	Revised Mar.20,2015
	31	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-1: Tests—Vibration (sinusoidal)	JIS C 61300-2-1	Nov.20,2012
	32	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-9: Tests—Shock	JIS C 61300-2-9	Nov.20,2012
	33	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-12: Tests—Impact	JIS C 61300-2-12	Jan.20,2011
	34	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-14: Tests—Optical power handling and damage threshold characterization	JIS C 61300-2-14	Jan.20,2011
	35	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-17: Tests—Cold	JIS C 61300-2-17	Jul.20,2009
	36	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-18: Tests—High temperature	JIS C 61300-2-18	Jul.20,2009
	37	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-19: Tests—Damp heat (steady state)	JIS C 61300-2-19	Jul.20,2009
	38	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-21: Tests—Composite temperature/humidity cyclic test	JIS C 61300-2-21	Nov.20,2012
	39	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-22: Tests—Change of temperature	JIS C 61300-2-22	Jan.20,2012
	40	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-26: Tests—Salt mist	JIS C 61300-2-26	Mar.21,2013
	41	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-45: Tests—Durability test by water immersion	JIS C 61300-2-45	Jul.20,2009
	42	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-46: Tests—Damp heat, cyclic	JIS C 61300-2-46	Mar.22,2011
	43	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-47: Tests—Thermal shocks	JIS C 61300-2-47	Jan.20,2012
	44	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 2-48: Tests—Temperature-humidity cycling	JIS C 61300-2-48	Mar.23,2010
	45	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-2: Examinations and measurements—Polarization dependent loss in a single-mode fiber optic device	JIS C 61300-3-2	Jan.20,2012
	46	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-3: Examinations and measurements—Active monitoring of changes in attenuation and return loss	JIS C 61300-3-3	Jul.20,2009
	47	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-6: Examinations and measurements—Return loss	JIS C 61300-3-6	Jan.20,2011
	48	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-7: Examinations and measurements—Wavelength dependence of attenuation and return loss of single mode components	JIS C 61300-3-7	Nov.20,2012
	49	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-20: Examinations and measurements—Directivity of fiber optic branching devices	JIS C 61300-3-20	Jul.20,2009
	50	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-28: Examinations and measurements—Transient loss	JIS C 61300-3-28	Jul.20,2009
	51	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-31: Coupled power ratio measurement for fiber optic sources	JIS C 61300-3-31	Jul.20,2009
	52	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-32: Examinations and measurements—Polarization mode dispersion measurement for passive optical components	JIS C 61300-3-32	Mar.21,2013
	53	Fiber optic interconnecting devices and passive components—Basic test and measurement procedures—Part 3-43: Examinations and measurements—Mode transfer function measurement for fiber optic sources	JIS C 61300-3-43	Nov.20,2012
Optical Devices (active)	1	General rules of laser diodes for fiber optic transmission	JIS C 5940	Revised Aug.20,1997
	2	Measuring methods of laser diodes for fiber optic transmission	JIS C 5941	Revised Aug.20,1997
	3	General rules of laser diodes used for recording and playback	JIS C 5942	Revised May.20,2010
	4	Measuring methods of laser diodes used for recording and playback	JIS C 5943	Revised May.20,2010
	5	General rules of laser diode modules for fiber optic transmission	JIS C 5944	Revised Apr.20,2005
	6	Measuring methods of laser diode modules for fiber optic transmission	JIS C 5945	Revised Apr.20,2005
	7	General rules of laser diode modules for optical fibre amplifier	JIS C 5946	Jan.20,2005
	8	Measuring methods of laser diode modules for optical fibre amplifier	JIS C 5947	Jan.20,2005
	9	Laser modules used for telecommunication—Reliability assessment	JIS C 5948	Mar.20,2007
	10	General rules of light emitting diodes for fiber optic transmission	JIS C 5950	Revised Aug.20,1997
	11	Measuring methods of light emitting diodes for fiber optic transmission	JIS C 5951	Revised Aug.20,1997
	12	Fibre optic active components and devices—Package and interface standards—Part 1 : General and guidance	JIS C 5952-1	Sep.20,2008
	13	Fibre optic active components and devices—Package and interface standards—Part 2 : SFF MT-RJ 10-pin transceivers	JIS C 5952-2	Sep.20,2008
	14	Fibre optic active components and devices—Package and interface standards—Part 3: SFF MT-RJ 20-pin transceivers	JIS C 5952-3	Sep.20,2008
	15	Fibre optic active components and devices—Package and interface standards—Part 4 : PN 1x9 plastic optical fibre transceivers	JIS C 5952-4	Sep.20,2008
	16	Fibre optic active components and devices—Package and interface standards—Part 5 : SC 1x9 fibre optic modules	JIS C 5952-5	Sep.20,2008
	17	Fibre optic active components and devices—Package and interface standards—Part 6 : ATM-PON transceivers	JIS C 5952-6	Sep.20,2008
	18	Fibre optic active components and devices—Package and interface standards—Part 7 : SFF LC 10-pin transceivers	JIS C 5952-7	Sep.20,2008
	19	Fibre optic active components and devices—Package and interface standards—Part 8 : SFF LC 20-pin transceivers	JIS C 5952-8	Sep.20,2008
	20	Fibre optic active components and devices—Package and interface standards—Part 9 : SFF MU duplex 10-pin transceivers	JIS C 5952-9	Sep.20,2008
	21	Fibre optic active components and devices—Package and interface standards—Part 10 : SFF MU duplex 20-pin transceivers	JIS C 5952-10	Sep.20,2008
	22	Fibre optic active components and devices—Package and interface standards—Part 11 : 14-pin modulator-integrated laser diode transmitters	JIS C 5952-11	Sep.20,2008

Standardization Meeting		Titles of standards	JIS No.	Establishment date
	23	Fibre optic active components and devices—Package interface standards—Part 12 : Laser transmitters with a coaxial RF connector	JIS C 5952-12	Sep.20,2008
	24	Fiber optic active components and devices—Performance standards—Part 1: General and guidance	JIS C 5953-1	Mar.20,2007
	25	Fiber optic active components and devices—Performance standards—Part 3: 2.5 Gbit/s modulator-integrated laser diode transmitters	JIS C 5953-3	Mar.20,2007
	26	Fiber optic active components and devices—Performance standards—Part 4 : 1 300 nm fiber optic transceivers for gigabit Ethernet application	JIS C 5953-4	Sep.20,2008
	27	Fiber optic active components and devices—Performance standards—Part 5 : ATM-PON transceivers with LD driver and CDR ICs	JIS C 5953-5	Oct.20,2008
	28	Fiber optic active components and devices—Performance standards—Part 6 : 650 nm 250 Mbit/s plastic optical fiber transceivers	JIS C 5953-6	Mar.20,2009
	29	Fiber optic active components and devices—Test and measurement procedures—Part 1 : General and guidance	JIS C 5954-1	Oct.20,2008
	30	Fiber optic active components and devices—Test and measurement procedures—Part 2 : ATM-PON transceivers	JIS C 5954-2	Oct.20,2008
	31	Fiber optic active components and devices—Test and measurement procedures—Part 3 : Optical transmitting and/or receiving modules for single fiber serial transmission link	JIS C 5954-3	Mar.21,2013
	32	General rules of photodiodes for fiber optic transmission	JIS C 5990	Revised Aug.20,1997
	33	Measuring methods of photodiodes for fiber optic transmission	JIS C 5991	Revised Aug.20,1997
	34	General rules of transmitting and receiving modules for low speed fiber optic transmission	JIS C 6110	Revised Nov.20,1997
	35	Measuring methods of transmitting and receiving modules for low speed fiber optic transmission	JIS C 6111	Revised Nov.20,1997
	36	General rules of optical modulator modules	JIS C 6114-1	Jan.20,2006
	37	Measuring method of optical modulator modules	JIS C 6114-2	Jan.20,2006
	38	General rules of pin-FET modules	JIS C 6115-1	Jan.20,2006
	39	Measuring methods of pin-FET modules	JIS C 6115-2	Jan.20,2006
Optical Amplifiers	1	Optical amplifiers—General specification	JIS C 6121	Revised Mar.23,2010
	2	Optical amplifiers—Part 5-2: Qualification specifications—Reliability qualification for optical fiber amplifiers	JIS C 6121-5-2	Mar.20,2007
	3	Optical amplifiers—Part 6-1: Interfaces—Command set	JIS C 6121-6-1	Nov.20,2013
	4	Optical amplifiers—Test methods—Part 1-1: Power and gain parameters—Optical spectrum analyzer method	JIS C 6122-1-1	Mar.22,2011
	5	Optical amplifiers—Test methods—Part 1-2: Power and gain parameters—Electrical spectrum analyzer method	JIS C 6122-1-2	Mar.22,2011
	6	Optical amplifiers—Test methods—Part 1-3: Power and gain parameters—Optical power meter method	JIS C 6122-1-3	Mar.22,2011
	7	Optical amplifiers—Test methods—Part 3: Noise figure parameters	JIS C 6122-3	Revised Mar.22,2011
	8	Optical amplifiers—Test methods—Part 3-1: Noise figure parameters—Optical spectrum analyzer method	JIS C 6122-3-1	Oct.20,2011
	9	Optical amplifiers—Test methods—Part 3-2: Noise figure parameters—Electrical spectrum analyzer method	JIS C 6122-3-2	Jan.20,2006
	10	Optical amplifiers—Test methods—Part 4-1: Transient parameters—Measurement of gain parameters using two-wavelength method	JIS C 6122-4-1	Nov.20,2013
	11	Optical amplifiers—Test methods—Part 4-2: Transient parameters—Measurement of gain parameters using broadband source method	JIS C 6122-4-2	Nov.20,2013
	12	Optical fiber amplifiers—Test methods—Part 5-1 : Test methods for reflectance parameters—Optical spectrum analyzer test method	JIS C 6122-5-1	Aug.20,2001
	13	Optical fiber amplifiers—Test methods—Part 6 : Test methods for pump leakage parameters	JIS C 6122-6	Feb.20,1998
	14	Optical fiber amplifiers—Test methods—Part 7 : Test methods for out-of-band insertion losses	JIS C 6122-7	Feb.20,1998
	15	Optical Amplifiers—Test Methods—Part 10-1: Multichannel parameters—Pulse method using an optical switch and optical spectrum analyzer	JIS C 6122-10-1	Mar.20,2007
	16	Optical amplifiers—Test methods—Part 10-2: Multichannel parameters—Pulse method using a gated optical spectrum analyzer	JIS C 6122-10-2	Mar.23,2010
	17	Optical amplifiers—Test methods—Part 10-3: Multichannel parameters—Probe methods	JIS C 6122-10-3	Jan.20,2012
	18	Optical amplifiers—Test methods—Part 10-4: Multichannel parameters—Interpolated source subtraction method using an optical spectrum analyzer	JIS C 6122-10-4	Nov.20,2012
	19	Optical amplifiers—Test methods—Part 11-1: Polarization mode dispersion parameter—Jones matrix eigenanalysis (JME)	JIS C 6122-11-1	May.20,2010
	20	Optical amplifiers—Performance specification template—Part 1: Optical amplifiers for single channel applications	JIS C 6123-1	Revised Mar.20,2015
	21	Optical amplifiers—Performance specification template—Part 4: Optical amplifiers for multichannel applications	JIS C 6123-4	Revised Mar.20,2015
	22	Optical amplifiers—Maximum permissible optical power for damage-free and safe use of optical amplifiers	TR C 0047	Public (Expire Oct.1,2007 Feb.28,2018)
	23	Optical amplifiers—General information—Polarization mode dispersion parameter	TR C 0048	Public (Expire Jul.1,2010 Jun.30,2015)
	24	Optical amplifiers—Distributed Raman amplification	TR C 0057	Public (Expire Aug.1,2014 Sep.31,2019)
Optical Subsystem	1	Fiber optic communication subsystem test procedures—Central wavelength and spectral width measurement	JIS C 61280-1-3	May.20,2010
	2	Fiber optic communication subsystem test procedures—Receiver sensitivity and overload measurement	JIS C 61280-2-1	May.20,2010
	3	Fiber optic communication subsystem test procedures—Optical eye pattern, waveform and extinction ratio measurement	JIS C 61280-2-2	May.20,2010
	4	Fibre optic communication subsystem test procedures—Part 2-3: Digital systems—Jitter and wander measurements	JIS C 61280-2-3	Nov.20,2013
	5	Fiber optic communication subsystem test procedures—Determination of low BER using Q-factor measurements	JIS C 61280-2-8	May.20,2010
	6	Fiber optic communication subsystem test procedures—Optical signal-to-noise ratio measurement for dense wavelength-division multiplexed systems	JIS C 61280-2-9	May.20,2010
	7	Fiber optic communication subsystem test procedures—Part 2-10: Digital systems—Time-resolved chirp and alpha-factor measurement of laser transmitters	JIS C 61280-2-10	Jan.20,2012
	8	Fiber optic communication subsystem test procedures—Averaged Q-factor determination using amplitude histogram evaluation for optical signal quality monitoring	JIS C 61280-2-11	Public (Expire May.20,2010 Dec.31,2016)
	9	Generic specification for fiber optic communication subsystems	JIS C 61281-1	May.20,2010
	10	Fiber optic communication system design guides—Calculating dispersion penalty from measured time-resolved chirp data	TR C 0046-2	Public (Expire Jan.1,2012 Dec.31,2016)
Optical Measuring Instruments	1	Measuring methods for laser output power	JIS C 6180	Aug.1,1991
	2	Power and energy measuring detectors, instruments and equipment for laser radiation	JIS C 6181	Jan.1,1995



Standardization Meeting		Titles of standards	JIS No.	Establishment date
	3	Test methods of optical power meters for laser beam	JIS C 6182	Aug.1,1991
	4	Test methods of fiber-optic spectrum analyzer	JIS C 6183	Sep.1,1992
	5	Test methods of optical power meters for optical fiber	JIS C 6184	Oct.1,1993
	6	Test methods of optical time domain reflectometer	JIS C 6185	Revised Jan.20,2008
	7	Optical time-domain reflectometers (OTDR)–Part 2: Calibration of OTDR for single mode fibers	JIS C 6185-2	Mar.20,2014
	8	Optical time-domain reflectometers (OTDR)–Part 3: Calibration of OTDR for multimode fibers	JIS C 6185-3	Mar.20,2014
	9	Calibration of fiber-optic power meters	JIS C 6186	Revised Jan.20,2008
	10	Test methods of optical wavelengthmeters	JIS C 6187	Jul.20,1999
	11	Optical wavelength meters–Part 2: Calibration	JIS C 6187-2	Mar.20,2014
	12	Test methods of measuring optical attenuators	JIS C 6188	Jul.20,1999
	13	Test methods of optical return loss meters	JIS C 6189	Mar.20,2004
	14	Test methods for fiber optic test sources	JIS C 6190	Oct.1,1993
	15	Test methods of tunable light source	JIS C 6191	Apr.20,2005
	16	Calibration of optical spectrum analyzers	JIS C 6192	Jan.20,2008
	17	End-face image analysis procedure for the calibration of optical fibre geometry test sets	JIS C 6828	Mar.20,2004
	18	Calibration of fibre optic chromatic dispersion test sets	JIS C 6829	Jan.20,2005
Laser Safety	1	Safety of laser products	JIS C 6802	Revised Sep.22,2014
	2	Safety of laser products–Safety of optical fiber communication systems	JIS C 6803	Revised Sep.20,2013
	3	Safety of laser products–Safety of free space optical communication systems used for transmission of information	JIS C 6804	Oct.20,2008
Optical Disks	1	Volume and file structure of CD-ROM for information interchange	JIS X 0606	Revised Oct.20,1998
	2	Information technology–Volume and file structure of write-once and rewritable media using non-sequential recording for information interchange	JIS X 0607	Mar.1,1996
		Technical Corrigendum 1 to Volume and file structure of write-once and rewritable media using non-sequential recording for information interchange	JIS X 0607	Revised Mar.20,2001
	3	Volume and file structure of high-density optical disks using non-sequential recording for information interchange	JIS X 0609	Feb.20,1998
		Volume and file structure of high-density optical disks using non-sequential recording for information interchange (Amendment 1)	JIS X 0609	Revised Nov.20,2012
	4	Volume and file structure of DVD read-only Disc	JIS X 0610	Mar.25,2006
	5	Universal Disk Format (UDF) 2.01	JIS X 0611	Feb.20,2012
	6	Universal Disk Format (UDF) 2.50	JIS X 0613	Feb.20,2015
	7	Universal Disk Format (UDF) 2.60	JIS X 0614	Feb.20,2015
	8	Volume and file structure of DVD-R Disk	JIS X 6235	Oct.20,2009
	9	Volume and file structure of DVD-RAM Disk	JIS X 6236	Oct.20,2009
	10	Volume and file structure of DVD-RW Disk	JIS X 6237	Oct.20,2009
	11	120 mm DVD–Read-only disk	JIS X 6241	Revised Dec.20,2004
	12	80 mm DVD–Read-only disk	JIS X 6242	Revised Dec.20,2004
	13	120 mm DVD Rewritable Disk (DVD-RAM)	JIS X 6243	Jan.20,1998
	14	Case for 120 mm DVD-RAM Disks	JIS X 6244	Jan.20,1998
	15	80 mm (1.23 GB/side) and 120 mm (3.95 GB/side) DVD-Recordable-Disk (DVD-R)	JIS X 6245	Mar.20,1999
	16	120 mm (4.7 Gbyte per side) and 80 mm (1.46 Gbyte per side) DVD Rewritable Disk (DVD-RAM)	JIS X 6246	Aug.20,2005
	17	Cases for 120 mm and 80 mm DVD-RAM disks	JIS X 6247	Aug.20,2005
	18	Information technology–80 mm (1.46 Gbytes per side) and 120 mm (4.70 Gbytes per side) DVD re-recordable disk (DVD-RW)	JIS X 6248	Jan.20,2007
	19	Information technology–80 mm (1.46 Gbytes per side) and 120 mm (4.70 Gbytes per side) DVD Recordable Disk (DVD-R)	JIS X 6249	Apr.20,2009
	20	Information technology–Data interchange on 120 mm and 80 mm optical disk using +RW format–Capacity: 4.7 Gbytes and 1.46 Gbytes per side (Recording speed up to 4X)	JIS X 6250	Apr.20,2009
	21	Information technology–Data interchange on 120 mm and 80 mm optical disk using +R format–Capacity: 4.7 and 1.46 Gbytes per side (Recording speed up to 16X)	JIS X 6251	Apr.20,2009
	22	Information technology–120 mm (8.54 Gbytes per side) and 80 mm (2.66 Gbytes per side) DVD recordable disk for dual layer (DVD-R for DL)	JIS X 6252	Sep.20,2011
	23	Information technology–Digitally recorded media for information interchange and storage–Data migration method for DVD-R, DVD-RW, DVD-RAM, +R, and +RW disks	JIS X 6255	Revised Mar.20,2015
	24	Information technology–Digitally recorded media for information interchange and storage–Tested method for the estimation of lifetime of optical media for long-term data storage	JIS X 6256	May.20,2014
	25	130 mm Optical disk cartridges, write-once, for information interchange	JIS X 6261	Jan.1,1991
	26	Information technology–Data interchange on 90 mm optical disk cartridges–Capacity: 2.3 Gbytes per cartridge	JIS X 6270	Jan.20,2011
		Information technology–Data interchange on 90 mm optical disk cartridges–Capacity: 2.3 Gbytes per cartridge (Amendment 1)	JIS X 6270	Revised Nov.20,2012
	27	130 mm Rewritable optical disk cartridges for information interchange	JIS X 6271	Aug.1,1991
	28	90 mm Rewritable and read only optical disk cartridges for information interchange	JIS X 6272	Sep.1,1992
		90 mm Rewritable and read only optical disk cartridges for information interchange (Amendment 1)	JIS X 6272	Revised Nov.20,2012
	29	Information technology–Data interchange on 90 mm optical disk cartridges–Capacity: 230 Mbytes per cartridge	JIS X 6275	Oct.20,1997
	30	Information technology–Data interchange on 90 mm optical disk cartridges–Capacity:640 Mbytes per cartridge	JIS X 6277	Jul.20,1998
	31	Information technology–Data interchange on 90 mm optical disk cartridges–Capacity: 1.3 Gbytes per cartridge	JIS X 6279	Jan.20,2011
		Information technology–Data interchange on 90 mm optical disk cartridges–Capacity: 1.3 Gbytes per cartridge (Amendment 1)	JIS X 6279	Revised Nov.20,2012
	32	Information technology–Data interchange on 130 mm magneto-optical disk cartridges–Capacity: 9.1 Gbytes per cartridge	JIS X 6280	Jan.20,2011
	33	Data interchange on read-only 120 mm optical data disks (CD-ROM)	JIS X 6281	Revised Jan.20,2006
		Data interchange on read-only 120 mm optical data disks (CD-ROM) (Amendment 1)	JIS X 6281	Revised Mar.21,2012
	34	Data interchange on Recordable 120 mm optical data disc (CD-R)	JIS X 6282	Oct.20,2009
		Data interchange on Recordable 120 mm optical data disc (CD-R) (Amendment 1)	JIS X 6282	Revised Mar.21,2012
	35	Data interchange on Rewritable 120 mm optical data disc (CD-RW)	JIS X 6283	Oct.20,2009
		Data interchange on Rewritable 120 mm optical data disc (CD-RW) (Amendment 1)	JIS X 6283	Revised Mar.21,2012
	36	Information technology–Data interchange on 90 mm overwritable and read only optical disk cartridges using phase change–Capacity : 1.3 Gbytes per cartridge	JIS X 6291	Jul.20,1998
	37	Information technology–Data interchange on 120 mm optical disk cartridges using phase change PD format–Capacity : 650 Mbytes per cartridge	JIS X 6292	Jul.20,1998

Table 2 List of OITDA Standard and OITDA/TP

(As of Mar. 31, 2015)

Standardization Meeting / Submeeting / Project		Title	No.	
Intra-building optical wiring	1	Optical fiber distribution system for detached houses in FTTH	TP01/BW (=TP-BW01) (2011Ed.3)	Revised 2011.8.3
Intra-building optical wiring	2	Optical fiber distribution system for apartment houses in FTTH	TP02/BW (=TP-BW02) (2011Ed.3)	Revised 2011.8.3
Intra-building optical wiring	3	Plastic optical fiber distribution system for customer premises	OITDA/TP 03/BW (=TP-BW03) (2012Ed.3)	Revised 2012.6.28
S-project and Optical passive device	4	Technical paper of investigation of high-power reliability for passive optical components for optical communication application	TP04/SP · PD (2008Ed.1)	2008.8.28
S-project and Dynamic module	5	Investigation on operational vibration and mechanical impact test conditions for optical modules for telecom use	TP05/SP · DM (2008Ed.1)	2008.8.28
S-project and Dynamic module	6	Group Delay Ripple Measurement Method for Tunable Dispersion Compensators—Technical Paper	TP06/SP · DM (2008Ed.1)	2008.10.9
Optical amplifier	7	Application guide for Four-wave mixing effect in optical amplifiers	TP07/AM (2009Ed.1)	2009.5.21
Optical amplifier	8	General information for optical fiber fuse	TP08/AM (2010Ed.1)	2010.3.1
S-project and Optical passive device	9	Technical paper of investigation of high-power reliability for passive optical components for optical communication application	TP09/SP · PD-2010 (2010 Ed.1)	2010.3.25
Optical active device	10	Laser modules used for optical amplifiers and fiber lasers—Reliability assessment guide	OITDA/TP 10/AD (2012 Ed.1)	2012.7.10
Intra-building optical wiring	11	Optical fiber distribution system for customer premises	OITDA/TP 11/BW (2012 Ed.1)	2012.8.22
T-project	12	Guideline of optical connector endface cleaning method for receptacle style optical transceivers	OITDA/TP 12/TP (2012 Ed.1)	2012.11.1
Optical active device	13	Fiber optic active components and devices—Performance standards—GEPON transceivers	OITDA/TP 13/AD (2013 Ed.1)	2013.3.22
Optical active device	14	Fiber optic active components and devices—Test and measurement procedures—GEPON transceivers	OITDA/TP 14/AD (2013 Ed.1)	2013.3.22
Dynamic module	15	Dynamic Crosstalk Measurement for Wavelength Selective Switch	OITDA/TP 15/DM (2013 Ed.1)	2013.10.15
Dynamic module	16	Investigation on Operating Conditions for Dynamic Modules for Telecom Use	OITDA/TP 16/DM (2013 Ed.1)	2013.10.15
Optical active device	17	Fiber optic active components and devices—Performance standard template—Wavelength tunable laser diode module for Dense WDM transmission	OITDA/TP 17/AD (2014 Ed.1)	2014.3.31
Optical active device	18	Fiber optic active components and devices—Test and measurement procedures—Wavelength tunable laser diode module for Dense WDM transmission	OITDA/TP 18/AD (2014 Ed.1)	2014.3.31
Optical connector	19	Investigation of examinations and measurements—Light-blocking performance of optical adaptor with shutter	OITDA/TP 19/CN (2014 Ed.1)	2014.3.31
Optical active device	20	Fiber optic active components and devices—Performance standards—GPON transceivers	OITDA/TP 20/AD (2015 Ed.1)	2015.2.6
Optical active device	21	Fiber optic active components and devices—Test and measurement procedures—GPON transceivers	OITDA/TP 21/AD (2015 Ed.1)	2015.2.6
Dynamic module	22	Discussion process of the standardization of wavelength selective switch interface specification	OITDA/TP 22/DM (2015 Ed.1)	2015.2.6

## 2. Fiber Optics Standardization Meeting

For OITDA to be a constant leader in the standardization of fiber optics, this meeting plays a vital role in planning and promoting standardization under the direction of the Standardization General Meeting.

Optical technology is becoming more important for industry, due to the advancement of information and communication technology including the rapid expansion of the Internet, and increased popularity of optical technology-based information home electronics. Also, the range of applications of optical technology is dramatically widening. Thus, standardization of fiber optics is anticipated to also gain importance. In addition, its applicability is expected to broaden, encompassing a diverse range of fields. Accordingly, it is important to identify items that should be standardized, and create a vision of ideal standardization by reviewing the purpose and targets regarding the standardization of fiber optics.

In this fiscal year, with its awareness of these issues, this meeting promoted extensive studies and research into fiber optics, and focused its efforts on addressing problems and proposing strategic plans in connection with JIS and international standardization. Regarding the organization's standards (OITDA standards) and OITDA technical papers (TPs) introduced by this meeting to complement JIS and international standards, the meeting decided to expedite standardization by increasing the number of standards it publishes.

This fiscal year, the meeting organized four research submeetings to undertake those activities: the Administrative Advisory Submeeting, Dynamic Module Submeeting, Intra-Building Optical Wiring Submeeting, and Optical Fiber Sensors Submeeting.

### 2.1 Administrative Advisory Submeeting

#### 2.1.1 Purpose and Activities

To create JIS standards and international standardization activities efficiently, the submeeting's JIS standardization strategies are created from the perspective of supporting international standardization to identify problems and consider improvement plans for the efficient preparation of draft of the standards. It continues to promote the publication of OITDA standards and technical papers (TPs) and to maintain them.

#### 2.1.2 Activities of this Fiscal Year

##### (1) Basic standardization strategy

The basic strategy on standardization will be maintained as one of OITDA's activities. However, since there have been some changes in the national standardization strategy and society's needs, reexamination of and supplements to relevant items will be carried out as necessary.

##### (2) Introduction of IEC status (ACTEL status)

Continuing from the previous fiscal year, information on the Advisory Committee on Telecommunication (ACTEL) was shared. ACTEL, which was affiliated with the IEC Standards Management Board (SMB), was deactivated, and an ad hoc group has been established to oversee the ICT of the IEC.

##### (3) Confirmation of the status of JIS application/TR

Thanks to the efforts of METI and JSA, many of the JIS draft standards were accepted, and as of the end of fiscal 2014, eighteen JIS proposals are under publication by the standardization meetings, nineteen published JIS proposals have been created and submitted to JSA for discussion, and three proposals have been made to METI and discussed by JISC. Twenty-five JISs have been issued this fiscal year, and one TR has been

published. Due to the reorganization of JISC and opening of the IEC Tokyo General Meeting, there was a delay in the JIS discussions but it was resolved by the end of the fiscal year. There are still many JIS proposals in the pipeline, so we will continue to follow up on the situation.

#### (4) Issues with preparing JIS drafts

The items on terminology and notation discussed by the JISC Electronics Technical Committee and the item pointed out by the JSA Standards Coordination Subcommittee were addressed.

Special usage of the Japanese translation of the term, “spectrum (spectral)” by OITDA, which was explained to the JISC Electronics Technical Committee in fiscal 2012, was allowed for the Optical Subsystem Standardization Meeting. However, the meeting has decided to modify its usage to be the same as other meetings.

At the JSA Standards Coordination Subcommittee, METI pointed out that it might be better to unify the Japanese translation of “method.” In consideration of this, it was decided to ask each standardization meeting for their opinion on whether there are any problems in unifying the translation. Concurrently, discussions on unifying the Japanese translations of “test method” and “measurement method” have started.

#### (5) Promoting OITDA standards and OITDA technical papers (TPs)

This fiscal year, three OITDA technical papers (TP) were published. These include two TPs that were prepared by the Optical Active Device Standardization Meeting following the previous year, and one TP that was prepared by the Dynamic Module Subcommittee.

## 2.2 Dynamic Module Subcommittee

To cope with an increase in communications traffic, large capacity optical transmission systems with transmission speeds of 100 Gbit/s have been introduced commercially step by step. However, at the same time, it is also necessary to build a flexible optical network that is adaptable to dynamic changes in traffic and to the shutting down of transmission routes due to sudden natural disasters, etc. In such a network, the adoption of a Reconfigurable Optical Add/Drop Multiplexing (ROADM) system, in which the optical path can be switched between multiple routes, is indispensable. The optical modules that comprise this system require autonomous control to stabilize signal quality against changes in the traffic environment. The dynamic module, which is under discussion by this subcommittee, would enable this. Standardization is also being carried out in the IEC by the TC 86/SC 86C/WG 5 Dynamic Module Group. The following is a report on the status of the activities of this subcommittee.

### 2.2.1 Status of Review

This fiscal year, the subcommittee reviewed the following IEC standards deliberation documents: Performance standards - General conditions (IEC 62343-1, old IEC 62343-1-4), Performance standards - Tuneable chromatic dispersion compensator (non-connectorized) (IEC 62343-1-2), Edition 2 of Dynamic modules - Reliability qualification (IEC 62343-2), Performance specification templates - Optical channel monitor (IEC 62343-3-2), Hardware and software interface standards of WSS (IEC 62343-4-1), Test methods - Dynamic gain tilt equalizer - Gain tilt settling time measurement (IEC 62343-5-1), Transient crosstalk measurement for WSS (IEC 62343-5-2), Technical report - ROADM (IEC/TR 62343-6-4), Edition 2 of Technical report - Investigation of operating mechanical shock and vibration tests for dynamic modules (IEC/TR 62343-6-5), Technical report - OCM (IEC/TR 62343-6-7), Technical report - Study of mechanisms and measurements of crosstalk in WSS (IEC/TR 62343-6-9), etc.

Also, a questionnaire survey was carried out on the  $N \times M$  WSS control interface standard, reliability test items, and high power tests,

along with a survey and review of dynamic module shared control interfaces and the name of a multi-cast optical switch. Further, the logic behind discussing standardization of the interface specifications of wavelength selection switches was publicized as an OITDA Technical paper (OITDA/TP 22/DM).

### 2.2.2 Trends in International Standardization

#### (1) Milpitas meeting outline (March 7, 2014)

The following papers were reviewed at the meeting: three papers on performance standards, two papers on performance templates, one paper on control interfaces, two papers on measurement methods, and five design guides (technical reports). Japan reported the results of a questionnaire on the  $N \times M$  WSS interface standard, and submitted a proposal on control interface standardization for multiple dynamic module systems.

#### (2) Tokyo meeting outline (November 5, 2014)

A total of ten papers were reviewed, mainly on comments about CD and CDV documents. A liaison report on JIS activities, a proposal on the name of a multi-cast optical switch, and a report on control interface standardization for multiple dynamic module systems were made by Japan. It was agreed to start work on the standardization of multi-cast optical switches.

### 2.2.3 Future Activity Plans

Implementation of dynamic modules in real systems is making good progress. This fiscal year, work on the standardization of multi-cast optical switches was started. Under these circumstances, a plan was made to actively support the domestic IEC committee, including reviewing IEC standardization documents and proposing new standards, etc., so that Japan's opinions would be sufficiently reflected in international standards. Also, plans were made to monitor standardization trends by the IEC, and to proceed with the formulation/review of JIS standards without delay where required.

## 2.3 Intra-Building Optical Wiring Subcommittee

According to the Ministry of Internal Affairs and Communications (MIC), there were 92 million subscribers to broadband services in September 2014. Among them, 26 million were Fiber To The Home (FTTH) customers, a 5.6% increase from the previous year, and the increasing trend continues. However, the percentage of FTTH subscribers of total broadband subscribers was 28.3% with an ongoing decline. This is because of a significant increase in mobile broadband access with LTE and WiMAX, and the trend has been intensifying further in recent years.

In order for residents and providers of buildings (builders/designers, etc.) to receive high-speed intra-building broadband data/video services, this subcommittee is providing information on optical wiring technology trends, etc., and also creating technical papers that summarize the information.

### 2.3.1 Collection of Technical Information on Intra-Building Optical Wiring Systems

#### (1) Optical Cable Technology

Recent international trends include efforts to develop smaller-diameter and multiple-core optical cables using cores with an outer diameter of 0.2 mm; research and development is ongoing. An overseas manufacturer presented at a conference a 1,728-core optical cable with an outer diameter of 23 mm or smaller that was produced by bundling 72 24-core micro-module cables with an outer diameter of 0.2 mm. In FY 2013, there was also a conference presentation from a domestic manufacturer on a 1,000-core or more optical cable with an eye toward further reducing the diameter and weight by applying 0.2 mm-diameter core technology

to an ultra-thin diameter high-density optical cable using rollable four-core optical fiber ribbon cores. It is thought that each manufacturer is considering implementations of these cables.

## (2) Connection Technology

LC connectors are being widely used for connecting optical fiber cables between data center equipment, and an LCF connector that can switch polarity and an MPO connector with changeable polarity and with detachable/reattachable pins were developed. From the aspect of fusion connection, a system for controlling fusion splicers through the Internet, called "SumiCloud™" was developed. It consists of a cloud server and a smartphone application. The cloud server accumulates/manages the information sent from the fusion splicer in a database. The system enables a wide range of machine management tasks by allowing the manager of the fusion splicer to check the "task history" and "machine status" in real time from a remote place over the Internet using the functions of the cloud server.

## (3) Construction Technology

A survey was conducted on the latest construction technology associated with intra-building wiring. The survey covered "air-conditioner duct through braids," "thin-diameter cable grips," "small wire pulling device storage cases," and "wire pulling tool kits."

## (4) Optical Systems

This fiscal year, a survey was conducted on the trends in technology for achieving 4K/8K broadcasting.

The need for high-quality images is gradually increasing. Looking at the domestic TV set market, with the growing demand for large screen sizes, the shipment of 4K TV sets in 2013 was favorable, approximately 270 thousand units, and the rapid expansion is expected to continue. In addition to TV sets, introduction of 4K-supporting equipment (cameras, professional projectors, etc.) into the market is increasing. A growing number of packages are produced in 4K for content that can be viewed on game machines and through the Internet. With the release of smartphones that can shoot 4K video, 4K products have started to be introduced into consumer markets, as well as professional markets.

## (5) POF Technology

The current status and progress of the POF physical layer standardization proposal in IEEE802.3 was outlined. That is, in an IEEE802.3 meeting held in March 2014, a proposal was made to start discussing the standardization of the physical/link layer of Gigabit Ethernet over a large-diameter SI-type Plastic Optical Fiber (POF) (GEPOF) and it was agreed by a majority of votes. Following the agreement, a Study Group (SG) was established to prepare a Task Force (TF) for compiling a draft standard. In addition, the 2014 International Conference on Plastic Optical Fibers (ICPOF) was held at Hiyoshi Campus of Keio University for three days from October 8 (Wednesday) to 10 (Friday), 2014. It had 129 participants from 13 countries with 75 presentations including posters and technology exhibitions from 14 organizations. The presentations are outlined in the report.

## (6) Market/Industry

Continuous surveys have been conducted on the latest trends in the market and industry with the intention of creating technical papers based on up-to-date information. To be more specific, the trends concerning communications were investigated in the Communications White Papers, scientific meetings and consortiums, and the trends in the 4K/8K market were studied.

### • Communications White Papers

The FY 2014 White Paper on Information and Communications in Japan was released in July by the Ministry of Internal Affairs and Communications (MIC). It consists of two parts: Part 1 features a special theme, "The Global Paradigm Shift Caused By ICT" and Part 2 is a summary, "Current State of ICT and Policy Trends." Part 2 presents the latest status of ICT in Japan based on the statistics

of approvals and tasks conducted by MIC in fiscal 2013, which has been updated every year.

### • 4K/8K Market

On September 9, 2014, MIC released an "Interim Report on 4K/8K Roadmap Follow-up Meetings." In summary, the 4k/8k broadcasting schedule will be moved up. Test broadcasting will start in 2014, 4K full-scale broadcasting in 2016, and 8K full-scale broadcasting in 2020.

## 2.4 Optical Fiber Sensors Subcommittee

International standardization of optical fiber sensors was discussed by IEC/TC 86/SC 86C/WG 2. "Generic Specification" (61757-1) covering optical fiber sensors was compiled as IEC 61757-1 in 1998. After that, the activity of WG2 was suspended. But at the TC 86 Queretaro meeting in Fall 2012, WG 2 revived and resumed discussion. In Japan, the Institute of Electronics, Information and Communication Engineers (IEICE) is responsible for TC 86. For WG 2, OITDA, who conducted a feasibility study on its establishment, is responsible, with the approval of the TC 86 Joint Committee. In fiscal 2013, the Optical Fiber Sensors Subcommittee was established under the OITDA Fiber Optics Standardization Committee. Its purpose is to serve as a domestic committee (mirror committee) of IEC/TC 86/SC 86C/WG 2, and to reflect Japan's opinions in the creation of international standards and actively publish Japanese technologies (Table 3).

Table 3 Activities of IEC Meeting in FY2014 (TC 86/SC 86C/WG 2)

Date	Place	Documents
Nov. 4-5, 2014	TOKYO	IEC61757-2-1/Ed1: Fibre optic sensors - Part 2-1: Strain measurement-Strain sensors based on fiber Bragg gratings IEC 61757-3-1/Fiber optic sensors Part3:Distributed temperature sensing
Mar. 19-20, 2015	San Luis Obispo	IEC61757-1/Ed2 86C/1059/FDIS IEC61757-2-1/Ed1: Fibre optic sensors - Part 2-1: Strain measurement-Strain sensors based on fiber Bragg gratings IEC 61757-3-1/Fiber optic sensors Part3:Distributed temperature sensing

### 2.4.1 Status of Standardizing FBG Strain Sensors

Following the Generic Specification of optical fiber sensors compiled in 1998, it has been decided that Strain measurement (61757-2) will be documented. Distortion measurement is divided into multiplexed point sensing and distributed sensing. The document covers multiplexed point sensing of FBG. IEC 61757-2-1/Ed11: "Fibre optic sensors - Part 2-1 : Strain measurement - Strain sensors based on fibre Bragg gratings" defines optical and environmental characteristics and durability, and specifies an evaluation method. The rule only for multiplexed point sensing does not cover long FBGs for OFDR, and systems and FBG measuring instruments using FBG strain sensors. Many comments submitted before the Tokyo meeting were from FBG manufacturers, and in particular, most of them were on methods for measuring durability and methods for fixing FBG during characteristic evaluations. The comments from Japan, the largest in number among the participating countries, were reflected in the opinions of the Optical Fiber Sensors Subcommittee. The document draft was compiled by Habel from Germany, which was the convenor country, as the standard for their domestic organizations. However, almost all comments from Japan were approved, and opinions in Japan were thus reflected in the document. The third CD will be held at the Tokyo meeting, and transition to CDV will be approved at the San Luis Obispo meeting. The voting results will become clear by the meeting in Autumn 2015.



## 2.4.2 Status of Standardizing Distributed Temperature Sensors

The documents of IEC61757-3 is concerned with Distributed Temperature Sensors (DTS), which include distributed sensors using Brillouin scattering and Rayleigh scattering, as well as sensors based on Raman scattering. It also specifies their performance and test methods. In recent years, DTSs have been used widely to develop oil fields, to monitor the temperatures of power cables and to detect fire at plants, which has raised expectations for standardization. Since the submission from an NP (proposal) in November 2012, many comments have been made by the United States, Russia, France, Germany, Switzerland, and Japan on NP, 1st CD, and 2nd CD. Japan, in particular, has submitted a large number of comments, most of which have been reflected. The comments on the 2nd CD were discussed at the Tokyo meeting. The current project leader, Daum (Germany), is preparing a CDV. Therefore, at the San Luis Obispo meeting in the spring of 2015, there may be an argument over the CDV. As the CDV is published in the near future, the voting results will become clear by the meeting in Autumn 2015.

## 3. Optical Fiber Standardization Meeting

This meeting carries out studies and research in order to standardize domestic optical fibers, with the aim of maintaining compatibility between optical fiber-related parts and devices, and securing economic viability and reliability for optical fibers. The meeting is setting up JIS standards to be compatible with the latest international standards. The meeting is also striving to be consistent with the IEC in terms of document format. The meeting always pays attention to the trends in the optics industries in Japan and overseas in order to carry out timely standardization.

### 3.1 Examinations related to Polarization-maintaining Optical Fiber

This fiscal year, the meeting took the initiative in making existing JIS standards consistent with the IEC standards, in an effort to promote standardization of polarization-maintaining optical fiber. To be more specific, the meeting supported IEC standardization activities for JIS C 6873 "Polarization-maintaining optical fiber," JIS C 6840 "Polarization crosstalk measurement in optical fiber," and JIS C 6872 "Beat length measurement of polarization-maintaining optical fiber."

### 3.2 Examinations related to Standardization of Optical Fiber

This fiscal year, the meeting considered revising the existing JIS standard to promote standardization of optical fiber. It continued its discussion on bare optical fibers and test procedures from the previous fiscal year to make the following JIS consistent with international standards: JIS C 6837 "All plastic multimode optical fiber," and JIS C 6827 "Test methods for chromatic dispersion of optical fiber." In addition, the meeting conducted activities for revising the existing JIS to reflect the revisions to optical fiber standards that are underway at the IEC. Specifically, it continued creating a revised draft of JIS C 6835 "Silica glass single-mode optical fiber," which it started in the last fiscal year, to be consistent with the revision to IEC 60793-2-50.

With regard to the revision to JIS C 6837, the corresponding international standard is IEC 60793-2-40:2009, Optical fibres - Part 2-40: Product specifications - Sectional specification for category A4 multimode fibres, which was published as the Third Version in 2009. This standard specifies step-index bare optical fiber that uses plastic for cores and cladding and graded-index bare optical fiber.

As for the revision to JIS C 6827, following the publication of the corresponding IEC 60793-1-42 Optical fibres - Part 1-42: Measurement methods and test procedures - Chromatic dispersion as Ed.3.0 by IEC SC86A WG 1, activities were conducted to modify JIS C 6827 based on IEC 60793-1-42 Ed.3.0. This standard specifies the chromatic

dispersion test methods for silica-based single mode optical fibers, silica-based graded-index multimode optical fibers, and all plastic graded-index multimode optical fibers.

During the review to revise JIS C 6835, following the revision to the referred standard, IEC 60793-2-50 Optical fibres - Part 2-50: Product specifications - Sectional specification for class B single-mode fibres, activities continued from the previous fiscal year to modify JIS C 6835. JIS C 6835 corresponds to the international standard IEC 60793-2-50 Ed.3.0. In the last fiscal year, activities targeted Ed.4.0 as the corresponding international standard. However, as a revision to Ed.5.0 was expected this fiscal year based on detailed monitoring of the trends in standardization activities at the IEC, tasks were conducted with reference to an Ed.5.0 draft (CDV), which were not formerly issued, so that when Ed.5.0 is published, JIS C 6835 can be modified as soon as possible. This fiscal year, the JIS C 6835 draft will be completed, and an application is scheduled in Category B in the fiscal 2015 JIS Draft Public Application System.

### 3.3 Examinations related to Standardization of Optical Fiber Cable

The IEC/SC 86A/WG 3 is currently revising IEC 60794-1-2 "Optical fibre cables - Part 1-2: Generic specification - Basic optical cable test procedures," which corresponds to JIS C 6851, in preparation for publishing its Ed.3.0. In response to this revision, the meeting has been revising the existing JIS since last fiscal year, to reflect the revisions made by the IEC to optical fiber testing methods. Concretely, based on the IEC 60794-1-2 draft that is now being revised, prior to the review of the individual test procedures, the meeting is examining the necessity for JIS standardization of the new test procedures from the viewpoint of whether they are applicable in Japan, and carrying out English-to-Japanese translation for items that were judged as needing JIS standardization. In addition, the progress so far was summarized.

### 3.4 Domestic Movements Concerning Optical Fiber Installation Technology

According to the press release on September 25, 2014 by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), the ministry has started a technical review of installing optical fiber cables under roads, which is restricted in Japan. To quote the release, a review committee has been established for the following purposes.

Utility poles have been eliminated from the viewpoint of improving disaster prevention on a road, securing a safe and comfortable sidewalk space, forming good landscape, and promoting tourism. With an eye toward the 2020 Tokyo Olympic Games, further cost reduction and standards relaxation are required to promote further development. To resolve technical issues, the "Technical committee for researching low-cost technology instead of poles for electric power cables, telecommunication cables and CATV cables (tentative name)" was established. Discussions are being held in cooperation with the relevant authorities including the Ministry of Internal Affairs and Communications (MIC), the Ministry of Economy, Trade and Industry (METI), and relevant organizations including communications providers and electric companies under the leadership of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). The chairperson of OITDA's Optical Fiber Standardization Meeting is participating in the discussion. The National Institute for Land and Infrastructure Management (NILIM) has conducted an experiment to verify the characteristic changes in cables when burying them at a depth shallower than the current standard.

### 3.5 Trends in International Standardization

In response to advances in optical fiber technology, the IEC and ITU-T, international standardization organizations related to optical fiber, are steadily updating their standardization. In order to set and revise JIS

on a timely basis, this meeting reports on the discussions held in each organization as necessary. The organization related to optical fiber at the IEC is TC 86/SC 86A, under which there are WG 1 (optical fiber) and WG 3 (optical fiber cables). The organization related to optical fiber at ITU-T is SG15 (Optical transport networks and access network infrastructures), under which there is WP2 (Optical access/transport network technologies and physical infrastructures), which includes Q.5 (Characteristics and test methods of optical fibers and cables) and Q.16 (Optical physical infrastructure and cables).

### 3.5.1 Trends in Standardization related to Optical Fibers

At an IEC/SC 86A/WG 1 Tokyo meeting held in November 2014, the following issues on optical fibers were reviewed.

#### (1) Establishment of new documents

Japan acted as the Project Leader (PL) for the standards for polarization-maintaining optical fiber products and their measurement methods and reported on the status of proposals. Concerning beat length measurement, basic agreement was reached to select the phase beat length measurement as an RTM. It was also confirmed that the power ratio method for polarization crosstalk measurement, which was proposed by Japan, will be described as an RTM. Based on these discussions, it was agreed that NP documents would be circulated.

#### (2) Revision of existing documents

Regarding the standards for optical fiber products, an outline of the optical fiber product standard, the plastic clad multimode fiber (Category A3) standard, and a proposal for changing the 200  $\mu\text{m}$ -coating diameter fiber standard were discussed. There were deliberations on modifications to the method of measuring the dimensions of optical fibers as optical fiber measurement standard, as well as stress corrosion susceptibility (fatigue coefficient), transmission loss, MFD, bandwidths, and chromatic dispersion.

### 3.5.2 Trends in Standardization related to Optical Fiber Cables

At the IEC/SC 86A/WG 1 Tokyo meeting held in November 2014, the following issues on optical fiber cables were reviewed.

#### (1) Establishment of new documents

Regarding optical fiber cable product standards, the standard for indoor breakout cables with connectors and specifications for an optical cable family for emergency deployment/recovery were discussed.

#### (2) Revision of existing documents

For the general rules, deliberations were held on the test methods and procedures for optical fiber cables, and the standards for optical fiber cable products, indoor optical fiber cables, outdoor optical fiber cables, ducts/direct burial outdoor optical fiber cables, self-supporting aerial outdoor optical cables, outdoor optical fiber cables laid inside sewer pipes, outdoor optical fiber cables laid inside gas pipes, outdoor optical fiber cables laid inside water supply pipes, and aerial optical fiber cables laid along power transmission lines, and ADSS.

#### (3) New proposals

Regarding an optical fiber ribbon, which is one of the elements of current cables, outdoor cable sectional specifications are mainly defined in IEC 60794-3. Other cable structures such as indoor cables are described in each document with reference to IEC 60794-3. The convenor proposed that, given the circumstances in which ribbons are actively used for indoor cables, they should be able to be referred to in a more generalized manner. As a result of discussion, it was agreed that a new documents on optical fiber ribbons would be established as IEC 60794-1-3.

## 4. Optical Connector Standardization Meeting

Domestic communication network traffic is continuing to grow rapidly by over 30% per year. As optical communications networks using optical

fibers as transport media serve as the infrastructure of communications networks, optical connectors, which connects optical fibers, are optical components that are used in the greatest quantities in optical communications equipment. Thus their standardization is extremely important from the viewpoint of configuring interfaces with communications devices and transmission lines.

When revising and setting the JIS standards, it is assumed that they would be made consistent with their corresponding IEC standards, based on the WTO/TBT Agreement. This eliminates the need to add product specifications and test/measurement methods, and facilitates the international distribution of optical connectors and optical devices using optical connectors. However, due to differences between the standardization systems adopted by both standards, this meeting has been reviewing the existing JIS standardization system and making it consistent with the IEC standardization system. We will continue to work on making each JIS standard consistent with IEC standards, and also make proposals for IEC standardization and carry out JIS standardization while studying the technological trends of next-generation new optical connectors and conducting technical verification as required.

### 4.1 Meeting Investigation Policy

The meeting intentionally uses standardization to reduce numbers, simplify the components, and provide proper order for optical connectors, to ensure convenience, efficiency, fairness, and advancement in economic and social activities related to optical connectors, and safety, health, and environmental protection in production and the use of optical connectors. Furthermore, it identifies the optic connector (technology) as a general use product (technology) and works to secure compatibility.

- Convenience: Assuring compatibility
- Efficiency: Mass production through reductions in product variations
- Fairness: Assuring benefits to consumers
- Advancement: Acquisition of new knowledge and supporting the development and spread of new technology

The following points should be considered as criteria for JIS standardization.

- (1) It is an optical connector (technology), which is identified as a general-purpose product (technology) installed in products such as systems and apparatus that are manufactured or sold by several companies.
- (2) It is an optical connector (technology) with sufficient technical information available to formulate a JIS standard.
- (3) There is no patent-related issue when used under normal circumstances.

The meeting will expedite the formulation of a JIS standard in the case where an optical connector (technology) was developed in Japan and is widely used overseas; furthermore international standardization such as IEC standardization is in progress. Also, if an optical connector (technology) is already assigned to a JIS standard but not to an IEC standard, the meeting will carry out a careful examination to determine if it requires an IEC standard. Then, the meeting will make a proposal to the IEC as appropriate. On the other hand, if an optical connector (technology) is already assigned to an IEC standard but not to a JIS standard, the meeting will conduct a careful examination to determine if it requires a JIS standard. Then, the meeting will promote JIS standardization when appropriate. Lastly, the meeting will formulate OITDA standards for optical connector (technology) as necessary when its JIS and IEC standards are cancelled, or when it has not yet been assigned to an IEC standard.

## 4.2 Outline of Meeting Activities

The Optical Connector Standardization Meeting is organized into several Working Groups (WGs) to deal with many issues on document drafts, research and study efficiently and smoothly. Each WG discusses the documents to be created, and research and study intensively and in detail. They are then discussed by the entire meeting. In this fiscal year (FY 2014), as in the previous fiscal year, two WGs were formed: WG 1 (multicore optical connectors, test and measurement method) and WG 2 (single core optical connectors). The organization of and work allocations to the working groups are shown in Table 4.

This fiscal year, the main activities of the meeting were a survey and discussion of document drafts for JIS proposals and IEC standardization proposals. Thus it created drafts for the items from the previous fiscal year and the application items in this fiscal year toward the amendment and enactment of JIS standards. Furthermore, liaison activities for the organizations closely associated with this meeting were also conducted.

Investigations for standardization and liaison activities which were carried out in this fiscal year are as follows.

### (1) Investigations for the Standardization of Optical Connectors

- Investigations for standardization of the general rules for optical connectors
- Investigations for standardization of individual standards for optical connectors
- Investigations for standardization of mechanical interface standards
- Investigations for standardization of optical interface standards
- Investigations for standardization of test and measurement procedures

### (2) Liaison Activities

- Liaison activities with IEC
- Liaison activities with JIS Optical Passive Components Standardization Meeting
- Liaison activities with T Project 2

Table 4 The Organization of and Work Allocations among the Working Groups

WG	Contents	Members
WG 1	<ul style="list-style-type: none"> <li>• Drafting and alignment to international standard of multicore interface standard, performance standard, optical interface standard and test and measurement procedure standard</li> <li>• Survey and research for strength test</li> </ul>	Shibuya (Leader), Yoita, Kato, Kamada, Suematsu, Shimazu, Nakamura
WG 2	<ul style="list-style-type: none"> <li>• Drafting and alignment to international standard of single core interface standard, performance standard, reliability and optical interface standard</li> <li>• Survey and research for measurement of angular misalignment of fiber insertion hole and cleaning end face</li> </ul>	Yamauchi (Leader), Taira, Ohkubo, Hojo, Nakazuru, F. Yoshida, Asakawa, (Observer: Isono)
Liaison	Liaison Activities with Other Committees and Meeting	IEC/TC 86/SC 86B
		Optical Passive Components Standardization Meeting
		T Project 2

## 5. Optical Passive Components Standardization Meeting

The Optical Passive Components Standardization Meeting prepares proposals to standardize new optical passive components, prepares proposals to revise existing JIS, conducts surveys and investigations on test and measurement procedures for optical passive components as well as JIS performance standards, and conducts surveys on international standardization trends. This fiscal year, the meeting has set up three working groups (WGs), held nine meetings, and engaged in standardization activities.

### 5.1 Standardization related to Generic Specifications, Optical Components and Elements, Reliability and High-power Assessment (WG 1)

WG 1 has been preparing a draft of JIS general principles, and responding to the comments made on the IEC generic specification document. Following discussions at the Standards Coordination Subcommittee and the Electronics Technical Committee, JIS C 5877-1 (Polarizer - Part 1: Generic specification) was adopted. The working group submitted a revised draft of JIS C 5920-1 (Fiber optic passive power control devices - Part 1: Generic specification) to the Japanese Standards Association (JSA), and following the discussions by the Standards Coordination Subcommittee, made a proposal to the Ministry of Economy, Trade and Industry (METI) through the JSA. It prepared revised drafts of Fiber optic WDM devices - Part 1: Generic specification and Fiber optic switches - Part 1: Generic specification, and submitted them to the JSA. In response to the IEC generic specification deliberation documents, the working group proposed organizing common terms and specifying basic terms associated with IEC generic specifications, and prepared comments on revisions to the optical switch generic specification, non-wavelength-selective fiber optic branching devices, optical filter generic specification and optical circulator, and also

proposed modifications to the issues associated with JIS revision.

### 5.2 Standardization related to Test and Measurement Procedures (WG 2)

WG 2 continued to carry out JIS documentation of the test and measurement methods for optical passive components, based on the IEC 61300 standards series, and following discussions at the Standards Coordination Subcommittee and the Electronics Technical Committee, JIS C 61300-1 (Fiber optic interconnecting devices and passive components - Basic test and measurement procedures-Part 1: General and guidance) was adopted. It submitted a proposal to the JSA to adopt JIS C 61300-3-38 (Fiber optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-38: Examinations and measurements - Group delay, chromatic dispersion and phase ripple), and following discussions by the Standards Coordination Subcommittee, made a proposal to METI through the JSA. It prepared JIS drafts of Fiber optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-21: Examinations and measurements - Switching time and Fiber optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-50: Examinations and measurements - Crosstalk for optical switches, and submitted them to the JSA. In response to comments on IEC circulation documents, and revision/preparation of IEC 61300 standards series documents, the working group supported Japan IEC members.

### 5.3 Standardization related to JIS Particular Standards and IEC Performance Standards (WG 3)

WG 3 prepared drafts for JIS particular standards, proposed drafts for IEC performance standards, and responded to comments on circulation documents. Following discussions at the Standards



Coordination Subcommittee and the Electronics Technical Committee, JIS C 5910-3 (Non-wavelength-selective fiber optic branching devices - Part 3: Non-connectorized single-mode 1xN and 2xN non-wavelength-selective branching devices) was adopted. It has started preparing a proposal to adopt JIS C 5914-3 (Optical circulators - Part 3: Non-connectorized single-mode fiber optic circulators) and JIS C 5920-3 (Optical power control devices - Part 3: Non-connectorized single-mode fiber electrically controlled variable optical attenuator). Regarding the performance standard proposal by the IEC, it supported making proposals to the IEC through IEC domestic members on the preparation/proposal of new documents, comment responses, document modification, and validation of specifications in documents under discussion.

#### 5.4 Trends in International Standardization (Trends in IEC Deliberations)

IEC/TC 86/SC 86B promotes the standardization of optical fiber connecting devices (optical connectors, fiber management systems, closures, splices, etc.) and optical passive components. This fiscal year, meetings were held in Ixtapa (Mexico) in May, and in Tokyo (Japan) in November.

##### (1) Optical passive components (WG 7)

WG 7 reviews the generic specifications, performance standards, reliability documents and technical reports. This year, regarding generic specifications, optical switch generic specifications (Version 5) and dispersion compensator generic specifications (Version 3) were published. Regarding performance standards, 1xN/2xN optical branching devices (Category C), 1xN/2xN optical branching devices (Category U), 1xN/2xN optical branching devices (Category O), pigtail OTDR reflective devices (Category C), plug OTDR reflective devices (Category C), pigtail electrically controlled variable optical attenuators (Category C), 1x2/2x2 single-mode optical switches (Category C), and middle-scale 1xN DWDM filters (Category C, Version 2) were published. Discussions mainly covered revisions to generic specifications and performance standards, and as of February 2015, the working group reviewed 10 circulation documents including maintenance documents (three documents on generic specifications, five documents on performance standards, and two documents on reliability).

##### (2) Test and measurement procedures (WG 4)

Test and measurement procedures are standardized under the 61300 series, and test and measurement procedures have been established for optical fiber connecting devices and optical passive components including optical connectors and closures. In that series, 61300-2 series describes test procedures, and 61300-3 series describes measurement procedures. Regarding optical passive component measurement methods, error and repeatability of the attenuation settings of a variable optical attenuator (Version 3), switching time measurement (Version 2), and spectral transfer characteristics of DWDM devices (Version 2) were published. As of February 2015, one revised document is being reviewed.

#### 5.5 Future Tasks

The meeting will continue to revise JIS generic specifications without delay, so they will always be consistent with the IEC generic specifications that have been revised or are being discussed at the IEC. Regarding application of JIS standardization to test and measurement procedures for the IEC 61300 standards series jointly conducted with the Optical Connector Standardization Meeting, the meeting will aim for an early enactment of the test and measurement items specified in JIS C 5901 (Test methods of passive devices for fiber optic transmission) and JIS C 5961 (Test methods of connectors for optical fiber cables) that must be maintained under JIS stipulations as a JIS C 61300 standards family. The meeting will also apply JIS standardization without delay to JIS individual standards for passive optical components, whose demand is expected to remain high in Japan, while making sure that the

JIS are consistent with the IEC standards. Moreover, the meeting will actively make proposals to address issues associated with IEC standards, as it discovers such issues while preparing drafts for JIS generic specifications, test and measurement procedures and individual standards. As it is important that the work of this meeting be reflected in international standardization, it will continue to make proposals to the IEC and reflect Japan's opinions, while maintaining coordination with the domestic IEC committee.

#### 6. Optical Active Device Standardization Meeting

Currently, various types of optical active equipment are widely used as key components in consumer devices such as video and audio, and industrial equipment such as information processing/optical transmission systems. Under the situation, promotion of standardization for optical active devices is imperative for reducing the equipment cost, maintaining the global competitiveness of the industry, and expanding the efficient use of the technology.

JIS standardization of major IEC standards on optical active devices has been almost completed. However, today, as new optical transmission systems are introduced one after another around the world, the IEC is discussing and enacting standards for new components, and it is thought that corresponding JIS standards will need to be established. The meeting has made it a basic policy to prepare JIS drafts to meet standardization needs, and undertake activities aimed at proposing new standards that will meet market demands, which were assessed through questionnaire surveys. In fiscal 2014, the meeting carried out activities based on the results of studies that have been carried out so far, while taking into consideration the trends in international standardization.

##### 6.1 Outline of Deliberations

###### 6.1.1 Creation of drafts for JIS standards

In fiscal 2014, it was decided to work to expedite JIS standardization in pace with the trends in international standardization by expanding reviews based on the results and issues of the previous fiscal year, creating specific standardization drafts, releasing OITDA standards and Technical Papers (TPs) as early as possible, and repeating questionnaire surveys if necessary. This fiscal year, six items were reviewed.

##### (1) Planning future standardization items (reviewing the need to standardize optical active components required for new optical transmission systems)

For surface emitting lasers and ROSA-type optical transceivers, and Transmitter/Receiver Optical Sub-Assemblies (TOSAs/ROAS) for ultra-high-speed transmission, for which standardization is underway by the IEC, including "Wavelength-tunable laser module for DWDM transmission performance standard template" and "Wavelength-tunable laser module for DWDM transmission measurement method" released as OITDA TPs in the last fiscal year, optical active components that need to be adopted in JIS will be investigated and the need will be surveyed, and guidelines for the future standardization activities will be created

##### (2) Semiconductor optical amplifiers

In cooperation with the IEC/SC 86C/WG 4 domestic committee and the Optical Amplifier Standardization Meeting, this meeting will proceed with creating standards on a performance specification template for semiconductor optical amplifiers and test/measurement methods that are compatible with the existing fiber amplifier standards.

##### (3) E/O and O/E devices for optical inter-connection

In addition to conducting JIS standardization on the performance specification template for an optical transmission/reception module for a single-fiber serial transmission link, for which the final draft was completed in the last fiscal year, the review of standards that will be required for multi-wavelength multiplex transmission/multi-channel



parallel transmission will continue.

#### (4) Optical transceivers for GPON/GEAPON-OLT/ONU

For the draft of the performance standard and test/measurement method for OLT/ONU optical transceivers for GPON, details of OITDA standardization (create technical papers) will be worked out. In addition, creating a JIS draft will be considered for the draft of the performance standard and test/measurement method for OLT/ONU optical transceivers for GEAPON, which was published as an OITDA/TP (Technical Paper) in the previous fiscal year.

#### (5) JIS support for “Laser modules used for telecommunication reliability assessment” (JIS C 5948)

For “Laser modules used for telecommunication reliability assessment” (JIS C 5948), which was introduced as a JIS standard the previous year, the meeting provides support so that a revised JIS draft that conforms to the corresponding international standard (IEC 62572-3) will be established promptly.

#### (6) JIS support for “Fiber optic active components and devices - Performance standard - Part 1: General specification” (JIS C 5953-1)

The meeting provides support for “Fiber optic active components and devices - Performance standard - Part 1: General specification” (JIS C 5953-1) so that a revised JIS draft that conforms to the corresponding international standard (IEC 62149-1) can be established promptly.

### 6.1.2 Trends in International Standardization

The international standardization organizations that are most relevant to the work of this meeting are SC 86C and SC 47E in the International Electrotechnical Commission (IEC). SC 86C is an SC under TC 86 that deals with fiber optics in general, including optical fibers and fiber cables, optical connectors, and passive optical devices, handles optical subsystems and active devices, specifically optical transmission subsystems, optical fiber amplifiers, and semiconductor devices/modules for optical transmission. The SC 47E group covers standardization of discrete semiconductor devices under TC 47 that deals with semiconductor devices in general, including ICs and LSIs. The scope of SC 47E includes normal electronic devices, as well as optical semiconductors.

### 6.2 Future Tasks

For active optical components, an advanced technology, it is desirable for this meeting to work with the JIS organization in a coordinated manner in the preparation of international standards, in order to expedite the preparation of JIS standards that correspond to international standards. Although not all of the items associated with the devices discussed by this meeting have been fully prepared yet as OITDA standards, we think it is important to make them available to associated parties as soon as they are ready.

Following proposals and discussions on standardization drafts for 40 Gbit/s ultra-high-speed optical transmission compact optical transceiver packages and surface emitting lasers at the IEC, there have been discussions on the necessity of the standardization of semiconductor optical amplifiers and wavelength-tunable laser modules, and optical integrated circuit packages. For the trends in and standardization need of these new active optical components, it is necessary to carry out activities so that JIS standardization will be achieved timely with conformity to international standards in mind.

On the other hand, some of the existing JIS standards, which are related to active optical components, have been used for more than 10 years, and they need revising due to technology expansion. Thus, the meeting should plan to undertake these revisions in a timely manner.

## 7. Optical Amplifier Standardization Meeting

Since the early 1990s, remarkable progress has been made in the development of optical fiber amplification technologies, especially the erbium-doped types. International standardization was undertaken by the IEC and CCITT (currently ITU-T) from September 1991 and February 1992 respectively. In Japan, the Optical Fiber Amplifier Standardization Committee was launched in FY 1994. In FY 2001, the committee was renamed the Optical Amplifier Standardization Committee, after the IEC extended its range of standardization to include Raman fiber amplifiers and semiconductor optical amplifiers, etc.

The two major activities of this committee are: (1) preparing JIS drafts by translating relevant standards while considering the IEC's situation with reviewing standardization and the domestic situation, and (2) grasping the trends in international standardization and submitting proposals in a timely manner via the relevant Japanese organizations.

### 7.1 Activities for Drafting JIS and Other Drafts

#### 7.1.1 Study of JIS Standardization

Two drafts of JIS and one Technical Report (TR), which this meeting prepared, were published after review by the Japanese Industrial Standards Committee.

- JIS C 6123-1: Optical amplifiers - Performance specification template - Part 1: Optical amplifiers for digital applications [Revised] (Published on March 20, 2015)
- JIS C 6123-4: Optical amplifiers - Performance specification template - Part 4: Optical amplifiers for multi-channel applications [Revised] (Published on March 20, 2015)
- TR C 0057: Optical amplifiers - Distributed Raman amplification [Released] (Published on August 1, 2014)

Furthermore, the meeting is planning to prepare the following two JIS drafts, which correspond to the following IEC standards, using JSA's JIS draft preparation system (FY 2014, Part B).

- IEC 61290-3-3 Ed.1.0: Optical amplifiers - Test methods - Part 3-3: Noise figure parameters-Signal to total ASE ratio [JIS Enactment]
- IEC 61290-10-5 Ed.1.0: Optical amplifiers - Test methods - Part 10-5: Multichannel parameters-Distributed Raman amplifier gain and noise figures [JIS Enactment]

The meeting will also start preparing the following drafts, which correspond to the following IEC standards and IEC/TRs.

- IEC 61290-4-3 Ed.1.0: Optical amplifiers - Test methods - Part 4-3: Power transient parameters - Single channel optical amplifiers in output power control [JIS Enactment]
- IEC/TR 61292-9 Ed.1.0: Optical amplifiers - Part 9: Semiconductor optical amplifiers (SOAs) [TR Publication]

#### 7.1.2 Study of the drafts of IEC technical reports (TR) and OITDA standards

The meeting studied the following items:

- IEC/TR draft (IEC/TR 61292-4) related to fiber fuses
- Measurement methods for gain parameters / IEC umbrella document draft (IEC 61290-1): document publication

Revised draft of IEC document (IEC 61290-1-1) related to measurement methods for gain parameters using an optical spectrum analyzer: CDV circulation

Revised draft of IEC document (61290-3-1) related to measurement methods for gain parameters using an optical power meter: FDIS circulation

- IEC TR draft (IEC/TR 61292-8) and new OITDA standard related to high-power optical amplifiers: CD circulation
- Performance template draft related to optical semiconductor amplifiers: CD circulation
- New document proposal related to test methods for gain transient

parameters for single channel optical amplifiers in gain control

- Draft of IEC technical report (TR) and new OITDA standard related to optical amplifiers for space division multiplexing optical fiber transmission

### 7.1.3 Other activities

The meeting checked the need to revise JIS C 6122-1-1:2011, JIS C 6122-1-2:2011, JIS C 6122-1-3:2011, JIS C 6122-3:2011, JIS C 6122-3-2:2006, JIS C 6122-5-1:2001, and JIS C 6122-11-1:2010. Furthermore, the meeting modified the translation table of terminology, which was created in the last fiscal year, and modified terms and added new terms as requested by JISC Electronics Technical Committee and JSA Standards Coordination Subcommittee, etc.

## 7.2 IEC Trend Survey and Collaboration for IEC Activities

The meeting surveyed trends in international standardization of optical amplifiers, with IEC/SC 86C/WG3, etc. Also, the meeting worked cooperatively with the domestic committee of IEC/TC 86.

### 7.2.1 Trends in Existing Documents

The following progress has been made.

- IEC 61290-1 Series (corresponding to JIS C 6122-1-1 to 1-3): As in the previous year, in response to the preparation of an umbrella document, the meeting reviewed the revised draft, which aims to make the umbrella document consistent with the existing two documents in this series.

IEC 61290-1-1 Ed.2.0 (corresponding to JIS C 6122-1-1) related to measurement methods for gain parameters using an optical spectrum analyzer: CDV circulated (Japan in charge)

IEC 61290-1-3 Ed.2.0 (corresponding to JIS C 6122-1-3) related to measurement methods for gain parameters using an optical power meter: FDIS circulation completed (Japan in charge)

- IEC 61290-4-1 Ed.1.0 (JIS C 6122-4-1) Gain transient parameters - Two-wavelength method: Discussing a revised draft that reflects modifications proposed by Japan: CD circulated
- IEC 61291-2 Ed.4.0 (JIS C 6123-1) Performance specification template - single-channel optical amplifiers: Discussing a revised draft that is intended to integrate the performance specification templates for optical fiber amplifiers and semiconductor amplifiers: CD circulated (Japan in charge)
- IEC 60291-5-2 Ed.2.0 (corresponding to JIS C 6122-5-1): Quality evaluation standard - Reliability assessment of optical fiber amplifiers: Describing the classification of test conditions according to weights with considerations given to the trend towards the miniaturization of optical amplifiers: CD circulated

### 7.2.2 Trends of New Documentation

The following progress has been made. For “(1),” and “(4)” to “(6).” this meeting had active discussions, gave a liaison report at an IEC meeting, and productively lead discussions.

- (1) IEC 61290-1: Optical power and gain parameters (gain parameter measurement method/umbrella document): IS issued (Japan in charge)
- (2) IEC 61290-4-3: Optical amplifiers - Test methods - Part 4-3: Power transient parameters - Single channel optical amplifiers in output power control: CDV circulated
- (3) IEC 61290-10-5 Optical amplifiers - Test methods - Part 10-5: Multichannel parameters – Distributed Raman amplifier gain and noise figure: IS issued
- (4) IEC/TR 61292-8: Optical amplifiers - Part 8: High power amplifiers: NP circulation scheduled (Japan in charge)

In addition, the meeting is planning to prepare the following new

documents:

- (5) Measurement methods for gain parameters for gain control single-wavelength amplifiers (Japan in charge)
- (6) Optical amplifiers for space division multiplexing optical fiber transmission

## 8. Optical Subsystem Standardization Meeting

IEC/TC 86/SC 86C/WG 1, which is a working group belonging to an international standardization organization, is working on the standardization of the physical layer of optical communication systems and subsystems, attempting to establish optical system design guidelines, and standardizing test methods involving optical systems (general systems, digital systems, optical cable facilities and optical links). The meeting has been supporting the standardization activities of SC 86C / WG1, and has been proceeding with JIS standardization of published IEC standards that are in great demand in Japan. Also, in order to more proactively promote Japan's leading technologies to the IEC, the meeting had been investigating new technologies and providing support in the preparation of contribution documents. In fiscal 2014, the meeting actively processed the JIS standardization of optical subsystems, and provided proposals/support for international standardization.

The achievements made in this fiscal year are summarized as follows:

- (1) The meeting made progress in the preparation of the JIS draft, for which it translated the IEC standards related to optical subsystems.

- IEC 61280-4-4: Polarization mode dispersion measurement for installed links:

The JIS draft was submitted to the Japanese Standards Association (JSA) in October 2014 and discussed by the Standards Coordination Subcommittee in January 2015.

- Revision of JIS standards

Started revising the following two standards, which are five years old, and an application was made in November 2014 to the JIS draft preparation system.

- JIS C 61280-1-3: Center wavelength and spectral width measurement (WG4)
- JIS C 61280-2-2: Optical eye pattern, optical waveform, and extinction ratio measurement (WG6)

- (2) The meeting continued to revise the existing translation reference list of technical terms for the unification of technical terms used in JIS standards. As a result, nine new terms that appeared in the standards translated this year were added to the list, and two terms were modified. The final list included a total of 323 terms that were translated into Japanese.

The revised technical terms list was provided to the IEC Translation Sharing WG, which has been set up under the Planning and Coordination Subcommittee of the Fiber Optics Standardization Committee. Hereafter, the meeting will continue to cooperate in building an optical technical glossary, with the aim of publicizing it on the web.

- (3) The meeting has been sending its members to the meetings to cooperate in international standardization by IEC/TC 86/SC 86C/ WG 1. The meeting attended two meetings held in Milpitas and Tokyo this fiscal year. The major contributions Japan made are as follows.

- Measuring eye diagrams and Q-factor using a software triggering technique for transmission signal quality assessment (IEC 61280-2-12): A method to evaluate optical transmission signal quality using asynchronous sampling through software triggering, which was proposed by Japan, was published in May 2014.
- Revision of the single-mode attenuation and optical return loss measurement (IEC 61280-4-2): It was decided to put the revised version that reflected comments from Japan into FDIS circulation.

- Optical eye pattern, optical waveform, and extinction ratio measurement (IEC 61280-2-2): Japan pointed out an imperfection that was found during the JIS translation. It was decided to determine measures by the next meeting.

## 9. Optical Measuring Instrument Standardization Meeting

The meeting continued its work from last year to review international standards and revise JIS drafts, to enact JIS standards that are consistent with international standards.

### 9.1 Trends in International Standardization (IEC/TC 86/WG 4)

At the Tokyo meeting held in November 2014, one document (IEC 62129 -1 Ed.1.0) was discussed for which Japan was the Project Leader (PL). This document was submitted to the meeting after discussions on its handling at the Optical Measuring Instrument Standardization Meeting and approval by the domestic committee of the IEC/TC 86. The Tokyo meeting deliberated on the comments to CD document version 3 that was published in June 2014. As most of them were editorial comments, it was agreed to make modifications accordingly and publish a CDV document.

At the general meeting of WG 4, reported were the start of revisions to two existing standard documents (End-Face Image Analysis Procedure for the Calibration of Optical Fibre Geometry Test Sets (61745 Ed.1)) and Calibration of fibre-optic power meters (61315 Ed.2)), the status of the document under discussion in SC 86C/WG 1 (determination of the uncertainties of attenuation measurements in fibre plants (IEC/TR 61282-14)), and the activities of each SWG.

### 9.2 Deliberations on the Revision of the JIS Standard for "Test methods of OTDR"

This fiscal year, in addition to examining the draft prepared in the last fiscal year with the intention of raising the level of perfection, the meeting revised the draft taking into account consistency with the results of the review of the expression of uncertainty in the "optical wavelength meter test method." Moreover, the meeting made an application to the JIS draft preparation system (FY 2015, Term A) to abolish JIS C 6185 "Test methods of optical time domain reflectometers (OTDR)" and establish JIS C 6185-1 "Optical Time Domain Reflectometers (OTDR) - Part 1: Test Methods."

The major revisions to the draft of the previous fiscal year are as follows:

- (1) To be consistent with the international standard, the setting of the group refractive index for converting delay time to distance has been changed from 1.500 to 1.460.
- (2) The method of measuring the distance scale deviation and distance offset in the distance accuracy (uncertainty) test has been changed from fitting based on the least squares approximation to two-point (short distance and long distance) measurement to simplify measurement.
- (3) The distance scale deviation and distance offset are parameters indicating the deviations for each product. Taking the range of these parameters as values that insure the accuracy of the overall products, variations in the values between products are now used as reference values for accuracy in the product specifications.
- (4) The distribution of the deviations observed in the individual uncertainty test is thought to indicate an almost uniform distribution (with no extreme deviations) within the range of the allowable operating environment. Therefore, the deviations under each operating condition are no longer added up and now treated as partial uncertainty.
- (5) The method for the reflectance test has been changed to one in which deviations due to differences in the back scattering light reflectance

of different fibers do not have any effect.

Following the above revisions, the glossary of terms and list of titles have been changed and annexes have been added.

### 9.3 Deliberations on Revisions to "Calibration of Optical Spectrum Analyzers"

The IEC committee has been revising the international standard IEC 62129 "Calibration of optical spectrum analyzers," which was established in 2006, and its revised version, IEC 62129-1 Ed.1.0: "Calibration of wavelength/optical frequency measurement instruments - Part 1: Optical spectrum analyzers," was published in July 2013 as a CD2 document. In line with this revision work, the Optical Measuring Instrument Standardization Meeting has been revising JIS C 6192 "Calibration of optical spectrum analyzers" from FY 2011, which was translated from IEC 62129. However, as substantial revisions were made to the above CD2 document, and its revised version was expected to be published as a CD3 document, the meeting temporarily stopped compiling the draft, and decided to resume work after publication of the CD 3 document. As the CD 3 document that reflected the above modifications was published in June 2014, the meeting resumed revision of JIS C 6192, extracting the difference between the above CD 3 document and the current IEC 62129-1 document, and proceeded with preparing a revised draft that reflects the differences on the current JIS C 6192. Then, in February 2015, a CDV document that is a further revision of the above CD3 document was published. Since there were only minor revisions in this CDV document, a final revised draft was prepared that reflected the revisions in the CDV document.

### 9.4 Deliberations on Revisions to "Test Methods for Fiber-Optic Spectrum Analyzers"

The meeting started revising JIS C 6183 "Test methods for fiber-optic spectrum analyzers." This fiscal year, it examined the content of the current JIS standard and extracted where revisions need to be considered. Major revisions are as follows:

- (1) In "Outline of Test," a general method of calculating an uncertainty has been described so that accuracy can be obtained from the uncertainty. In addition, a test for evaluating uncertainties has been added in the "wavelength" and "power level" tests, and an annex (Annex A), which explains the definition of an uncertainty, has been appended.
- (2) The accuracy of the light source wavelength listed in [Table 1](#) in "Wavelength Test" has been enhanced to 0.001 nm. Since at that degree of accuracy, the difference between the wavelength in air and the wavelength in vacuum is obvious, wavelengths have been represented as "wavelengths in vacuum".
- (3) An annex (Annex B) has been added to precisely evaluate optical power per unit wavelength of wavelength-continuous light that specifies the resolutions used for evaluation and describes the measurement method.

In addition to the above items, the following item has also been revised.

- (4) For "Strength Test," since JIS C 1003, which it refers to, has been abolished, the reference has been changed to the JIS C 60068-2 "Environmental testing - Electricity and electronics" series, and the content of the test has been changed accordingly.

### 9.5 Deliberations on Revisions to JIS "Optical wavelength meters - Part 1: Test methods"

The meeting made corrections to the revised draft, based on discussions carried out up to the previous fiscal year on JIS C 6187 "Test methods for optical wavelength meters" and completed the draft after interim checks by the JSA. This draft was submitted to the JSA in February 2015. The revisions are as follows:



In the uncertainty evaluation under the operating conditions corresponding to an individual error test in the present JIS, it is possible to calculate a mean deviation for each operating condition (wavelength dependency, temperature dependency, power level dependency, etc.). However, after a re-examination of the validity of obtaining an overall deviation by adding up deviations, it has been decided that  $1/\sqrt{3}$  of the maximum deviation is calculated as the standard uncertainty without the mean deviation. Moreover, the “accuracy,” which is the “error limit,” is represented as  $k \cdot u$  ( $k$ : Coverage factor;  $u$ : Standard uncertainty), with  $k$  selectable between 2 and 3 according to the level of confidence. In addition, the method for estimating the “accuracy” was described in a note as a reference for cases where it is necessary to evaluate it as a product specification. Specifically, it has been decided that it is allowable to use  $1/\sqrt{3}$  of the maximum deviation obtained from a test on several optical wavelength meters as the standard uncertainty for a possible range of deviations, and include the standard uncertainty in an “accuracy.” As the accuracy of an optical wavelength meter is at the level of ppm, the percentage representation of the accuracy has been removed. The humidity under standard test conditions has been changed to  $50\% \pm 20\%$  with consideration given to the actual conditions of test fields, and it has been confirmed that the change does not significantly affect the uncertainties.

## 10. TC 76/Laser Safety Standardization Meeting

### 10.1 Outline

This fiscal year, the meeting conducted international standardization in response to IEC/TC 76 as a commissions project, the details of which is described in Chapter 16. This chapter focuses on JIS standardization discussions on laser safety.

### 10.2 JIS standardization discussions

For revision of JIS C 6802 “Safety of laser products” that conforms to IEC 60825-1 Ed.3, the meeting prepared a draft in the previous fiscal year based on an FDIS of IEC 60825-1 Ed.3, and following the discussions by the JSA Standards Coordination Subcommittee, submitted the modified draft to the JSA.

For the task of revising JIS C 6802 in this fiscal year, the meeting started by reflecting the differences from an FDIS of IEC 60825-1 Ed.3 published in May 2014 in the JIS draft. After submission, the JIS draft was discussed by the JISC Electronics Technical Committee in June, at the same time released for 60 days from June to August on the JISC Web site based on the WTO/TBT Agreement, and following final modifications to the description, announced in September. The JIS was established ten months after the JIS application, or four months after the publication of the IEC standard, which set a record in the history of revisions to JIS C 6802 “Safety of laser products.”

### 10.3 Future Tasks

IEC 60825-1 Ed.3 includes some inadequate explanations. However, for timely publication, it was agreed at TC 76 that an Interpretation Sheet (I-SH) would be issued as a supplement. As of the end of fiscal 2014, the I-SH is still under discussion. When the IEC issues an I-SH, Japan also needs to make additional revisions in the form of JIS C 6802: 2014 annex. Moreover, the necessity of publishing errata will be discussed.

## 11. ISO/TC 172/SC 9 Standardization Meeting

This meeting compiles domestic opinions and reviews draft international standards proposed by ISO/TC 172/SC 9 (composed of WG 1: Laser test methods, test equipment, and terminology, WG 3: Safety, WG 4: Laser systems for medical applications, WG 6: Optical components and their test methods, WG 7: Electro-optical systems other

than lasers, and JWG 1: Coordination with IEC standardization activities associated with laser characteristics), which is in charge of preparing international standards on lasers.

A SC 9 international meeting is generally held twice every three years. Therefore, it is not held this fiscal year. In Japan, discussions on circulated documents were conducted via email, and no meetings were held.

The items proposed by Japan and the items for which Japan participated in preparing standard drafts as the project leader are progressing smoothly. The results of discussions in this fiscal year are listed in Table 5.

A vote was called for on the extensions of the terms of convenors in WGs 1, 4, 6, and 7, and all the extensions were approved.

## 12. Optical Disc Standardization Meeting

The Optical Disc Standardization Meeting is a standardization group specializing in the standardization of optical disk related technologies. Its main objectives are to prepare domestic standards drafts, and conduct surveys on trends in related technologies.

This is a parent meeting, under which there are three experts subcommittees and one Experts Group set up. The parent meeting decides the activity policies of each experts subcommittee, coordinates activities, and reviews and approves prepared JIS drafts. The actual work is carried out by the experts subcommittees.

The experts subcommittees comprise a Media Submeeting related to each type of media, such as photomagnetic/change of phase/ postscript/ read-only, an Application Submeeting related to optical disk applications and reliability evaluation, etc., and a Format Submeeting related to logical formats. In addition to this, a Maintenance Experts Group that takes charge of maintaining standards has been set up.

For JIS standardization, the Media Submeeting completed preparation of four JIS drafts in response to the physical standards of BD. Also, the Application Submeeting conducted follow-up work on two JIS drafts up to their enactment, and the Format Submeeting also conducted follow-up work on two JIS drafts up to their enactment, and a total of four JIS drafts were prepared.

In the surveys and research, the Media Submeeting and the Application Submeeting conducted a future technology trend survey. In addition, they also carried out an international standardization trend survey, independent of the expert submeeting framework, providing the latest information to optical disk users.

### 12.1 Media Submeeting

The Media Submeeting is responsible for the standardization of physical aspects for all optical disks (magneto-optical disks, phase change optical disks, recordable optical disks, and read-only media [ROM] optical disks).

Regarding JIS standardization, the submeeting prepared the following JIS drafts (the numbering and titles are tentative) using the complete translation of physical standards (a total of four documents) for recordable BD disk published in July 2013, and submitted them to the Japan Standards Association (JSA) at the end of February 2015.

- (1) JIS X 6230:2015, Information technology - Digitally recorded media for information interchange and storage - 120 mm single layer (25,0 Gbytes per disk) and dual layer (50,0 Gbytes per disk) BD recordable disks
- (2) JIS X 6231:2015, Information technology - Digitally recorded media for information interchange and storage - 120 mm triple layer (100,0 Gbytes single side disk and 200,0 Gbytes double sided disk) and quadruple layer (128,0 Gbytes per disk) BD recordable disks
- (3) JIS X 6232:2015, Information technology - Digitally recorded media for information interchange and storage - 120 mm single layer (25,0



Table 5 Circulated documents of ISO/TC 172/SC 9 and Japanese National Body's attitude (FY2014)

No.	Closing Date [JNB attitude]	Documents
01	2014/04/30 [approval]	ISO/DIS 17901-1: Optics and photonics — Holography — Part 1: Methods of measuring diffraction efficiency and associated optical characteristics of holograms
02	2014/04/30 [approval]	ISO/DIS 17901-2: Optics and photonics — Holography — Part 2: Methods for measurement of hologram recording characteristic
03	2014/06/30 [approval]	ISO/DIS 13694: Optics and optical instruments — Laser and laser-related equipment — Test methods for laser beam power (energy) density distribution
04	2014/07/06 [approval]	ISO/DIS 11145: Optics and photonics — Laser and laser-related equipment — Vocabulary and symbols
05	2014/08/03 [abstention]	NP: Lasers and laser-related equipment — Test method for angle resolved scattering
06	2014/08/19 [approval]	ISO/DIS 13142: Electro-optical systems — Cavity ring-down technique for high reflectance measurement
07	2014/08/20 [approval]	ISO/FDIS 11553-1: Safety of machinery — Laser processing machines — Part 1: General safety requirements
08	2014/08/20 [approval]	ISO/FDIS 11553-2: Safety of machinery — Laser processing machines — Part 2: Safety requirements for hand-held laser processing devices
09	2014/09/17 [approval]	ISO/SR 11810: Laser and laser-related equipment — Test method and classification for the laser resistance of surgical drapes and/or patient protective covers — Primary ignition, penetration, flame spread and secondary ignition —
10	2015/01/20 [approval]	ISO/FDIS 11151-2 (SC 9 N 456): Laser and laser related equipment — Standard optical components — Part 2: Components for the infrared spectral range
11	2015/01/27 [approval]	ISO/CD 11151-1 (SC 9 N 455): Laser and laser related equipment — Standard optical components — Part 1: Components for the UV, visible and near-infrared spectral range
12	2015/02/28 [approval]	ISO/CD 10110-17: Optics and photonics — Preparation of drawings for optical elements and systems — Part 17: Laser irradiation damage threshold
13	2015/03/16 [approval]	ISO/SR 11551: Optics and optical instruments — Lasers and laser-related equipment — Test methods for absorptance of optical laser components
14	2015/03/16 [approval]	ISO/SR 11554: Optics and optical instruments — Laser and laser-related equipment — Test methods for laser beam power, energy and temporal characteristics
15	2015/03/16 [approval]	ISO/SR 11670: Lasers and laser-related equipment — Test methods for laser beam parameters — Beam positional stability
16	2015/03/16 [approval]	ISO/SR 13696: Optics and optical instruments — Test method for radiation scattered by optical components
17	2015/03/16 [approval]	ISO/SR 13697: Optics and photonics — Lasers and laser-related equipment — Test method for specular reflectance and transmittance of optical laser components
18	2015/03/16 [approval]	ISO/SR 14880-2: Optics and photonics — Microlens arrays — Part 2: Test method for wavefront aberrations
19	2015/03/16 [approval]	ISO/SR 14880-3: Optics and photonics — Microlens arrays — Part 3: Test methods for optical properties other than wavefront aberrations
20	2015/03/16 [approval]	ISO/SR 14880-4: Optics and photonics — Microlens arrays — Part 4: Test methods for geometrical properties
21	2015/03/16 [approval]	ISO/SR 14880-5: Optics and photonics — Microlens arrays — Part 5: Guidance on testing
22	2015/03/16 [approval]	ISO/SR 15367-1: Laser and laser-related equipment — Test methods for determination of the shape of a laser beam wavefront — Part 1: Terminology and fundamental aspects
23	2015/03/16 [approval]	ISO/SR 15367-2: Lasers and laser-related equipment — Test methods for determination of the shape of a laser beam wavefront — Part 2: Shack-Hartmann sensors
24	2015/03/16 [approval]	ISO/SR 17526: Optics and optical instruments — Laser and laser-related equipment — Lifetime of lasers
25	2015/03/16 [approval]	ISO/SR 24103: Optics and photonics — Laser and laser-related equipment — Measurement of phase retardation of optical components for polarized laser radiation

Gbytes per disk) and dual layer (50,0 Gbytes per disk) BD rewritable disks

- (4) JIS X 6233:2015, Information technology - Digitally recorded media for information interchange and storage - 120 mm triple layer (100,0 Gbytes per disk) BD rewritable disks

In the surveys and research, the submeeting carried out surveys on technical trends related to enhancement of the functionality of high-speed recording and multi-layer recording on optical disks, and surveys on research and development trends of next-generation optical disks, based on academic society information related to optical disks such as ISOM' 14, etc.

## 12.2 Application Submeeting

The Application Submeeting handles the type of standardization not undertaken by the Media Submeeting or the Format Submeeting, such as test methods for estimating the life of optical disks. This fiscal year, three meetings were held to plan the aforementioned activities. Specifically the submeeting conducted work for the revision of JIS X 6255 "Data migration method for DVD- R, DVD-RW, DVD-RAM, +R, and +RW disks." The submeeting provided explanation to comments from members made at the JSA Standards Coordination Subcommittee meeting held on July 4. In addition, it responded to the comments from

members of the Japanese Industrial Standards Committee/Standards Board for the IEC area/2nd Technical Committee on Information Technology, and approval was given at one of the above committee meetings held on January 21. JIS X 6255:2015 was issued on March 20, 2015.

For future technological trends, publications were checked at ISOM' 14, etc. and related announcements were surveyed.

## 12.3 Format Submeeting

The Format Submeeting conducted the following activities, including the projects that were continued from the previous fiscal year, in the surveys and research on volume and file formats for optical disks.

### (1) Follow-up of the enactment of JIS (X 0613, 0614) for UDF 2.50 and UDF 2.60

Based on the instructions at the JISC Technical Committee on Information Technology meeting held on September 22, 2014, the submeeting took measures including consideration of the method for indicating registered trademarks included in the JIS text, and modified the draft. JIS X 0613, 0614 were published on February 20, 2015.

### (2) Preparation of revised drafts of JIS X 6235, 6236, and 6237, and follow-up

The submeeting completed preparations for the revised drafts in FY

2015, Part B, and submitted the drafts to the Japan Standards Association in June 2014. Then, following the response to the Standards Coordination Subcommittee meeting in December 2014, a proposal was made to the Ministry of Economy, Trade and Industry on March 27, 2015.

### (3) Preparation of the draft of JIS X (X 0612) in response to UDF1.50, and follow-up

As the revised draft of JIS X 6236 refers to UDF1.50, the submeeting conducted preparations for the JIS draft in FY 2014, Part A with an eye toward simultaneous enactment with the JIS X 6236 revised draft, and submitted the draft to the Japan Standards Association in October 2014. Then, following the response to the Standards Coordination Subcommittee meeting on December 2014, a proposal was made to the Ministry of Economy, Trade and Industry on February 23, 2015.

### 12.4 Maintenance Experts Group

Maintenance of standards is generally undertaken by experts on a daily basis. For JIS standards prepared by OITDA in the past, the Maintenance Experts Group checks the status of updates, etc. of the corresponding international standards, which are the original standard, and updates the maintenance table. This fiscal year, no updates were made to the maintenance table for JIS standards being maintained.

The Maintenance Experts Group monitors the status of draft preparation work, from the preparation of the first draft to their publication as JIS standards, and posts it on the OITDA website (<http://www.oitda.or.jp/>). It checks the progress of preparing a draft by stages as illustrated in **Figure 2**. The progress status table is updated after the administration office checks the progress and the group carries out an overall check.

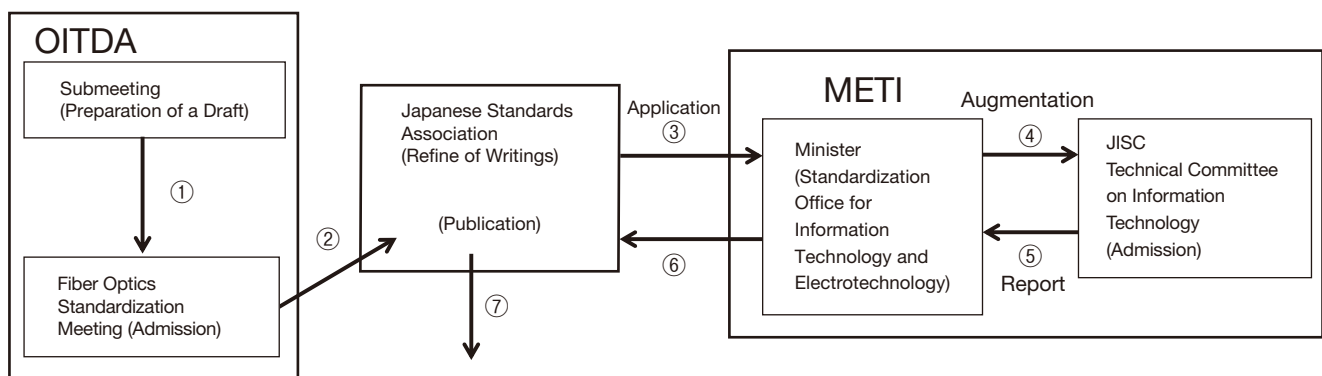


Figure 2 Flow to Publication from the Preparation of JIS Draft

## 13. International Standardization and Dissemination Committee for High-speed Communication Network Performance over Large Core Multimode Optical Fiber (V-Pro 2)

### 13.1 Purpose

This project builds the foundations for international standardization and dissemination of in-vehicle cabling systems for communication networks (in-vehicle LANs) mainly using short-distance optical fibers with the aim of generalizing in-vehicle optical components and reducing their costs.

Specifically, targeting high-speed in-vehicle LANs using large core multimode optical fibers, which will become the mainstream, international standards on test and measurement methods for optical signals are developed in IEC, and international standards on optical components such as connectors and cables for in-vehicle LANs are developed in ISO. In addition to the development of international standards, the project prepares IEEE standards on in-vehicle LANs using optical fibers through activities on in-vehicle Ethernet in the IEEE as part of the efforts for dissemination. Moreover, the project indicates the effectiveness of the international standards and IEEE standards, develops demonstration systems including devices and their evaluation tools, and promotes dissemination of the next generation vehicles. Use of optical fibers in in-vehicle LANs can reduce carbon dioxide emissions and improve fuel consumption due to the reduced weight and power saving, so that it contributes to saving energy in automobiles.

### 13.2 Implementation Plan

This project (1) develops ISO and IEC standards, (2) builds and verifies prototype in-vehicle optical devices as part of its international standardization activities, (3) conducts dissemination activities in the

IEEE, etc., (4) develops optical system design tools, and (5) builds in-vehicle optical systems and a certification infrastructure for constructing a foundation for dissemination. The specific plans for international standardization are as follows:

#### 13.2.1 Developing ISO and IEC standards

An international standardization/dissemination infrastructure building committee will be established to develop the following standardization in cooperation with the domestic IEC and ISO committees.

##### (1) IEC standards

- Follow-up of international standardization for optical signal measurement and test methods (Encircled Angular Flux (EAF) measurement standard)
- International standardization for optical component loss measurement methods (EAF standard for loss measurement)
- International standardization for the specifications of transmitters achieving 1 to 10 Gbps transmission (transmitter emission EAF standard)
- Acquiring related data by experiments, etc. and forming a logical background toward international standardization 'a' to 'c'

##### (2) ISO standards

- International standardization for the specifications of in-vehicle optical connectors (bandwidth guaranteed connector standard)
- International standardization for the specifications of in-vehicle cables (composite cable standard)

#### 13.2.2 Dissemination activities at the IEEE, etc.

The international standardization/dissemination infrastructure building committee conducts standardization activities and holds symposiums at the IEEE in cooperation with other committees to build an international

Table 6 Summary of Progress in International Standardization

International Standard	IEC	ISO	IEEE
Place of Proposal	TC86/SC86B/WG4	TC22/SC31, TC22/SC32	P892.bv
Domestic Committee	Institute of Electronics, Information and Communication Engineers 86B Optical Component Subcommittee	Society of Automotive Engineers of Japan Optical Communications Subcommittee	JasPar/Next Generation High-Speed LAN WG OPEN Alliance SIG /TC7
Ultimate Goal (~FY2018)	(1) EAF measurement method (2014) (2) Specification of an EAF template for loss measurement (2017) (3) Specification of an EAF template for transmitter emission (2017)	(4) Bandwidth guaranteed connectors (2018) (5) Composite cables (2018)	(6) In-vehicle Ethernet (1 Gbps) (2016) (7) In-vehicle Ethernet (10 Gbps) (2018)
Goal for this fiscal year (FY 2014)	(1) Publication of IS document (2) Proposal for new projects (3) Preparation for proposal (introduction of experimental equipment)	(4)(5) Establishing a committee in the Society of Automotive Engineers of Japan (JSAE), which is a national institute for ISO to provide a place for consolidating opinions in Japan with an eye toward an NP proposal in FY 2015	(6) Promotion to task force (TF) to prepare standardization documents (7) Preparation for proposal (introduction of experimental equipment)
Results for this fiscal year (FY 2014)	(1) The members of this project take charge of the process, and the international standard document (IEC 61300-3-53) was published on February 5. (2) A proposal incorporating a loss measurement method in the form of an addendum to the revision of the existing general rules document (IEC 61300-1) on the loss measurement method, rather than in the form of a new document, will be made at the Annecy meeting in April 2015 (in the CD stage). (3) Introduction of optics, network analyzers, etc.	(4)(5) "Optical Communications Subcommittee" was launched in JSAE on February 17. The chief administrator is Mr. Kagami of Toyota Central R&D Labs, and the secretariat is the OITDA. Discussions on the content and timing of the proposal started, and general rules a proposal and document architecture proposal were prepared. Based on these, subcommittee meetings will be held every month for the time being to give it concrete form.	(6) Promotion to TF was decided in January 2015. The project name is P802.3bv. The date of enactment is set at December 2016, which is the target of this project. The port name is 1000BASE-RH. (7) The construction of a 10 Gbps demonstration system using HPCF started and the principle of single-core bi-directional communications at 1 Gbps was confirmed.
Future Tasks	- It is necessary to determine immediately which of IEC, ISO, or ISO/IEC/JTC 1 should be the place to prepare standardization for an EAF template for transmitter emission. (Each one has merits and demerits.)	- As the specifications involve the requirements of the automobile manufacturers, it is necessary to provide a forum for discussion. - For standardization to be established at TC 22, the support of Europe, especially Germany, is indispensable. Prior lobbying and strengthened collaboration are required.	- It is necessary to broadly extend the results of standardization to the housing and industrial machinery fields. It is preferable to promote collaboration by exchanging information inside and outside Japan.

consensus required for constructing a dissemination infrastructure and developing IEC and ISO standards.

### 13.3 Results of international standardization

Currently, in the IEC, ISO, and IEEE, standardization activities are conducted to correlate and systematically build these international standards. The activities are led by the international standardization and dissemination infrastructure building committee established in OITDA, with each member sharing responsibility in standardization. The ultimate goal of the initial plan, the goal and results for this fiscal year, and future tasks are summarized in Table 6.

## 14. Committee for International Standardization of Fiber Optic Connector Optical Interfaces for Fiber Interface Connectors (T-pro 2)

### 14.1 Background and purpose

With the spread of various ICT services based on mobile services using smartphones and cloud computing services in which information processing is centralized at a data center, communications network traffic is rapidly increasing. To cope with this, high-speed large-capacity networks are developed including the introduction of 100 Gb/s-class digital coherent transmissions to trunk lines and metro systems. In addition, network sizes have been expanded by building transmission routes and communication systems including access systems and data center systems in optical communication networks. As a result, up to the present, the development of optical communication equipment and optical components has been directed to performance enhancement and scale expansion (mass production). However, in recent years, upsizing of communications equipment/devices (increase in building and air-conditioning costs), the significant rise in power consumption, and increase in environmental loads due to the use of components containing toxic substances such as lead, and risks to maintenance staff due to the increase in the power of the light used for communication are posing problems. Therefore, it is required to develop communications devices/components that are friendly to both people and the environment, aimed

at miniaturization and low power consumption, that are free from toxic substances, allow easy separation for disposal, work efficiently and are safe to handle. In addition, as communication networks are social infrastructures indispensable to peoples' lives and economic activities, high reliability and resistance to disasters are becoming increasingly important.

Fiber PC (Physical Contact) connectors including SF connectors are extremely small but can provide stable multi-fiber PC connection. In high-end routers and servers, which form the center of communications networks and cloud computing services, optical interconnection within equipment has been introduced to increase signal-processing speed and reduce power consumption. The development of an optical node with multi-directions (three or more links) is underway with an eye toward realizing mesh optical communication networks that have a high redundancy in communication routes and superior fault-tolerance. Fiber PC connectors are suitable for multi-fiber connectors connecting optical fibers for high-density optical interconnection within a board/between boards in this information processing equipment and optical communications equipment, and they increase the efficiency of the implementation process for large-scale and complex optical interconnection and increase the density by eliminating the need for excessive lengths, which are expected to contribute to cost reductions and the miniaturization of equipment. Fiber PC connectors were developed in Japan ahead of the others, and the mating structure of an SF connector has been internationally standardized at the IEC. However, an optical compatibility standard is in the process of establishment.

Under the theme of "international standardization of Fiber Optic Connector Optical Interfaces for Fiber Interface Connectors," this research and study covers the planning of an optical compatibility standard, and prepares a draft standardization document, with an eye toward establishing an optical compatibility standard for fiber PC connectors. This year (fiscal 2014), an "International Standardization Committee on the Optical Compatibility of Connectors for Mutual Connection of Optical Fibers" was established and started research and study. The goal of this committee is to complete a three-year project:

NP registration (fiscal 2014), CFV circulation (fiscal 2015), and FDIS circulation (fiscal 2016) of a standardization document for optical compatibility of fiber PC connectors at the IEC.

#### 14.2 Survey results

The standardization of optical fiber connectors has been discussed at IEC/TC 86 (Fibre optics) / SC 86B (Fibre optic interconnecting devices and passive component). At the WG 6 meeting of the SC 86B interim meeting (Ixtapa, Mexico) in May 2014, a proposal was made on an optical compatibility standard for fiber PC connectors. However, a problem was pointed out in the results of loss measurement in random connection with the insertion method (C) according to IEC 61300-3-4. The reasons were that the measurements depended on the connection loss in the master cord, and the amount of data was limited. This time, measurement was conducted according to the insertion method (B), and the data obtained suggests the actual distribution of the connection loss.

On the other hand, a random connection loss simulation of fiber PC connectors was commissioned to a consultant from another country. The data from the random connection loss distribution experiment and the Monte-Carlo simulation showed good agreement. The result indicates that if the outer diameter of the optical fiber and inner diameter of the micro-hole are specified to be optically compatibility dimensions, the random connection loss can be estimated, which clarified the structural conditions for optical compatibility.

In working with the above consultant, a draft standardization document was created, and a presentation was given at the IEC TC 86/SC 86B Tokyo meeting held in November 2014. The NP proposal was approved, and following NP documentation, NP registration, which is the goal for this fiscal year, has been achieved. Currently, the NP is in circulation and the vote closed on March 13, 2015. The proposal was passed and discussed at the IEC meeting at Annecy (France). In addition, the results of the above random connection loss measurement and simulation were reported at the 2015 general meeting of the Institute of Electronics, Information and Communication Engineers, which increased recognition for these activities.

The research and study on the optical compatibility of fiber connectors will continue, responding to comments from each country on the standardization document, and international standardization will proceed by forming an agreement with each country.

### 15. Committee for International Standardization of Highly Laser-resistant Laser Guards (C-Pro)

Research and study on "International standardization of test procedures for highly laser-resistant laser guards" was conducted as part of the "FY 2014 International standardization activities concerning government strategic fields" outsourced by the Ministry of Economy, Trade and Industry, and subcontracted by Mitsubishi Research Institute.

#### 15.1 Background and Purpose

Laser guards are a means of protection that shield against laser beams. They are currently constructed of metal, wood, etc. However, with the development of high power laser technology, even safer protective measures are demanded. There is an international standard for laser guards: IEC 60825-4. One problem is that guard materials that are sufficiently durable against high power laser beams and their evaluation method have not been proposed. The purpose of this project is to build prototype laser guards using the superior qualities of Carbon Fiber Reinforced Plastics (CFRPs), a material that hitherto has not been considered and in which Japanese companies enjoy high competitiveness, and conduct evaluation tests to verify their protection performance against laser beams, review the effectiveness of their performance characteristics (light weight, high thermal resistance, etc.) as laser guards,

and establish a method to properly evaluate their characteristics and to propose a new international standard. Specifically, the project aims to propose a new working item (in FY 2016) with an eye toward publishing a new IEC standard on the test procedures for highly laser-resistant laser guards or revising IEC 60825-4 by adding an annex.

#### 15.2 Major results and issues for this fiscal year

This fiscal year, which is the first fiscal year of the three-year plan, the project evaluated the performance of CFRP laser guards, reviewed methods for evaluating the performance of CFRP laser guards, and surveyed the status of international standardization, yielding the following results:

- The project obtained basic data on highly laser-resistant laser guard candidate materials and their evaluation methods by conducting performance evaluation tests using a high power laser, and confirmed the high protection performance of the CFRP material against laser beams. Issues include improvements in the measurement accuracy of the evaluation parameters, a statistical processing method that will allow pass/fail judgments, a method for evaluating emissions (dust particles, gas, etc.), and consideration of a mechanism for obtaining high protection from supporting data.
- A symposium held with specialists invited from overseas and participation in an IEC international meeting (Tokyo) allowed the issues with the current IEC standard to be clarified and a beachhead from which to build cooperative relationships for future proposal activities to be built. Germany is ahead in the standardization of laser guards. They have proposed a revision to IEC 60825-4, Annex D. While looking closely at overseas trends as before, it is also necessary for Japan to take the initiative in presenting the results of this project at international conferences and IEC meetings and to proceed with the development of an international standard.

#### 15.3 Future Tasks

Based on the results of this fiscal year, prototype highly laser-resistant laser guards will be built/evaluated, and according to the results of the performance evaluation tests, the project will start preparing a draft standard on test procedures for highly laser-resistant laser guards. In addition, through the survey of IEC international meetings and international conferences, and by inviting specialists from overseas as before, the status of international standardization of laser guards, the status of related markets, and technical trends will be investigated. As high power laser processing machines are developed mainly by overseas manufacturers, none of them have paid attention to CFRP laser guards. It is thought that domestic laser-related industries can become competitive internationally by resolving the issues identified in the survey conducted this fiscal year and pushing forward with this project.

### 16. Committee for Standardization of Laser Safety (J-Pro)

#### 16.1 Background

The ultimate purpose of this project is to promote international standardization of the safety of projectors with new light sources, and the safety of fiber beam delivery in systems that are equipped with fiber lasers. Specifically, the project has the following two goals:

- As a child standard of IEC 62471 "Photobiological safety of lamps and lamp systems," proposing a new safety standard for image projector systems including laser irradiation
- Revising ISO 11553-1 (Laser processing machine safety - General safety requirements)

Towards these ultimate goals, this fiscal year, a CDV document for enacting a new child standard of IEC 62471 and a CD document for revising ISO/IEC 11553-1 were circulated, and members participated in the IEC/TC 76 (Optical radiation safety and laser equipment)



international meeting to discuss comments. As both standards are closely related to the overall discussions at TC 76, this chapter covers international standardization as a whole concerning TC 76 with particular emphases on the TC 76 Tokyo meeting held in November 2014 and the TC 76/WG 1 & WG 8 Albuquerque meeting held on March 2015.

## 16.2 Activities of Each WG at TC 76

### (1) TC 76/WG 1 (Optical radiation safety)

Ed. 3 of IEC 60825-1 "Laser Equipment classification and requirements," for which an FDIS was circulated at the end of the previous fiscal year and voted/approved, was issued in May 2014. As discussions proceeded with the assumption that technical comments submitted through CDV circulation the last previous year would not be reflected in the FDIS, but addressed with an Interpretation Sheet (I-SH) after the publication of Ed. 3, this fiscal year, discussions started with eight presentations proposed as I-SHs to 60825-1 Ed. 3 at the Tokyo meeting. The eight I-SH proposals were integrated into one by the secretary of WG 1 through detailed discussions at the WG 8 meeting.

The I-SH draft was discussed again at the Albuquerque meeting based on the comments submitted by various countries including Japan. The revised proposals from Japan were mostly accepted, and the draft that reflects the discussions will be circulated in the next fiscal year.

For IEC 62368-1 "Audio/Video, Information and Communication Technology Equipment – Safety Requirements" prepared by TC 108, the fact that the concepts of Radiation energy Source classes (RS') and safeguards are inconsistent with IEC 60825-1 and IEC 62471 prepared by TC 76 was confirmed at the Tokyo meeting, TC 76 sent a liaison letter to TC 108 to start negotiations on IEC 62368-1 Ed. 2. Proposals have been made to define the classification of lasers and lamps (including LEDs) in IEC 62368-1 with Class 1 to Class 4 in IEC 60825-1 and RG-0 to RG-3 in IEC 62471 respectively, without using RS 1 to RS 3.

### (2) TC 76/WG 3 (Laser radiation measurement)

Action items were organized at the Tokyo meeting with an eye toward revising IEC/TR 60825-13 Ed. 2 "Measurements for classification of laser products" in 2018.

It was decided that the angular subtense of irregular source would be reviewed according to the results produced by WG 1, and Measurement Condition 2 would be reviewed according to the discussions on IEC 60825-2 at WG 5. It was confirmed that assuming there would be an I-SH draft of IEC 60825-1 Ed. 3, it was necessary to add broader guidance to IEC 60825-13.

Moreover, following the publication of IEC 60825-1 Ed. 3, it was confirmed that it was necessary to consider determination of the maximum radiance in the exclusion rules for laser products that function as conventional lamps, light source sizes related to time measurement, different opening sizes at different radiation durations, provision of a method for properly using measuring instruments without false perception between the peak power and average power of a scanning laser for laser shows, pulse duration of a scanning beam that traverses a large opening, evaluation of a large light source using a simplified method, and alternative methods for measuring a light source including hot spot analysis.

### (3) TC 76/WG 4 (Safety of medical laser equipment)

The Tokyo meeting discussed the addition of Class 1C requirements to IEC 60601-2-22 "Particular requirements for basic safety and essential performance of surgical, cosmetic, therapeutic and diagnostic laser equipment" and the addition of an annex on laser protective glasses to IEC/TR 60825-8 "Guidelines for the safe use of laser beams on humans" (with reference to the JWG 12 document). For these additions, completing CD drafts within the fiscal year are intended. For IEC 60601-2-57 "Particular requirements for the basic safety and essential performance of non-laser light source equipment intended for therapeutic,

diagnostic, monitoring and cosmetic/aesthetic use," it was decided to propose an I-SH that recommends the exclusion of light sources that provide eyes with photobiological effects (effects produced by ophthalmic diagnostic devices, light sources for the treatment of seasonal affective disorder, etc.).

In addition, as the risks of ophthalmopathy in the treatment of the upper part of the eyelid using a laser or Intense Pulsed Light (IPL) are deeply related to IEC/TR 62471-3 (Guidelines for the safe use of intense pulsed light source equipment on humans) and IEC/TR 60825-8, it was confirmed to proceed with reviews in cooperation with ISO/TC 94/SC 6/WG 4, and to answer in the negative to a question from TC 61/WG 30 on whether household IPL appliances are included in the application range of IEC 60601-2-57.

For IEC 60335-2-113 "Particular requirements for cosmetic and beauty care appliances incorporating lasers and intense light sources," a vertical standard that specifies the requirements for referring to IEC 60825-1 Class 1C for laser equipment and referring to the Exempt group in IEC 62471 for IPL (intense pulsed light) equipment, an NP and CDV were circulated simultaneously at TC 61.

### (4) TC 76/WG 5 (Safety of fibre optics communications systems)

The Tokyo meeting discussed the following three items.

For Ed. 2 of IEC/TR 60825-17 "Safety aspects for use of passive optical components and optical cables in high power optical fibre communication systems," DTR comments were discussed, and preparation of a TR was approved.

For the discussion of 2nd CD for Ed. 2 of IEC 60825-12 "Safety of free space optical communication systems used for transmission of information," the United Kingdom and the United States proposed deletion of Measurement Condition 2. Japan explained applications using an extended light source and the necessity of Measurement Condition 2, and it was decided to leave Measurement Condition 2, and to prepare a CDV for the modified version based on the existing Measurement Condition 2. It was also decided that IEC 60825-1 Ed. 3 in conjunction with the modification to IEC 60825-2 would be reflected at the next stage, and the sample calculation in Annex A, which was deleted this time, would be restored.

For the revision toward Ed. 3 of IEC 60825-2 "Safety of optical fibre communication systems," as Measurement Condition 2 has been left from IEC 60825-1 Ed.3 to this revision, it is appropriate to specify a proprietary condition. For the C<sub>7</sub> problem, Japan proposed the idea of using the MPE limits on the skin (including corneas, irises/lenses). The United Kingdom and the United States accepted Japan's idea. On the other hand, the WG 1 convenor raised the problem of disorder due to the gathering of light on the surface of the eye, and it was decided to continue discussions with WG 1. Moreover, following the previous year, the United Kingdom proposed the reconstruction to the clauses of IEC 60825-2, and moving the requirements from IEC/TR 60825-17 to IEC 60825-2. Japan commented that discussions should focus on the C<sub>7</sub> problem in the first place to reject the proposal.

The activities of TC 86, TC 76, and TC 86-TC 76 CGS were introduced at a joint meeting with IEC/TC 86, which was held for the first time in three years. It was confirmed that the joint meeting in the next fiscal year would be held on the Web if possible.

### (5) TC 76/WG 7 (High power lasers)

The Tokyo meeting discussed the revised draft of IEC 60825-4 Annex D "Proprietary Laser Guard Testing," and it was confirmed that the draft would be applied as a means of determining the specifications for laser guards for external sales in which the laser output is 4 kW or lower and the beam parameter product (BPP) exceeds 4 mm·mrad, and not applied to laser processing machines. The convenor raised a problem that when using a fiber laser with high output and high beam quality (low BPP), if the core diameter of the fiber is small, there is a high possibility that

the return light will damage the fiber optics. As Annex D does not describe this risk, it was decided to add a note: "If the return light from the workpiece or the target damages the output edge of the fiber, a "fiber fuse" phenomenon can occur, which can cause a flame to spread to the input edge of the fiber." and "It is recommended to take appropriate protective measures."

This draft will be modified and circulated in WG 7, and submitted to TC 76.

#### **(6) TC 76/WG 8 (Development and maintenance of basic standards)**

The Tokyo meeting discussed the details of the IEC 60825-1 Ed3 I-SH proposal. And the following items were discussed at the Tokyo meeting and the Albuquerque meeting.

For the revision of Ed. 2 of IEC/TR 60825-14 "Safety of laser products - A user's guide," discussions were held on reprinting the MPE table in IEC 60825-1, adding an item on accidental risks while using Class 3B and Class 4 equipment, and regarding risk management by eyeball examinations, the necessity of new examinations for visual disorders that cannot be detected by normal ophthalmological examinations including funduscopy. A DTR will be prepared by June 2015.

There were discussions on the necessity of revising IEC/TR 60825-3 "Guidance for laser displays and shows" by incorporating the latest draft of ANSI Z136.10, with consideration given to "intentional irradiation." The United States will prepare a draft by May 2015.

The European Commission announced that it had been decided to proceed with enactment of a standard and legal regulations on laser products for general consumers, and to exclude laser products that functions as toys, Class 1C and conventional lamps. TC 76 has decided to collaborate in the work of enacting an EN standard.

#### **(7) TC 76/WG 9 (Non coherent sources)**

The WG 9 and WG 1 + WG 8 + WG 9 joint meetings in Tokyo discussed the following items. The discussions on IEC 62471-1 are described in (8).

For IEC 62471-2 (scheduled to transition from a TR to a vertical safety standard on light sources for general illumination), there were discussions on whether to leave a description of "500 lx" during the transition of the specific descriptions on general lighting sources (GLS) to IEC 62471-2 because IEC 62471-1 was the basic horizontal standard. It was decided to consider putting it on the Web by the end of this year after listening to the opinions of the Commission Internationale de l'Eclairage (CIE).

For IEC/TR 62471-4, as there were opinions that they should listen to CIE, it was decided to include CIE in the circulation route.

Regarding the enactment of IEC 62471-5 "Photobiological safety of lamps and lamp systems," the project leader introduced some of the major comments collected during CDV circulation. An FDIS that reflected these comments started to be circulated at the end of the fiscal year.

The United States made a presentation on IEC 62471-6 "Photobiological safety of ultraviolet lamp products." And its NP circulation started at the end of the fiscal year.

#### **(8) JTC 5 (IEC 62471-1 Special Joint TC)**

Modification of "Photobiological safety of lamps and lamp systems" has been conducted by CIE Div. 2 and Div. 6, and IEC/TC 34 and TC 76 jointly (JTC 5) since April 2013. This fiscal year, a Kuala Lumpur meeting was held in April 2014 and a Tokyo meeting was held on November 2014. For the CIE S009/IEC 62471-1 (double-logo) draft, which was re-edited to reflect the discussions at the Kuala Lumpur meeting, the following items were discussed at the Tokyo meeting.

The majority thought that the range of application covers all light emission sources except lasers, and basic matters concerning risk classification and emission limits, and basic measurement conditions

should be specified as a horizontal standard. There were discussions on whether the requirements for a product is allowed in the CIE standard. A proposal was made to prepare an Annex (informative). The description on environmental lighting (a condition of 500 lx) is likely to be deleted from the draft.

During discussions on technical details, the definition of a pulse width was proposed. For pseudo CW light sources, it was decided to prepare a draft on handling the light source by PWM control. The JTC 5 chairperson made a proposal to change the measurement distance from 200 mm to 1 m, and it reached a conclusion that it was preferable to define the default measurement distance while allowing room for setting according to the circumstances of individual products.

The content of the discussion will be reflected in the draft and an Annex on measurement uncertainties will be added. Comments will be solicited on Web meetings.

#### **(9) TC 76/JWG 10 (Safety of lasers and laser equipment in an industrial materials processing environment)**

The Tokyo meeting discussed the comments in CD circulation on the revision of ISO/IEC 11553-1 and ISO/IEC 11553-2. For each item, a different CD was circulated for IEC and ISO. In the discussions, comments in IEC circulation were ignored and comments in ISO circulation were checked. A proposal from Germany to incorporate European proprietary rules to these specifications was rejected. Based on the modifications, the convenor will fill in the observations of the secretariate column and complete the CDV text.

#### **(10) TC 76/JWG 12 (Eye and face protection against laser radiation)**

Following the approval at the ISO/TC 94/SC 6 meeting in June 2014, this WG has been established as a JWG since this fiscal year. In the Tokyo meeting, the following discussions were held on the WD 1st version of ISO/IEC 19818 "Requirements for eye and face protection against laser radiation."

The optical density of protective filters should be 8 at a maximum except in the ultraviolet ranges, the optical density should be separated from the damage thresholds (laser resistance classes), and the concept of laser resistance classes should be described only in "User Guidelines" maintained in ISO/IEC 19818. The amount of information for product indication that needs to be included was defined. Modifications were proposed to several tables. The WD 2nd Edition, which reflected these, was circulated after the meeting.

WD Edition 3 will be discussed at a meeting established in parallel with the ISO/TC 94/SC 6 meeting on June 2016, and a CD will be circulated for ISO and IEC.

### **16.3 Future Tasks**

I-SH discussions on IEC 60825-1 (Ed. 3) are a priority issue. Errors were found in FDIS circulation of IEC 62471-5 (Ed. 1), and will be followed up. For revision of ISO/IEC 11553-1 (Ed. 2) and IEC 60825-12 (Ed. 2), the CC and CDV drafts will be immediately checked. For other projects, progress management will be conducted and the next TC 76 meeting will be held in October 2015.

### **17. Committee for Standardization of Optical Disc Evaluation Criteria (O-Pro)**

In the optical disc field, JIS standards have been enacted concerning the reliability of digital data including a life estimation standard and data migration standard for optical discs, as well as physical and logical standards for each product such as CDs and DVDs, and a wide range of markets have been cultivated. In particular, with the explosive growth in the amount of information in recent years, optical discs are expected to encourage the creation of an archive market, serving as strategic media for storing digital data.

The purpose of this project is to establish the grading of media with the initial performance of optical discs themselves being the index, based on the enacted physical standard and life estimation standard for each product (DVD-R, BD-R, etc.), and evaluation criteria for use as an optical disc archive system that includes the integrity with drives to ensure the recording quality of digital data, and based on these, develop a JIS standard.

In addition, based on the JIS standard developed by this project, international standardization will be developed through proposals to ISO/IEC JTC 1/SC 23, and collaboration will take place with industry organizations that manage digital documents over the method of using this JIS standard to build an optical archive product certification system.

### 17.1 Project Content

For optical discs, JIS standards have been enacted concerning the life estimation standard and data migration standard to evaluate reliability, as well as physical and logical standards for CDs and DVDs, and a wide range of markets have been cultivated.

This project establishes grading and evaluation methods (Figure 3-(1)) for media with the initial performance of optical discs themselves being the index, based on the enacted physical standard and life estimation standard for each product (DVD-R, BD-R, etc.), and new evaluation criteria (Figure 3-(2)) on the provisions in operating/evaluation guidelines for an optical archive system that includes integrity with drives that will ensure the recording quality of digital data, and based on these, develops a JIS draft.

### 17.2 Results of FY 2014 Activities and Issues for the Next Fiscal Year

In fiscal 2014, the project conducted optical disc life estimation tests for grading media for archiving and considered evaluation methods, and drive/media compatibility evaluation tests for operating/evaluation guidelines for an archive system.

For optical disc life estimation tests, which targeted BD-R SL, DVD-R SL, and DVD-R DL, the test conducted were those specified in ECMA-396 3rd Edition. As these tests require carrying out up to 2,500 hours of accelerated degradation tests, they are being performed in 2014 and 2015. When the latter half of the tests is completed in fiscal 2015, the

results will be evaluated.

For the drive/media compatibility evaluation test, initial recording characteristics were evaluated on 24 types of optical disc media and four types of drives. For DVD-Rs in particular, the results of evaluation indicated that some discs do not satisfy the criteria required by JIS Z 6017; there are some cases where there is a significant differences in recording quality depending on the combination of drive and media. A test on some discs for which individual write optimization were conducted, confirmed the effectiveness of individual estimations of the initial recording quality.

As described above, this fiscal year the project started (1) evaluation experiments on grading media with the initial performance of the optical discs themselves being the index, and (2) obtained knowledge on evaluation guidelines based on the results of evaluation experiments on integrity with drives that will ensure the recording quality of the digital data. Based the results of two types of evaluation experiments, accelerated degradation experiments on discs on which optimal recording has been performed are being performed to investigate the effects of individual optimization on the long-term preservation characteristics of recorded data.

## 18. Research Committee on Safety and Security of Laser Equipment

### 18.1 Background and Purpose

The laser was invented in 1960. Over the past 50 years, laser technology has developed until it covers wavelengths from the ultraviolet range to the visible and infrared ranges to terahertz waves as well as various capabilities and oscillation forms. This technology has been applied to optical communications, optical discs, laser printers, laser processing machines, bar code readers, laser pointers, laser medicine/diagnosis, etc. Thus, the laser has become an indispensable to society. On the other hand, while laser technology was originally intended to support safety and security in a social environment, its improper handling has led to unfortunate events such as loss of eyesight caused by accidental irradiation of the eyes at manufacturing and entertainment facilities, skin injuries with laser epilators, and fire accidents due to improper use of radiation shielding and blackout curtains, etc. during scientific

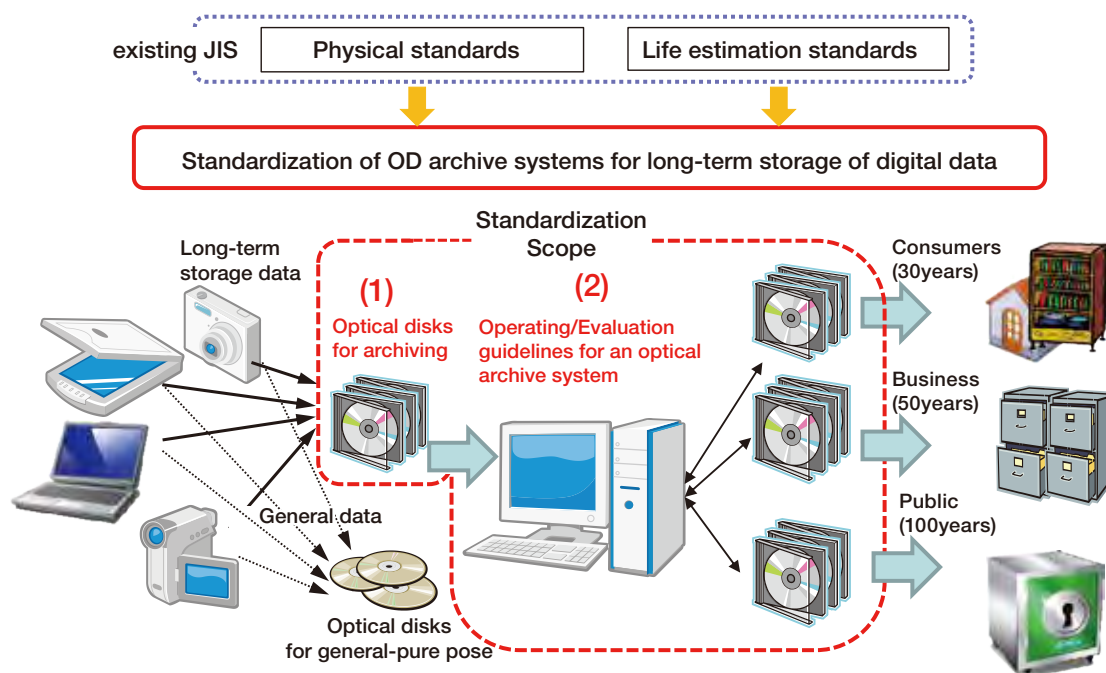


Figure 3 Configuration of the standardization of OD archive systems for long-term storage of digital data

experiments. Taking multifaceted measures for laser safety is a pressing issue.

The international standardization of laser safety was discussed and prepared in IEC/TC 76. Japanese Industrial Standards (JIS), which are domestic standards within Japan, have been enacted and revised based on the IEC standards. At present, not all IEC safety standards published are included in JIS safety standards. Thus, it is necessary to further improve JIS in Japan.

To prevent accidents caused by inappropriate laser products and improper handling, OITDA also holds a laser safety school when appropriate, and holds a laser equipment engineers examination every year, aiming to achieve a “safe and secure” society. However, since the schooling is tending to become a mere means of passing the examination, it is desirable to hold proper symposiums to provide education on the safe use of lasers in a wide range of social environments including the home and the workplace.

## 18.2 Summary of Survey Research

To meet the aforementioned objectives, we formed a survey and research committee consisting of domestic experts and users, which engaged in the following survey research activities.

- Experts were sent to the ILSC2015 (international meeting on laser safety) and the IEC/TC 76/WG 1 & WG 8 Albuquerque meeting. They exchanged views and collected information on standardization.
- As Ed. 3 of IEC 60825-1 has been published and discussions on the interpretation sheet of Ed.3 have started simultaneously, the committee translated the draft with the assumption that an addendum will be added to JIS C 6801 “Safety of laser products.” In addition, in order to introduce the latest basic standards for laser safety, the committee translated the preface of a paper introducing

IEC 60825-1 Ed.3.

- The committee held an international standardization symposium on basic standards for laser safety and the safety of medical laser equipment, to describe the basic standards for laser safety in JIS and IEC and introduce new ideas on the safety of medical laser equipment.

Details on the international standardization symposium are given in the next section.

## 18.3 International Standardization Symposium

The 1st International Standardization Symposium was held with the theme of “Safety and security of laser equipment - The latest basic standards for laser safety.” European authorities on laser safety were invited, and there were more than 70 participants. Titles of the lectures and speakers are listed in [Table 7](#) below.

The 2nd International Standardization Symposium was held with the theme of “Safety and security of laser equipment - Safety of medical laser equipment.” European authorities on laser safety were invited, and there were more than 30 participants. Titles of the lectures and speakers are listed in [Table 8](#) below.

Some of the participants at the 1st symposium expressed the view that it was a good opportunity to learn about the latest JIS and IEC standards, and participants at the 2nd symposium said that they are glad to hear talks about the latest trends in medical lasers. Some participants also said that they want this type of symposium to be held in the future, and thus we would like to consider another opportunity to provide information on the latest trends in laser safety.

This survey research work was supported by JKA and its promotion funds from KEIRIN RACE.

Table 7 International Standardization Symposium Program

	Speaker	Title
1	Prof. Yuichi Hashishin Kinki University	Japanese Laser Safety Standard – the latest version of JIS C 6802
2	Dr. Karl Schulmeister Seibersdorf Laboratories GmbH	The revised international laser product safety standard IEC 60825-1 (2014) – Part 1: Overview of contents of IEC 60825-1
3	Dr. Karl Schulmeister Seibersdorf Laboratories GmbH	The revised international laser product safety standard IEC 60825-1 (2014) – Part 2: General changes
4	Dr. Karl Schulmeister Seibersdorf Laboratories GmbH	The revised international laser product safety standard IEC 60825-1 (2014) – Part 3: Changes in retinal thermal limits

Table 8 International Standardization Symposium Program

	Speaker	Title
1	Prof. Yuichi Hashishin Kinki University	Recent trends in laser safety standards for medical application in Japan
2	Dr. Wolfram Gorisch Convenor, IEC/TC 76/WG 4	Medical Laser Safety Standards – International Safety Standards for the equipment design and for the safe use of lasers on humans in view of recent trends of technology and application



# Educational and Public Relations Activities

## 1. Symposiums

### 1.1 FY 2014 Symposium on the Optoelectronics Industry and Technology

The FY 2014 Symposium on the Optoelectronics Industry and Technology was jointly sponsored by OITDA and the Photonics Electronics Technology Research Association (PETRA). The theme was "Optical Communications Developing New Social Paradigm Shifts." It was held with the support of the Ministry of Economy, Trade and Industry (METI) on February 4 (Wednesday), 2015 at the Rihga Royal Hotel, Tokyo with over 230 participants.



The day began with an opening address by OITDA President Yasuhisa Odani, followed by an address to visitors by Takatoshi Miura, Director of the Information and Communication Electronics Division, Commerce and Information Policy Bureau, METI. Mr. Miura commended the efforts OITDA has made since 1980 to aggressively promote a research and development/commercialization strategy on optoelectronics, which is a key technology in setting out a growth strategy, and the ever expanding activities of PETRA, which is now in its 6th year from its foundation in 2009.

Mr. Miura said that the economy is gradually recovering from deflation, but to make that growth sustainable, it is important to develop a growth strategy, in particular in frontiers of the economy/market, and the Japanese government was striving to create environments to support that development, including expanding the reduction in corporate taxes and research and development tax credits. For industrial/business activities, he also expressed optimism over the development of optoelectronics technology because new technologies and new product services/markets are required to reinvigorate the entire economy. Since optoelectronics is seen as a key industrial technology in various fields including optical communications networks, displays and sensors, it is an important industry that can support future trends, such as the Internet of Things (IoT). With this in mind, Mr. Miura introduced "Photonics Electronics Convergence Technology for Power-Reducing Jisso System," which has been ongoing for three years by METI as part of its "Future Pioneering Projects." He added that it was a ten-year high-risk high-return project but that steady efforts have been spent to achieve its goals, and he not only anticipated the completion of the project but also new technological developments and their commercialization.

It was hoped that this symposium would serve as an opportunity to stimulate technological innovation in the optical industry by acting as an interface between the industrial world and academia and that there will be more and more developments in future.

This speech was followed by six talks: two in the morning and four in the afternoon. The first talk was a keynote speech by Professor Naoaki Yamanaka from the Department of Information and Computer Science in the Faculty of Science and Engineering at Keio University, entitled "Photonic Networks that Support the Evolving Information Society." It

is no exaggeration to say that optical communications technology is built upon many breakthrough technologies including optical amplifiers, wavelength division multiplexing, digital coherent signal processing, and elastic optical networks, and has been rapidly developing to supporting the explosive growth of the Internet. On the other hand, it is mainly based on transport technology, and not oriented to the latest applications. He explained current services centered on cloud computing, the photonic network architecture, which leads to IoT that connects everything to the Internet, and their foundations, which would develop into dynamic and flexible Optical Layer 2 networks. He also introduced some future optical network architectures. The first example is optical aggregation networks. With energy-efficient large-capacity routers and high-speed optical switches, low-power consumption (1/10 to 1/20 of the current) networks can be built. The second example is the Ubiquitous Grid (uGrid), which is the concept of a network that connects everything from cameras and displays, to software. As Photonic Software Defined Networking (SDN), which implements this concept, a new Optical Layer 2 technology tailored to a transport network orientation that takes maximum advantage of optoelectronics has been proposed. He expressed hopes for optical network processors that use silicon photonics as the key technology.

In the second talk, Chief Engineer Mr. Shinya Nakamura from the Converged Network Division at NEC gave a lecture entitled "Realizing More Flexible Optical Networks and SDN." Following an introduction in which he explained that carrier networks have started introducing new paradigms such as "SDN" and "Network Function Virtualization (NFV)," he foresaw global market trends including the introduction of large-capacity optical technology, the integration of optical packet technologies, and SDN, and he summarized the technologies corresponding to these new paradigms. Then he discussed the meaning of the new paradigms for carriers and system vendors, and introduced some application examples and the status of deliberations concerning SDN and NFV. He gave some interesting examples of research and development in the optoelectronics field to realize more flexible large-capacity optical networks including improvements in flexibility with an application of coded modulation schemes, ultra-small optical switches using silicon photonics, the implementation of flexible client interfaces (Ethernet/OTN), and applications of optical switches in data center networks. At the end he mentioned some issues in the carrier business and concluded the lecture by pointing out the role of challenges in advancing technologies.

The first talk in the afternoon by Mr. Kunihiro Tanaka, President and Representative Director of Sakura Internet Inc., was titled "Ishikari Data Center, an Example of Both High-Quality and Energy-Saving Data Centers." The Ishikari Data Center was constructed in Ishikari City, Hokkaido, in November 2011, and is one of the largest data centers in Japan. By taking advantage of a location where there is little risk of disasters and where facilities can have robustness and expandability, the data center is meeting various challenges for its client companies. With its vantage point connecting the Pacific Ocean, the Sea of Japan, Europe/America and Asia, it has the great advantage of being a node in the optical fiber infrastructure. Mr. Tanaka gave some specific information on previous examples and the status of operation, with the latest numbers. The data center launched new initiatives, including outdoor air-cooling using the cool climate of Hokkaido and direct-current power supplies with high power efficiency. To achieve further power saving and to upgrade to higher-grade network equipment, the optical fiber connections in the data center have been expanded. The data center will also test out high-temperature superconducting direct-current power transmission that has almost no power loss in transmission. The company is seeking a next-generation power saving data center by further improving the energy efficiency.

The second talk in the afternoon was by Mr. Akira Hirano, Senior Research Engineer and Group Leader of the Photonic Transport Network Laboratory, NTT Network Innovation Laboratories at Nippon Telegraph and Telephone Corporation. He gave a lecture entitled “FY 2014 Optical Technology Roadmap—Optical Communications Technology.” He introduced a summary of the Optical Communications Technology Roadmap established by clarifying social need in the 2030’s and by conducting a technology trend survey in related fields, for the purpose of “Enriching People’s Life,” which is the fourth theme in the Optical Technology Roadmap Implementation Project, a five-year project at OITDA since 2011.

Optical communications technology has built today’s information society by responding economically to growing traffic demands with numerous innovative technologies. Global optical communications networks connect the world, overcoming distances on a global scale. It is thought that optical communications will handle ever increasing traffic volumes with further technological innovations, disseminate to data centers, be linked with software for improved convenience, and evolve in the direction of reliability during disasters, etc. On the other hand, when proving the integrity of optical communications, sustainable approaches are mandatory to contribute to avoiding the energy crisis and global warming. Moreover, to prepare for the aging society and the decline in the working population, it is also important to develop networks with simplified maintenance and to build a disaster-proof infrastructure. In preparing the Optical Technology Roadmap for this fiscal year, technology trends in related fields were analyzed from the viewpoints of both optical communications users and optical communications providers. When creating an actual roadmap, a complete image of the future roles of optical communications were shared among specialist committee members, and the fields to focus on were isolated by breaking down the image from the above two viewpoints. Then for each field, two milestones were set: one for 2020 and the other for 2030. He concluded his speech by hoping that the Roadmap will act as a guide in determining the direction of research and development in optical technology to enrich people’s lives.

The third lecture in the afternoon was by Mr. Takuji Soeno from the Advanced Television Systems Research Division of NHK Science and Technology Research Laboratories, and was titled “Development of an Optical Interface for 8K/4K Video Equipment.” He first introduced the ongoing development of equipment for 8K Super Hi-Vision (SHV), a next-generation broadcasting system. As the maximum data rate of an SHV video signal is approximately 144 Gbit/s, an interface between equipment using optical cables was developed aiming for the start of SHV test broadcasting. The interface developed was proposed to the Association of Radio Industries and Businesses (ARIB) and an ARIB standard, STD-B58 “Interface for UHDTV Production Systems” was established in March 2014. This interface is called U-SDI and the external dimensions of U-SDI optical cables are similar to current Hi-Vision coaxial cables. He gave an easy-to-understand overview of the status of development of U-SDI equipment with many photos. He concluded that it is necessary to develop recording and storage technology, and TV production equipment before starting test broadcasting, and expressed hopes for optical wiring technology and systemization technology that are under development under PETRA.

Finally, Mr. Ichiro Ogura and Mr. Hiroshi Onaka of PETRA gave a lecture entitled “Photonics Electronics Convergence Technology for Power-Reducing Jisso System - Optical I/O Core and Digital Coherent Transceiver.” The “Photonics Electronics Convergence Technology for Power-Reducing Jisso System” project is almost into its third year. They introduced two technologies as the results of technological developments that are near practical application: optical I/O core and digital coherent transceivers. Following a summary of the project, Mr. Ichiro Ogura

described the purpose of optical I/O cores and the status of development, explaining in detail standardization activities, which are important for putting optical I/O cores into application. The conventional optical interconnection is built from discrete components. However, providing an optical I/O core as a single component that has a simple optical-electric interface enables everybody to manufacture a compact and low-power consumption device. This optical I/O core can transmit signals over a distance of 500 m through a multi-mode fiber. It can fill the area where no standard exists. He concluded his speech by stating that future standardization activities are very important for actualizing optical I/O cores.

Mr. Hiroshi Onaka reported the state of development of digital coherent transceiver technology for data center networks. After explaining the development of 100 Gbit/s digital coherent modulation/demodulation technology and the status of developing a transceiver, he introduced a wavelength tunable LD, polarization multiplexing modulator, and coherent receiver, which are components of the newly developed low-power consumption digital coherent DSP. These technological developments have enabled construction of a transceiver with one third the power consumption and half the mounting area compared to conventional transceivers, demonstrating error-free transmission over a distance of 840 km. As oriented for data center networks, selecting DSP modes enables low-power consumption transmission/reception according to the transmission distance. At the end, he expressed his hopes of further miniaturization and reductions in power consumption in the transceiver by applying silicon photonics technology, etc.

## 1.2 Fourth Symposium on Optoelectronics Technology

The Fourth Symposium on Optoelectronics Technology was held jointly by the Electronics and Photonics Research Institute of AIST and OITDA at the Akihabara UDX Conference on February 18, 2015. On the day, nearly 131 people from industry and related research institutes participated, displaying the high level of interest this field has drawn. This fiscal year, under the theme “Applications of Ultra-Short Pulse Lasers and the Future of Portable Sensors,” a total of 11 oral presentations including six invited lectures and a panel discussion on sensors were held.

In the morning session, there was a lecture by Dr. Kunihiro Washio of Paradigm Laser Research entitled “World Laser Application Technology Trends,” which introduced work on ultra-short pulse lasers across the world. Dr. Katsumi Midorikawa of the Institute of Physical and Chemical Research (RIKEN) introduced a summary of the cutting edge research and development at RIKEN under the title “Strategy for Quantum Optics Engineering at RIKEN.” Dr. Hiroyuki Niino of the Research Institute for Innovation in Sustainable Chemistry of AIST reported the results of a national project running for approximately five years under the title “Laser Processing of CFRP Materials - Results of the Advanced Laser and Process Technology Research Association (ALPROT).” Then, Dr. Masayuki Kakehata of the Electronics and Photonics Research Institute of AIST gave a lecture entitled “Materials Processing by Femtosecond Laser Irradiation and Its Application” and Dr. Dai Yoshitomi of the same organization spoke on the subject “Deployment of Ultrashort Pulse Light Technology by Multicolor Coherent Synthesis,” both of which drew the attention of the participants.

In the afternoon, there were lectures on “The Future of Portable Sensors” including “High-Sensitivity Spectrometer for Living Bodies and Its Application to Non-invasive Testing of Substances in Blood” (by Dr. Hiromitsu Furukawa), “V-Trench Biosensor” (by Dr. Hiroki Ashiba), and “Waveguide-Mode Sensor: Review” (by Dr. Makoto Fujimaki), which reported the results of state-of-the-art research and development on portable sensors. Then, three invited talks were given with a variety of content: “Sensing Materials and Development of Chemical Sensors” (by

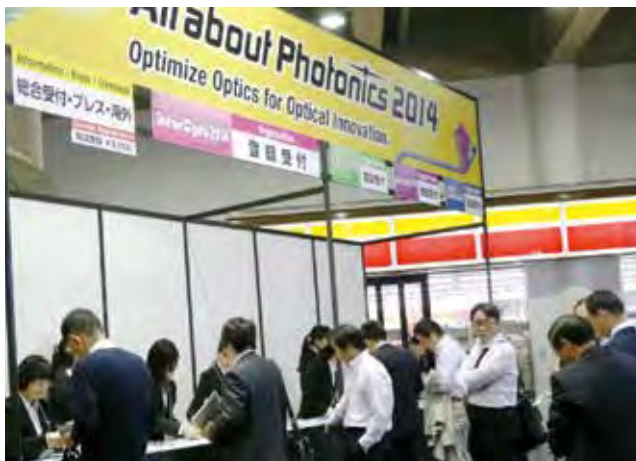


Professor Koji Suzuki, Keio University), “Functionalization of a Solid/Liquid Interface and Bio-transistors” (Professor Yuji Miyahara, Tokyo Medical and Dental University), and “Development of Water Quality Sensors in the Asia Strategy Water Project” (by Dr. Masaki Torimura of the Research Institute for Environmental Management Technology of AIST). Finally, with the lecturers as panelists on the stage, a panel discussion entitled “Future Outlook of Sensor Development” was held. They had lively discussions with many participants interested in each field and the symposium closed with great success.

## 2. InterOpto

The International Optoelectronics Exhibition 2014 (InterOpto 2014) was held from October 15 (Wed) to 17 (Fri), 2014 with the theme “All about Photonics.” It was held at the Pacifico Yokohama Exhibition Hall in the Minato Mirai zone of Yokohama City with three other conventions: BioOpto JAPAN 2014 (held by ICS Convention Design, Inc.), LED JAPAN – Strategies in Light 2014 (held by ICS Convention Design, Inc. and PennWell Corporation) and LaserTech 2014 (held by ICS Convention Design, Inc.). InterOpto was organized by OITDA, with planning and promotion by ICS Convention Design, Inc. and with the support/sponsorship of the Ministry of Economy, Trade and Industry and many other organizations.

The exhibition covers a wide range of fields such as; lasers/light sources, optical elements/parts, materials, optical machinery/devices, optical industry related services/software. A wide range of technologies were also exhibited, ranging from optical related materials to optical application systems.



One hundred and seven domestic and foreign optoelectronics manufacturers, trading companies, etc. (85 the last year) participated in the exhibition with 174 booths (138 the last year) and there were 8,467 registered visitors (including visitors to the simultaneously held exhibitions) over the three days (8,157 the last year). As well as Japanese companies and institutes, foreign trading companies from North America, Europe, Asia, etc. joined the exhibition to share technologies and information on a wide range of optical fields and give an overview of cutting edge optical products and their development status.

A “Notable Optoelectronics Technology and Special Exhibit Zone” was set up in the Pacifico Yokohama Exhibition Hall. In this zone, six companies recommended by each working group of OITDA’s Optoelectronics Technology Trend Committee exhibited their recommended technologies. The zone also had technology exhibits from three small and medium enterprises, to which OITDA provided support for the exhibition for their new optoelectronics industry related projects. Meanwhile, OITDA displayed panels presenting an outline of the optoelectronics industry and technologies and showed various survey

reports from research in the optoelectronics industry and technologies. OITDA also carried out public relations activities such as distribution of the Annual Technical Report of OITDA (Japanese and English edition), introduction of OITDA and presentation of the latest information on the optoelectronics industry and technologies.

Just before the opening of the Exhibition, there was an announcement that three Japanese scientists: Professor Isamu Akasaki of Meijo University, Professor Hiroshi Amano of Nagoya University, and Professor Shuji Nakamura of the University of California, Santa Barbara, had been awarded the 2014 Nobel Prize in Physics “for the invention of efficient blue light-emitting diodes which has enabled bright and energy-saving white light sources.” The announcement drew attention to optical technology and exhibitors received questions from many visitors not only at the LED-related (low-power LED lighting) exhibition booths but also at the BioOpto medical photonics exhibition booths, the booths exhibiting laser processing technology including the LaserTech and the booths exhibiting other new optical technologies. Many business negotiations were also held at all the booths, indicating visitors’ strong interest in technologies that lead to improvements in business performance. Also, the Notable Optoelectronics Technology Seminar and an Exhibitors Presentation were held for three days from October 15 to 17 at the same venue. These also bricked up the event.

Further, on October 15 in Seminar Room A, there was a special lecture entitled “Lies and the Reality of the 3D Printer Boom” by Mr. Daichi Watanabe, President/CEO of JMC Corporation and eight seminars on optoelectronics industry trends were presented by OITDA’s Optoelectronics Industry Trend Research Committee. And on October 16, Professor Hiroshi Segawa of the Research Center for Advanced Science and Technology at the University of Tokyo gave a special lecture entitled “Evolving Organic Solar Cells – Efficiency and Performance Improvements” and Optoelectronics Technology Trend Research Committee of OITDA held seminars on technology trends in seven optoelectronics technology fields.



InterOpto 2015 will be held for three days from October 14 (Wed) to 16 (Fri), 2015. The venue will be the Pacifico Yokohama, the same site as the last year, and it will be held under the title “All about Photonics.”

## 3. 30th Kenjiro Sakurai Memorial Prize (Sakurai Prize)

This year, the Sakurai Prize was awarded to two persons among 14 applicants for achievements in their pioneering roles in the optoelectronics industry and technology since 2004. The prize for “Advanced research on super-resolution microscopy based on plasmon effects” was awarded to Dr. Satoshi Kawata of Osaka University/Institute of Physical and Chemical Research (RIKEN)/Nanophoton Corporation, and the prize for “Realization of 2nd-generation thin film solar cells based on CIS thin film technology” was awarded to Dr. Katsumi Kushiya

of Showa Shell Sekiyu K.K./Solar Frontier K.K.



(From left) Dr. Katsumi Kushiya, Dr. Satoshi Kawata

The Sakurai Prize was established as a memorial to the former Director of OITDA, Dr. Kenjiro Sakurai, who played a major role in developing the optoelectronics industry, and for the purpose of promoting technological development of the optoelectronics industry. Of the 29 times it has been offered, the prize has been awarded to 21 individuals and 34 groups, totaling 132 people.

Dr. Satoshi Kawata of Osaka University was awarded for his leading domain expansion and technological development of plasmonics by proposing and demonstrating many new concepts on mutual reactions between metal nanostructures and photons, in particular developing the world's first super-resolution microscopic system using Raman scattering based on plasmon effects by using a metal probe with a nano-size tip diameter. He has made great contributions to a range of fields and industries by expanding the targets of measurement from molecules to nano-semiconductor materials and nano-bio materials. In addition to these superior research achievements, he created innovation in the optoelectronics industry by manufacturing and selling Raman microscopes to researchers on leading-edge research for more than 10 years through a venture company he established."

Dr. Katsumi Kushiya of Showa Shell Sekiyu K.K./Solar Frontier K.K. received an award for achieving a conversion efficiency that could not be realized with the 1st generation thin film solar cells, with  $\text{CuInSe}_2$  Chalcopyrite (CIS) thin film solar cells in a Cd- and lead-free form that is effective in reducing environmental impact, and also for succeeding in its commercialization. CIS thin film solar cells, whose performance is comparable to single-crystal Si solar cell technology, are produced at full-capacity operation on the world's largest one-gigawatt line, and are expanding from solar houses to solar power generation plants through the "made in Japan" thin film solar business. It is recognized that the development of CIS thin film solar cell technology will make great contributions to the future development of the optoelectronics industry, mainly based on opto-electric conversion technology, as well as resolving energy security and global environmental problems.

The award ceremony for these two awardees was performed following the Symposium on the Optoelectronics Industry and Technology held on February 4, 2015.

At the ceremony, Dr. Yasuhiko Arakawa (Professor at the University of Tokyo), chairperson of the Kenjiro Sakurai Memorial Prize Committee, reported on the selection process and results. After that, the certificates, medals and extra prizes were presented to the awardees. Dr. Kawata and Dr. Kushiya then gave their greetings and thanks, and the ceremony ended.

As these, the 30th awards, were particularly memorable, Mrs. Shizuko Sakurai, the widow of Kenjiro Sakurai was invited to the ceremony and gave a greeting at the reception after the ceremony.

#### 4. Flash Reports on International Conferences (For Supporting Members)

The Flash Reports on International Conferences constitute an information service that distributes the latest trends in optoelectronic research and development presented at major international conferences. These reports include the subjective opinions of the author, and are sent via e-mail. This fiscal year, 50 reports were distributed. The conferences covered by flash reports, flash report theme, conference starting date, and field of technology are shown in [Table 1](#).



Table 1 List of Flash Reports on International Conferences FY 2014

No.	Meeting	Theme	Starting Date	Technology Field
1	OFC2014	Optical fiber	Mar. 9, 2014	Optical Communication
2	OFC2014	Optical devices and module for communication	Mar. 9, 2014	Inorganic Optical Devices and Materials
3	IPRM2014	Optical devices and materials for communication	May. 11, 2014	Inorganic Optical Devices and Materials
4	META'14	Optical Calculation	May. 20, 2014	Information Processing Photonics
5	LOPEC2014	Printed electronics	May. 26, 2014	Organic Optical Devices and Materials
6	WLED-5	White LED lighting	Jun. 1, 2014	Organic Optical Devices and Materials
7	SID2014	OLED	Jun. 1, 2014	Optical User Interfaces
8	SID2014	LCT	Jun. 1, 2014	Optical User Interfaces
9	CLEO2014	Optical devices/basic technologies	Jun. 8, 2014	Inorganic Optical Devices and Materials
10	LPM2014	Laser microfabrication	Jun. 17, 2014	Optical Laser Processing and Measurement
11	IEEE PVSC	Compound thin-film solar cell	Jun. 8, 2014	Light Energy
12	SolarFuel14	Solar power - Chemical energy conversion	Jun. 24, 2014	Light Energy
13	HCII2014	Communication related	Jun. 22, 2014	Optical User Interfaces
14	SID2014	3D	Jun. 1, 2014	Optical User Interfaces
15	LALS2014	Life Sciences	Jun. 29, 2014	Optical Laser Processing and Measurement
16	DH2014	Holography	Jul. 13, 2014	Optical Laser Processing and Measurement
17	GFP2014	Group IV photonics	Aug. 27, 2014	Inorganic Optical Devices and Materials
18	IWN2014	GaN, visible / ultraviolet light source	Aug. 24, 2014	Inorganic Optical Devices and Materials
19	EPCOS2014	Phase change materials	Sep. 7, 2014	Information Processing Photonics
20	ISLC2014	Semiconductor Laser	Sep. 7, 2014	Inorganic Optical Devices and Materials
21	ECOC2014	Backbone transmission	Sep. 21, 2014	Optical Communication
22	ECOC2014	Optical access	Sep. 21, 2014	Optical Communication
23	ECOC2014	Optical fiber	Sep. 21, 2014	Optical Communication
24	ECOC2014	Silicon Photonics	Sep. 21, 2014	Information Processing Photonics
25	39th IRMMW-THz	Infrared and millimeter-wave and terahertz	Sep. 14, 2014	Inorganic Optical Devices and Materials
26	ECOC2014	Optical devices for communication	Sep. 21, 2014	Inorganic Optical Devices and Materials
27	29thEUPVSC	PV evaluation technologies	Sep. 22, 2014	Light Energy
28	ICALEO2014	Laser processing	Oct. 19, 2014	Optical Laser Processing and Measurement
29	29thEUPVSC	Crystalline silicon solar cell	Sep. 22, 2014	Light Energy
30	ICFPE2014	Flexible devices, Printed devices	Oct. 21, 2014	Organic Optical Devices and Materials
31	IEEE Sensors2014	Sensors	Nov. 3, 2014	Optical Laser Processing and Measurement
32	ISOM'14	Optical memory	Oct. 20, 2014	Information Processing Photonics
33	PCOS2014	Phase change materials and devices	Dec. 4, 2014	Information Processing Photonics
34	fNIRS2014	Life sciences	Oct. 10, 2014	Optical Laser Processing and Measurement
35	TSS	Trillion Sensors Universe	Nov. 12, 2014	Organic Optical Devices and Materials
36	IDW'14	OLED	Dec. 3, 2014	Optical User Interfaces
37	IDW'14	Quantum dot, Printed electronics	Dec. 3, 2014	Optical User Interfaces
38	IDW'14	AR/VR	Dec. 3, 2014	Optical User Interfaces
39	PW2015 LASE	Laser processing	Feb. 7, 2015	Optical Laser Processing and Measurement
40	PW2015 BIOS	Single molecule measurement	Feb. 7, 2015	Optical Laser Processing and Measurement
41	2015FLEX	Flexible electronics	Feb. 23, 2015	Organic Optical Devices and Materials
42	Label-Free	Bio sensors	Mar. 12, 2015	Optical Laser Processing and Measurement
43	PW2015 OPTO	Organic materials	Feb. 7, 2015	Organic Optical Devices and Materials
44	OFC2015	Optical network	Mar. 22, 2015	Optical Communication
45	OFC2015	Optical access	Mar. 22, 2015	Optical Communication
46	OFC2015	Backbone transmission	Mar. 22, 2015	Optical Communication
47	OFC2015	Optical Interposer substrate	Mar. 22, 2015	Information Processing Photonics
48	OFC2015	Optical fiber	Mar. 22, 2015	Optical Communication
49	OFC2015	Optical Transmitting device	Mar. 22, 2015	Inorganic Optical Devices and Materials
50	LOPE-C 2015	Printed electronics	Mar. 3, 2015	Organic Optical Devices and Materials

## Committees &amp; Meetings in FY 2014

(As of March 31, 2015)

Committees & Meetings	Number of Meetings	Number of Members	Chairperson, etc. (Affiliation)	Secretariat
Technological Strategy Development Committee	2	14	Y. Arakawa (Univ. of Tokyo)	Iguchi, Yoshikawa
Optical Communication Technology Joint Committee	6	9	A. Hirano (NTT)	Iguchi, Nakano, Yamashita
Optoelectronics Technology Trend Research Committee	2	54	Y. Nakano (Univ. of Tokyo)	Watanuki, Yoshikawa
Inorganic Optical Devices and Materials Group	3	8	T. Tsuchiya (Hitachi)	Tom. Yamada
Information Processing Photonics Group	3	9	O. Matoba (Kobe Univ.)	Ushioda
Optical Processing and Measurement Group	4	11	M. Fujita (ILT)	Tak. Yamada
Light Energy Group	3	9	A. Yamada (Tokyo Inst. of Tech.)	Yamashita
Organic Optical Devices and Materials Group	3	8	N. Yamamoto (AIST)	Ishimori
Optical User Interface Group	3	7	M. Hasegawa (Merck)	Takahashi
Patent Application Trend Survey Committee	5	9	Y. Kodama (AIST)	Takahashi
Optoelectronics Industry Trend Research Committee	2	10	N. Kobayashi (Waseda Univ.)	Ishimori, Yoshikawa
Optical Communication Research Committee	3	6	T. Kataoka (NTT)	Tak. Yamada, Yoshikawa
Optical Storage Research Committee	3	6	K. Nakagawa (Nihon Univ.)	Iguchi, Yoshikawa
Optical Input/Output Research Committee	3	6	M. Okutomi (Tokyo Inst. of Tech.)	Watanuki, Yoshikawa
Display and Solid-state Lighting Research Committee	3	4	M. Omodani (Tokai Univ.)	Takahashi, Yoshikawa
Photovoltaic Energy Research Committee	4	15	K. Kurokawa (Tokyo Inst. of Tech.)	Ushioda, Yoshikawa
Laser Processing Research Committee	3	8	K. Sugioka (Riken)	Suzaki, Yoshikawa
Optical Sensing and Measurement Research Committee	3	7	M. Itoh (Univ. of Tsukuba)	Tom. Yamada, Yoshikawa
Kenjiro Sakurai Memorial Prize Committee	1	9	Y. Arakawa (Univ. of Tokyo)	Suzaki, Kazumoto
Standardization Society General Meeting	1	38	K. Kondo (Mitsubishi)	Murata, Masuda, Kobayashi
Fiber Optics Standardization Meeting	3	18	M. Kawase (Chitose Inst., Sci. Tech.)	Murata, Ushioda
Administrative Advisory Submeeting	3	6	M. Kawase (Chitose Inst., Sci. Tech.)	Murata
Dynamic Module Submeeting	6	18	M. Itoh (NTT)	Watanuki, Nakano
Intra-Building Optical Wiring Submeeting	5	12	K. Ieda (NTT)	Ishimori
Optical Fiber Sensors Submeeting	6	22	H. Murayama (Univ. of Tokyo)	Yamashita, Tak. Yamada
Optical Fiber Standardization Meeting	5	17	H. Izumita (NTT)	Suzaki, Yamashita
Optical Connector Standardization Meeting	9	20	S. Asakawa (NTT)	Tak. Yamada, Murata
Optical Passive Components Standardization Meeting	9	16	T. Mizumoto (Tokyo Inst. of Tech.)	Iguchi, Murata
Optical Active Device Standardization Meeting	7	13	J. Yoshida (Chitose Inst., Sci. Tech.)	Suzaki, Tak. Yamada
Optical Amplifier Standardization Meeting	5	18	M. Yamada (Osaka Prefecture Univ.)	Nakano, Watanuki
Optical Subsystem Standardization Meeting	5	17	H. Takara (NTT)	Ushioda, Takahashi
Optical Measuring Instrument Standardization Meeting	5	16	K. Noguchi (Tohoku Inst. of Tech.)	Tom. Yamada, Ishimori
TC 76/Laser Safety Standardization Meeting	0	30	Y. Hashishin (Kinki Univ.)	Murata, Kobayashi
ISO/TC 172/SC 9 Standardization Meeting (Japanese National Body)	0	18	G. Hatakoshi (Toshiba)	Masuda, Kobayashi
Optical Disc Standardization Meeting	3	18	M. Irie (Osaka Sangyo Univ.)	Takahashi, Ishimori
Media Submeeting	8	10	S. Taniguchi (Pioneer)	Takahashi, Ishimori
Application Submeeting	3	11	H. Osawa (Toshiba)	Ishimori, Takahashi
Format Submeeting	13	10	Y. Komachi (Kokushikan Univ.)	Takahashi
International Standardization and Dissemination Committee for High-speed Communication Network Performance over Large Core Multimode Optical Fiber (V-Pro 2)	3	46	M. Kagami (Toyota Central R&D Labs.)	Tak. Yamada, Masuda, Kobayashi
Committee for International Standardization of Fiber Optic Connector Optical Interfaces for Fiber Interface Connectors (T-Pro 2)	4	10	S. Asakawa (NTT)	Nakano, Masuda, Kobayashi
Committee for Standardization of Laser Safety (J-Pro)	4	30	Y. Hashishin (Kinki Univ.)	Murata, Suzaki
Subcommittee for New Light Projector	6	4	S. Mitsuhashi (Sony)	Murata
Subcommittee for Beam Delivery	4	8	K. Washio (Paradigm Laser Research)	Suzaki, Murata
Committee for International Standardization of Highly Laser-resistant Laser Guards (C-Pro)	5	10	K. Washio (Paradigm Laser Research)	Watanuki, Murata, Masuda, Kobayashi
Committee for Standardization of Optical Disc Evaluation Criteria (O-Pro)	4	13	M. Irie (Osaka Sangyo Univ.)	Takahashi, Masuda, Kobayashi
Research Committee on Safety and Security of Laser Equipment	4	6	Y. Hashishin (Kinki Univ.)	Murata, Masuda, Kobayashi
Laser Safety School Steering Committee	2	8	T. Arai (Chuo Univ.)	Okuma, Hirashima
Laser Equipment Engineering Examination Committee	2	8	H. Irie (JWSC)	Okuma, Hirashima

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