Annual Technical Report 2017

Year Ended March 31, 2018

OITDA

Optoelectronics Industry and Technology Development Association

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Message from OITDA

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It is my pleasure to present to you our Annual Technical Report 2017, which outlines the result of our surveys, research and development activities in FY 2017.

According to the Optoelectronics Industry Trends Survey conducted every year by OITDA, the total shipments of the optoelectronics industry recorded positive growth of 1.2% to reach 14,432.7 billion yen in FY 2017, compared to －15.5% in FY 2016. Domestic production also showed signs of recovery, with a 1.0% decrease to finish at 7,716.8 billion yen in FY 2017, compared to a decrease of 12.4% in FY 2016. The improvement is attributable to positive growth in shipments in almost all fields of the optoelectronics industry, with the photovoltaic energy field alone recording a significant drop (－19.3%). The breakdown is: +20.8% for image sensors, +10.1% for laser/optical processing, +9.6% for display equipment, +7.3% for optical sensing and measuring, +4.0% for optical input/output equipment, +3.3% for optical storage, and +2.9% for LED lighting.

The fields that showed good performance in FY 2017 were led by new emerging markets such as investment in data centers following the development of artificial intelligence (AI), the Internet of Things (IoT) and Big Data, and automated driving systems in the automotive field, with the effects of the Winter Olympic and Paralympic Games evident. The new markets require new technologies for collection, communication and processing of massive amounts of data as common technologies. Optoelectronics technologies include many key technologies such as various sensors including image sensors and high-speed cameras in data collection, high-speed large-capacity optical network systems in data communication, and high-speed, low-power optoelectronic integrated circuits in data processing.

OITDA has been promoting the formulation of a research and development strategy and commercialization strategy through cooperation among industry, academia and government regarding the optoelectronics technologies. At the same time, OITDA has engaged in the following priority issues: survey and research on the optoelectronics technology and industry, promotion of technology development, promotion of standardization, creation of new business, and development of human resources. In FY 2017, 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 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 2017. First, we established the Automobile/Mobility Photonics Study Group to examine and discuss optoelectronics technologies utilized in vehicles such as (1) automated driving systems including camera technology and ranging technology, (2) in-vehicle networks and (3) data processing technology. Furthermore, in the Optoelectronics Technological Strategy Development Committee, we drew up a vision for developing optoelectronics technologies toward the Age of AI/IoT in a broad range of fields, including (1) optical communication systems and optical sensors required for IoT and (2) optical devices and optical switches required for AI processing systems. This vision was presented at the Symposium on the Optoelectronics Industry and Technology held on February 7, 2018 and is expected to be reflected effectively in research and development undertaken by industry, academia, and government.

With regard to standardization, we actively carried out international standardization activities at IEC, ISO, and other forums, primarily for the standardization of in-vehicle high-speed optical Ethernet, connectors for interconnection of optical fibers, and optical switches through the project of the Ministry of Economy, Trade and Industry.

In order to support the growth of optoelectronics industry and technology, 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 and 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.

Optoelectronics Industry Trends

1. Introduction

Technologies that will dramatically change our society, such as automated driving, AI and IoT, are rapidly being put into actual use. At this major turning point, it is crucial to create new technologies and industries toward our future society and markets. Optoelectronics technology includes many technologies that will serve as the basis of new industries, such as communication technology and sensing technology. The optoelectronics industry, which has greatly contributed to the economic growth of Japan by leading new innovation and industrializing advanced technologies, is expected to take further strides as an industry leader.

Thanks to the great support and cooperation of its affiliated members and enterprises, OITDA has conducted its annual "Survey of Trends in the Optoelectronics Industry" since its foundation in 1980. The resulting data, accumulated over more than 30 years, are highly regarded as providing 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 subcommittees—namely, on optical communications, optical storage, input/output equipment, display and solid-state lighting, photovoltaic energy, laser/optical processing, and sensing and measuring—were established under the Optoelectronics Industry Trend Research Committee (parent committee) to survey and analyze the trends in each field and the optoelectronics industry as a whole.

2. Total Shipments and Domestic Production for the Optoelectronics Industry

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

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

In order to determine the industry trends of domestic enterprises that manufacture optoelectronics-related products (optoelectronics equipment/systems and optical components), a survey was carried out by sending questionnaires to 263 enterprises in October 2017. Questions were asked about actual results for FY 2016, estimated values for FY 2017, and qualitative projections for FY 2018 concerning total shipments and domestic production. The completed questionnaires were then collected from December 2017 to February 2018.

In addition to the questionnaire survey, we also referred to the data of the Japan Photovoltaic Energy Association (JPEA), Japan Lighting Manufacturers Association (JLMA), Japan Electronics and Information Technology Industries Association (JEITA), Camera & Imaging Products Association (CIPA), and Fuji Chimera Research Institute, Inc. regarding the photovoltaic energy field, solid-state lighting field, display field, and input/output equipment field.

Based on the results of the questionnaire and the reference data, total shipments including overseas production, domestic production, and the industry trend in each product field were analyzed by the field-specific research subcommittees. The validity of the data and analysis results were reviewed by the Optoelectronics Industry Trend Research Committee, and the research results were compiled as a report on the optoelectronics industry trends in Japan.

In this survey, the optoelectronics industry is categorized into the following seven product fields, plus an additional field labeled "Others." Each product field is further divided into equipment/systems and components.

1. Optical Communication:	Optical transmission equipment/systems, optical fiber fusion splicer, light emitting devices, photo detectors, optical passive components, optical fiber, optical connectors, etc.
2. Optical Storage:	Optical disc equipment (read-only, recordable), optical disc media, laser diodes, etc.
3. Input/Output:	Optical printers, multifunction printers, digital cameras, digital video cameras, camera mobile phones, image sensors, etc.
4. Display and Solid-state Lighting:	Flat panel display devices and equipment, projectors, solid-state lighting devices and equipment, LED (for lighting and displays), etc.
5. Photovoltaic Energy:	Photovoltaic power generation systems, photovoltaic cells and modules
6. Laser/Optical Processing:	Laser/optical processing equipment, lamp/LD lithography, additive manufacturing (3D printers), laser oscillators
7. Sensing and Measuring:	Optical measuring instruments, optical sensing equipment
8. Others:	Hybrid optical devices, etc.

(Notes)	Dotted underline:	Items added to the optoelectronics products classification since the FY 2009 research.
	Single underline:	Items added to the optoelectronics products classification since the FY 2010 research.
	Dashed underline:	Items added to the optoelectronics products classification since the FY 2013 research.
	Wavy underline:	Items added to the optoelectronics products classification since the FY 2014 research.

2.2 Overview of Survey Results of Total Shipments

Table 1 shows actual total shipments for FY 2016, estimated total shipments for FY 2017, and a qualitative projection of total shipments for FY 2018. The blue shaded sections in Table 1 represent optoelectronics equipment/systems, and the yellow sections represent optical components.

● FY 2016 (results): 14,262.0 billion yen, growth rate: −15.5%

In FY 2016, total shipments (results) for the optoelectronics industry amounted to 14,262.0 billion yen (growth rate: −15.5%). This breaks down as: 9,812.3 billion yen for optoelectronics equipment/systems (growth rate: −17.6%, component ratio: 68.8%) and 4,449.8 billion yen for optical components (growth rate: −10.4%, component ratio: 31.2%).

The shipments by field were:
523.7 billion yen for the optical communication field (growth rate: −0.5%, component ratio: 3.7%),
1,173.3 billion yen for the optical storage field (growth rate: −3.9%, component ratio: 8.2%),
3,385.5 billion yen for the input/output equipment field (growth rate: −16.6%, component ratio: 23.7%),
5,343.2 billion yen for the display and solid-state lighting field (growth rate: −17.1%, component ratio: 37.5%),
2,831.2 billion yen for the photovoltaic energy field (growth rate: −24.2%, component ratio: 19.9%),
658.6 billion yen for the laser/optical processing field (growth rate: +18.1%, component ratio: 4.6%), and
260.6 billion yen for the sensing and measuring field (growth rate: +3.5%, component ratio: 1.8%).

● FY 2017 (estimation): 14,432.7 billion yen, growth rate: +1.2%

Total shipments for the optoelectronics industry in FY 2017 are estimated to remain roughly flat at 14,432.7 billion yen (growth rate: +1.2%). This breaks down as: 9,931.0 billion yen for optoelectronics equipment/systems (growth rate: +1.2%, component ratio: 68.8%) and 4,501.6 billion yen for optical components (growth rate: +1.2%, component ratio: 31.2%).

The shipments by field are estimated to be:
503.7 billion yen for the optical communication field (growth rate: －3.8%, component ratio: 3.5%),
1,211.8 billion yen for the optical storage field (growth rate: +3.3%, component ratio: 8.4%),
3,635.7 billion yen for the input/output equipment field (growth rate: +7.4%, component ratio: 25.2%),
5,692.5 billion yen for the display and solid-state lighting field (growth rate: +6.5%, component ratio: 39.4%),
2,285.1 billion yen for the photovoltaic energy field (growth rate: －19.3%, component ratio: 15.8%),
724.9 billion yen for the laser/optical processing field (growth rate: +10.1%, component ratio: 5.0%), and
279.5 billion yen for the sensing and measuring field (growth rate: +7.3%, component ratio: 1.9%).

● FY 2018 (projections): slight increase

Total shipments are projected to increase slightly for the optoelectronics industry overall, as well as for optoelectronics equipment/systems and optical components in FY 2018.

By field, the optical communication field will increase slightly, and the optical storage field will slightly decrease. The input/output equipment field will remain steady, and the display and solid-state lighting field will remain steady. The photovoltaic energy field will decrease, while the laser/optical processing field and the sensing and measuring field will increase slightly.

2.3 Overview of Survey Results of Domestic Production

Table 2 shows the actual domestic production for FY 2016, estimated domestic production for FY 2017, and a qualitative projection of domestic production for FY 2018.

● FY 2016 (results): 7,796.6 billion yen, growth rate: －12.4%

Domestic production (results) for the optoelectronics industry in FY 2016 decreased significantly to 7,796.6 billion yen (growth rate: －12.4%). This breaks down as: 4,519.8 billion yen for optoelectronics equipment/systems (growth rate: －13.9%, component ratio: 58.0%) and 3,276.7 billion yen for optical components (growth rate: －10.3%, component ratio: 42.0%).

The domestic production by field was:
441.1 billion yen for the optical communication field (growth rate: －1.2%, component ratio: 5.7%),
218.8 billion yen for the optical storage field (growth rate: －7.1%, component ratio: 2.8%),
1,035.7 billion yen for the input/output equipment field (growth rate: －2.3%, component ratio: 13.3%),
3,014.8 billion yen for the display and solid-state lighting field (growth rate: －9.9%, component ratio: 38.7%),
2,198.1 billion yen for the photovoltaic energy field (growth rate: －27.5%, component ratio: 28.2%),
638.3 billion yen for the laser/optical processing field (growth rate: +17.3%, component ratio: 8.2%), and
173.5 billion yen for the sensing and measuring field (growth rate: +3.2%, component ratio: 2.2%).

● FY 2017 (estimation): 7,716.8 billion yen, growth rate: －1.0%

The domestic production of the optoelectronics industry in FY 2017 is estimated to remain steady at 7,716.8 billion yen (growth rate: －1.0%). This breaks down as: 4,232.1 billion yen for optoelectronics equipment/systems (growth rate: －6.4%, component ratio: 54.8%) and 3,484.7 billion yen for optical components (growth rate: +6.3%, component ratio: 45.2%).

The domestic production by field was:
424.5 billion yen for the optical communication field (growth rate: －3.8%, component ratio: 5.5%),
218.1 billion yen for the optical storage field (growth rate: －0.3%, component ratio: 2.8%),
1,071.5 billion yen for the input/output equipment field (growth rate: +3.5%, component ratio: 13.9%),
3,232.1 billion yen for the display and solid-state lighting field (growth rate: +7.2%, component ratio: 41.9%),
1,794.7 billion yen for the photovoltaic energy field (growth rate: －18.4%, component ratio: 23.3%),
699.4 billion yen for the laser/optical processing field (growth rate: +9.6%, component ratio: 9.1%), and
188.0 billion yen for the sensing and measuring field (growth rate: +8.4%, component ratio: 2.4%).

● FY 2018 (projections): slight increase

Domestic production in FY 2018 is projected to increase slightly for the optoelectronics industry overall, as well as for optoelectronics equipment/systems and optical components.

By field, the optical communication field will slightly increase, while the optical storage field will decrease slightly. The input/output equipment field and the display and solid-state lighting field will remain steady. The photovoltaic energy field will decrease, while the laser/optical processing field and the sensing and measuring field will increase slightly.

2.4 Trends in Total Shipments for the Optoelectronics Industry

(1) Changes in Total Shipments for the Optoelectronics Industry

Fig. 1 shows the changes in the total shipments of the Japanese optoelectronics industry and the rate of growth from the previous fiscal year for the nine years from FY 2009 to FY 2017. The nominal GDP (one-tenth of the actual value) and the total (domestic and overseas) production of the Japanese electronics industry are added as a reference to allow comparison between the total shipments for the optoelectronics industry and domestic production for the Japanese economy and other industries.

In FY 2016, the overall output of the optoelectronics industry decreased considerably (－15.5%) due to the significant decrease in the photovoltaic energy field.

In FY 2017, the output of the entire industry is expected to remain steady at +1.2% despite a continued decrease in the photovoltaic energy field due to positive growth in the fields other than optical communication and photovoltaic energy, especially in the display and solid-state lighting field and the input/output equipment field.

Fig. 2 shows the changes by field. In FY 2016, five fields, that is, all fields except for the laser/optical processing field and the sensing and measuring field, recorded negative growth. The laser/optical processing field increased considerably due to the increase in capital investment mainly in the automotive industry. The sensing and measuring field also increased slightly due to strong sales of photoelectric switches, laser microscopes, etc. In the input/output equipment field, image sensors remained strong but could not compensate for the decrease in digital cameras, etc., resulting in a significant decrease in the total shipment. In the display and solid-state lighting field, the total shipment of solid-state lighting remained strong while that of display equipment and devices decreased significantly because of declining prices due to the globally intense competition, and decrease in demand for iPhones in the global market, leading to the overall substantial decrease. The optical communication field remained almost flat, as an increase in light emitting devices and other components compensated for the decrease in optical transmission equipment for trunk lines and metro lines. The optical storage field decreased slightly due to the continuous price decline and

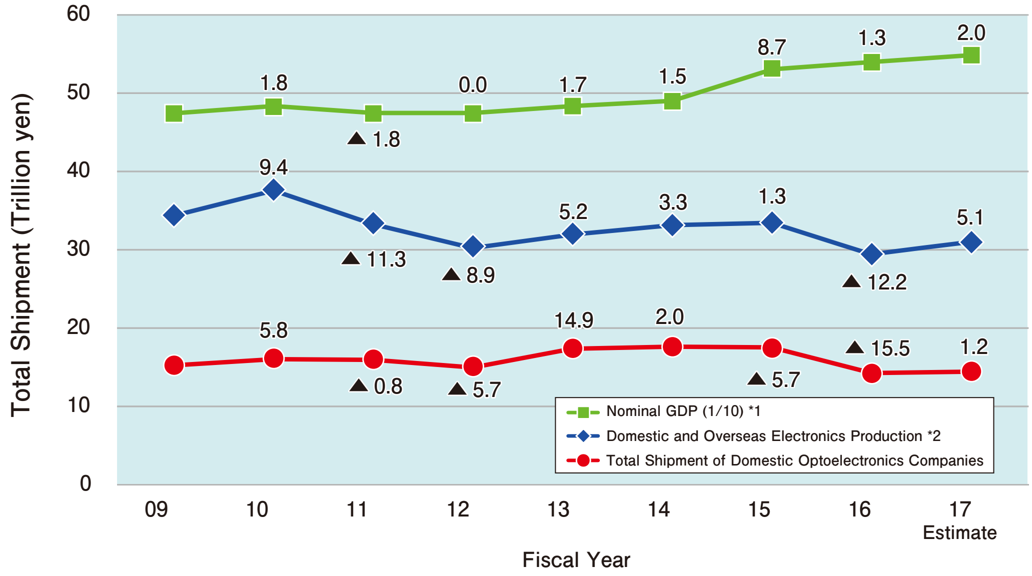
Table 1　Shipment of Optoelectronics Industry (Summary)

	Product Items	FY 2015 Shipment Actual (in million yen)		Growth Rate(%)	FY 2016 Shipment Actual (in million yen)		Growth Rate(%)	FY 2017 Shipment Estimate (in million yen)		Growth Rate(%)	FY 2018 Shipment Projection
	Optical Communications Field	526,187		1.7	523,719		▲ 0.5	503,681		▲ 3.8	slight increase
Optical Equipment	Optical Transmission Equipment	171,654		▲ 16.2	144,701		▲ 15.7	136,621		▲ 5.6	flat
Optical Equipment	Truck Line and Metro Line		93,916	▲ 10.0		71,450	▲ 23.9		59,453	▲ 16.8	flat
Optical Equipment	Subscriber Line		40,437	▲ 22.5		35,551	▲ 12.1		39,226	10.3	flat
Optical Equipment	Router and Switch		25,235	▲ 19.1		27,335	8.3		27,498	0.6	slight increase
Optical Equipment	Video Transmission (CATV, etc)		2,985	▲ 6.1		3,070	2.8		3,347	9.0	slight increase
Optical Equipment	Optical Fiber Amplifier		9,081	▲ 35.1		7,295	▲ 19.7		7,097	▲ 2.7	increase
Optical Component	Optical Transmission Component	331,145		13.7	357,764		8.0	343,706		▲ 3.9	slight increase
Optical Component	Optical Transmission Link		77,874	17.7		76,919	▲ 1.2		70,592	▲ 8.2	slight increase
Optical Component	Light Emitting Device		55,405	31.9		66,658	20.3		58,518	▲ 12.2	slight increase
Optical Component	Photo Detectors		17,076	22.3		25,328	48.3		21,103	▲ 16.7	slight increase
Optical Component	Optical Fiber		99,635	7.8		98,002	▲ 1.6		101,090	3.2	slight increase
Optical Component	Optical Connector		23,222	1.8		23,227	0.0		25,617	10.3	slight increase
Optical Component	Optical Passive Component		26,856	17.3		26,237	▲ 2.3		24,980	▲ 4.8	flat
Optical Component	Optical Circuit Component		19,203	▲ 4.5		28,749	49.7		29,738	3.4	slight increase
Optical Component	Others (Semiconductor Amplifying Device, Composite Optical Device)		11,874	9.8		12,644	6.5		12,068	▲ 4.6	flat
Optical Equipment	Optical Fiber Fusion Splicer	23,388		9.7	21,254		▲ 9.1	23,354		9.9	slight increase
	Optical Storage Field	1,220,344		▲ 6.9	1,173,306		▲ 3.9	1,211,768		3.3	slight decrease
Optical Equipment	Optical Disk	1,202,197		▲ 6.7	1,155,326		▲ 3.9	1,194,928		3.4	slight decrease
Optical Equipment	Equipment		1,109,427	▲ 6.6		1,064,939	▲ 4.0		1,106,712	3.9	slight decrease
Optical Equipment	Read-only (CD, CD-ROM UNIT, DVD, BD)		817,922	▲ 4.2		798,612	▲ 2.4		835,379	4.6	slight decrease
Optical Equipment	Recordable		291,505	▲ 12.8		266,327	▲ 8.6		271,333	1.9	flat
Optical Equipment	Media		36,522	▲ 8.7		36,395	▲ 0.3		32,106	▲ 11.8	slight decrease
Optical Equipment	Others (Optical Head, etc.)		56,248	▲ 6.6		53,992	▲ 4.0		56,110	3.9	flat
Optical Component	Laser Diode	18,147		▲ 19.9	17,980		▲ 0.9	16,840		▲ 6.3	decrease
	Input/Output Field	4,060,824		▲ 7.4	3,385,544		▲ 16.6	3,635,731		7.4	flat
Optical Equipment	Optical I/O Equipment	3,483,730		▲ 9.6	2,706,794		▲ 22.3	2,816,136		4.0	flat
Optical Equipment	Optical Printer・Multifunction Printer		769,431	▲ 1.0		720,809	▲ 6.3		714,949	▲ 0.8	flat
Optical Equipment	Digital Camera・Digital Video Camera		1,092,906	▲ 10.1		914,593	▲ 16.3		1,003,876	9.8	slight increase
Optical Equipment	Camera Mobile Phone		1,508,440	▲ 12.6		977,123	▲ 35.2		1,008,349	3.2	slight decrease
Optical Equipment	Others (Barcode Reader, Image Scanner, Tablet Computer, etc.)		112,953	▲ 17.8		94,269	▲ 16.5		88,962	▲ 5.6	slight decrease
Optical Component	Image Sensor	577,094		9.4	678,750		17.6	819,595		20.8	increase
	Display and Solid-state Lighting Field	6,441,759		3.6	5,343,178		▲ 17.1	5,692,480		6.5	flat
Optical Equipment	Display Equipment	3,050,215		▲ 1.9	2,350,655		▲ 22.9	2,576,992		9.6	flat
Optical Equipment	Flat Panel Display		2,722,612	▲ 1.7		2,064,792	▲ 24.2		2,214,890	7.3	flat
Optical Equipment	Projector		280,299	3.0		249,341	▲ 11.0		268,933	7.9	increase
Optical Equipment	Large-scale LED Display, OELD TV, etc.		47,304	▲ 28.9		36,522	–		93,169	155.1	increase
Optical Component	Display Device	2,372,839		10.3	1,927,605		▲ 18.8	2,047,055		6.2	flat
Optical Component	LED	357,660		▲ 5.2	367,317		2.7	357,032		▲ 2.8	flat
Optical Equipment	Solid-state Lighting/Lamp	661,045		14.2	697,601		5.5	711,401		2.0	slight decrease
Optical Equipment	LED Lighting		553,891	16.7		598,063	8.0		615,520	2.9	slight decrease
Optical Component	LED Lamp		107,154	2.9		99,538	▲ 7.1		95,881	▲ 3.7	slight decrease
	Photovoltaic Energy Field	3,733,350		▲ 19.6	2,831,220		▲ 24.2	2,285,106		▲ 19.3	decrease
Optical Equipment	Photovoltaic Power System	2,691,860		▲ 14.6	1,983,736		▲ 26.3	1,635,006		▲ 17.6	decrease
Optical Component	Photovoltaic Cell/Module	1,041,490		▲ 30.1	847,484		▲ 18.6	650,100		▲ 23.3	decrease
	Laser/Optical Processing Field	557,574		9.0	658,615		18.1	724,928		10.1	slight increase
Optical Equipment	Laser and Optical Processing Equipment	484,046		9.4	591,134		22.1	652,964		10.5	slight increase
Optical Equipment	CO_2 Laser		64,460	▲ 8.6		50,957	▲ 20.9		59,501	16.8	slight decrease
Optical Equipment	Solid State Laser		37,002	11.0		40,208	8.7		45,159	12.3	slight increase
Optical Equipment	Excimer Laser		124,133	8.1		151,136	21.8		126,465	▲ 16.3	slight increase
Optical Equipment	Fiber Laser		41,656	18.7		68,845	65.3		92,088	33.8	slight increase
Optical Equipment	Semiconductor Laser Direct Processing Equipment		2,487	▲ 5.3		3,145	26.5		5,612	78.4	increase
Optical Equipment	Lamp/LD Exposure Machine		211,210	15.2		274,573	30.0		322,074	17.3	flat
Optical Equipment	Additive Manufacturing (3D Printer)		3,098	14.3		2,270	▲ 26.7		2,065	▲ 9.0	flat
Optical Component	Oscillator	73,528		6.5	67,481		▲ 8.2	71,964		6.6	flat
	Optical Sensing and Measuring Field	251,845		7.7	260,602		3.5	279,507		7.3	slight increase
Optical Equipment	Optical Measuring Instrument	18,628		10.8	19,414		4.2	19,631		1.1	slight increase
Optical Equipment	Optical Sensing Equipment	233,217		7.4	241,188		3.4	259,876		7.7	slight increase
	Others Field	84,802		4.3	85,837		1.2	99,468		15.9	slight increase
	Product Items	FY 2015 Shipment Actual (in million yen)		Growth Rate(%)	FY 2016 Shipment Actual (in million yen)		Growth Rate(%)	FY 2017 Shipment Estimate (in million yen)		Growth Rate(%)	FY 2018 Shipment Projection
	Sub Total for Optoelectronics Equipment	11,912,826		▲ 6.8	9,812,265		▲ 17.6	9,931,028		1.2	slight increase
	Sub Total for Optoelectronics Components	4,963,859		▲ 2.9	4,449,756		▲ 10.4	4,501,641		1.2	slight increase
	Total for Optoelectronics Products	16,876,685		▲ 5.7	14,262,021		▲ 15.5	14,432,669		1.2	slight increase

Table 2 Domestic Production of Optoelectronics Industry (Summary)

	Product Items	FY 2015 Production Actual (in million yen)		Growth Rate(%)	FY 2016 Production Actual (in million yen)		Growth Rate(%)	FY 2017 Production Estimate (in million yen)		Growth Rate(%)	FY 2018 Production Projection
	Optical Transmission Equipment	446,374		1.9	441,070		▲ 1.2	424,512		▲ 3.8	slight increase
Optical Equipment	Optical Communications Field	159,263		▲ 13.8	132,538		▲ 16.8	123,949		▲ 6.5	flat
	Truck Line and Metro Line		92,370	▲ 9.5		70,727	▲ 23.4		58,635	▲ 17.1	flat
	Subscriber Line		38,909	▲ 22.0		34,260	▲ 11.9		37,926	10.7	flat
	Router and Switch		17,779	▲ 6.2		18,451	3.8		18,498	0.3	slight decrease
	Video Transmission (CATV, etc)		2,900	▲ 0.2		3,040	4.8		3,370	10.9	slight increase
	Optical Fiber Amplifier		7,305	▲ 33.2		6,060	▲ 17.0		5,520	▲ 8.9	increase
Optical Component	Optical Transmission Component	263,723		13.6	287,278		8.9	277,209		▲ 3.5	slight increase
	Optical Transmission Link		48,880	24.3		50,406	3.1		47,869	▲ 5.0	slight increase
	Light Emitting Device		36,894	21.4		43,482	17.9		37,125	▲ 14.6	flat
	Photo Detectors		11,042	32.2		18,230	65.1		13,730	▲ 24.7	slight increase
	Optical Fiber		93,939	9.4		94,382	0.5		96,680	2.4	slight increase
	Optical Connector		19,205	2.9		19,005	▲ 1.0		20,623	8.5	flat
	Optical Passive Component		25,255	19.3		23,712	▲ 6.1		22,983	▲ 3.1	flat
	Optical Circuit Component		17,802	▲ 5.5		26,435	48.5		27,369	3.5	slight increase
	Others (Semiconductor Amplifying Device, Composite Optical Device)		10,706	13.1		11,626	8.6		10,830	▲ 6.8	flat
	Optical Fiber Fusion Splicer	23,388		9.7	21,254		▲ 9.1	23,354		9.9	slight increase
	Optical Storage Field	235,465		0.6	218,837		▲ 7.1	218,094		▲ 0.3	slight decrease
Optical Equipment	Optical Disk	235,465		0.6	218,837		▲ 7.1	218,094		▲ 0.3	slight decrease
	Equipment		214,927	▲ 0.3		203,375	▲ 5.4		202,482	▲ 0.4	slight decrease
	Read-only (CD, CD-ROM UNIT, DVD, BD)		184,927	2.2		175,783	▲ 4.9		169,841	▲ 3.4	slight increase
	Recordable		30,000	▲ 13.6		27,592	▲ 8.0		32,641	18.3	flat
	Media, Optical Head, etc.		20,538	12.3		15,462	▲ 24.7		15,612	1.0	slight decrease
	Input/Output Field	1,059,868		2.4	1,035,661		▲ 2.3	1,071,530		3.5	flat
Optical Equipment	Optical I/O Equipment	634,520		▲ 2.2	539,974		▲ 14.9	478,599		▲ 11.4	flat
	Optical Printer・Multifunction Printer		117,405	12.3		87,993	▲ 25.1		69,891	▲ 20.6	slight decrease
	Digital Camera・Digital Video Camera		282,972	▲ 4.0		264,133	▲ 6.7		270,304	2.3	flat
	Camera Mobile Phone		190,022	▲ 1.9		149,809	▲ 21.2		102,488	▲ 31.6	decrease
	Others (Barcode Reader, Image Scanner, Tablet Computer, etc.)		44,121	▲ 20.4		38,039	▲ 13.8		35,916	▲ 5.6	slight decrease
	Image Sensor	425,348		9.9	495,687		16.5	592,931		19.6	increase
	Display and Solid-state Lighting Field	3,347,281		5.0	3,014,775		▲ 9.9	3,232,127		7.2	flat
Optical Equipment	Display Equipment	543,251		▲ 0.8	534,901		▲ 1.5	552,733		3.3	flat
	Flat Panel Display		481,781	2.1		476,660	▲ 1.1		466,211	▲ 2.2	flat
	Projector		23,466	▲ 6.3		21,719	▲ 7.4		18,353	▲ 15.5	slight decrease
	Large-scale LED Display, OLED TV, etc.		38,004	▲ 24.9		36,522	▲ 3.9		68,169	86.7	increase
	Display Device	2,078,078		5.0	1,701,622		▲ 18.1	1,902,147		11.8	slight decrease
	LED	327,664		▲ 0.8	348,143		6.3	334,217		▲ 4.0	slight decrease
	Solid-state Lighting/Lamp	398,288		20.7	430,109		8.0	443,030		3.0	slight decrease
	LED Lighting		387,739	21.9		418,647	8.0		430,864	2.9	slight decrease
	LED Lamp		10,549	▲ 10.9		11,462	8.7		12,166	6.1	flat
	Photovoltaic Energy Field	3,030,032		▲ 13.2	2,198,132		▲ 27.5	1,794,669		▲ 18.4	decrease
	Photovoltaic Power System	2,626,198		▲ 11.9	1,907,821		▲ 27.4	1,588,056		▲ 16.8	decrease
	Photovoltaic Cell/Module	403,834		▲ 20.5	290,311		▲ 28.1	206,613		▲ 28.8	decrease
	Laser/Optical Processing Field	544,112		9.1	638,338		17.3	699,362		9.6	slight increase
Optical Equipment	Laser and Optical Processing Equipment	471,642		9.6	572,380		21.4	628,422		9.8	slight increase
	CO_2 Laser		62,696	▲ 8.6		47,125	▲ 24.8		57,008	21.0	slight decrease
	Solid State Laser		32,819	11.6		34,298	4.5		38,803	13.1	slight increase
	Excimer Laser		120,776	8.7		147,831	22.4		123,531	▲ 16.4	slight increase
	Fiber Laser		38,830	18.6		62,764	61.6		79,321	26.4	slight increase
	Semiconductor Laser Direct Processing Equipment		2,213	▲ 13.1		3,519	59.0		5,620	59.7	increase
	Lamp/LD Exposure Machine		211,210	15.2		274,573	30.0		322,074	17.3	flat
	Additive Manufacturing (3D Printer)		3,098	14.3		2,270	▲ 26.7		2,065	▲ 9.0	flat
	Oscillator	72,470		6.2	65,958		▲ 9.0	70,940		7.6	flat
	Optical Sensing and Measuring Field	168,067		4.6	173,495		3.2	188,048		8.4	slight increase
	Optical Measuring Instrument	15,707		6.3	17,122		9.0	16,985		▲ 0.8	slight increase
	Optical Sensing Equipment	152,360		4.4	156,373		2.6	171,063		9.4	slight increase
	Others Field	71,767		▲ 3.4	76,243		6.2	88,505		16.1	slight increase

Product Items	FY 2015 Production Actual (in million yen)	Growth Rate(%)	FY 2016 Production Actual (in million yen)	Growth Rate(%)	FY 2017 Production Estimate (in million yen)	Growth Rate(%)	FY 2018 Production Projection
Sub Total for Optoelectronics Equipment	5,249,533	▲ 5.0	4,519,847	▲ 13.9	4,232,119	▲ 6.4	slight increase
Sub Total for Optoelectronics Components	3,653,433	1.7	3,276,704	▲ 10.3	3,484,728	6.3	slight increase
Total for Optoelectronics Products	8,902,966	▲ 2.4	7,796,551	▲ 12.4	7,716,847	▲ 1.0	slight increase



*1 "Fiscal 2018 Economic Outlook and Basic Stance for Economic and Fiscal Management" (Jan. 2018) [Cabinet Decision]
*2 "Production Forecasts for the Global Electronics and Information Technology Industries," JEITA, Dec. 19, 2017

Fig.1 Total Optoelectronics Shipment, Nominal GDP, and Domestic & Overseas Electronics Production

decrease in demand. The photovoltaic energy field decreased significantly due to changes in the Feed-in Tariff (FIT) system and the falling purchase price.

In FY 2017, the laser/optical processing field and the sensing and measuring field are estimated to increase moderately due to the increase in capital investment (mainly in the automotive industry) and strong sales of photoelectric switches and in-vehicle cameras, etc., respectively. The optical communication field as a whole is estimated to decrease slightly as optical transmission equipment for trunk lines and metro lines is likely to decrease substantially due to reduction in domestic investment, although that for subscriber lines is estimated to increase due to replacement demand. The display and solid-state lighting field is likely to recover from the substantial decrease in the previous year and remain steady overall with the solid-state lighting field remaining strong due to the growing awareness of energy conservation and with the growth of 4K TV sets due to replacement for the Tokyo Olympic and Paralympic Games and the release of organic EL TV sets. The input/output equipment field is estimated to increase slightly due to an increase related to digital cameras and strong sales of image sensors. The optical storage field as a whole is estimated to increase slightly due to an increase in sales related to optical disks for business use. The photovoltaic energy field is estimated to continue to decrease significantly due to changes in the FIT and the falling purchase price.

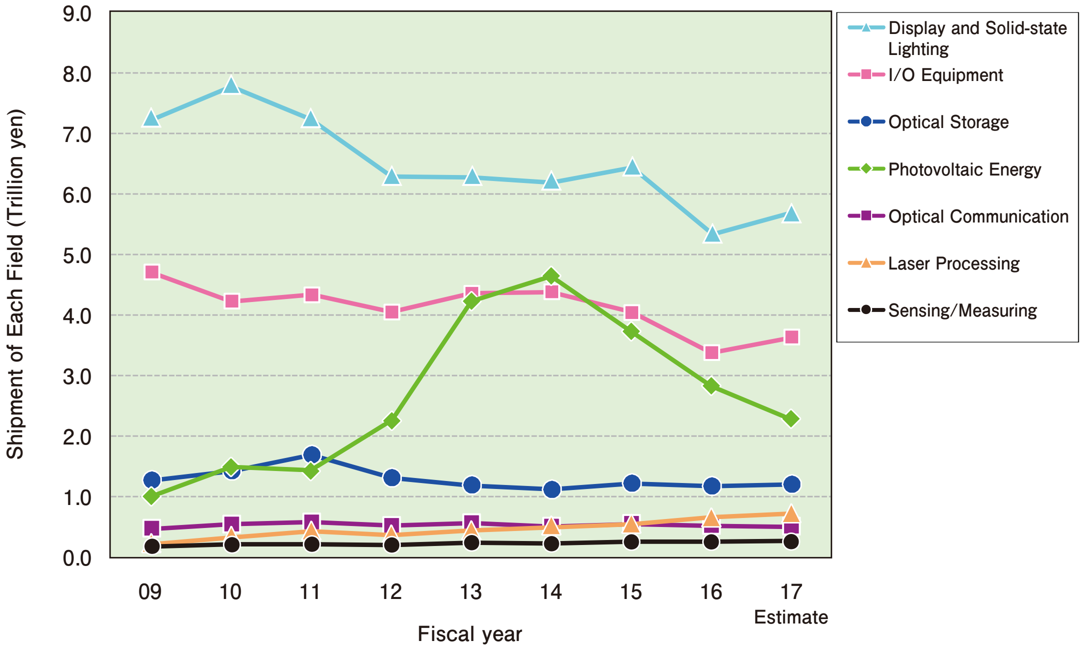


Fig.2 Shipment by Product Field

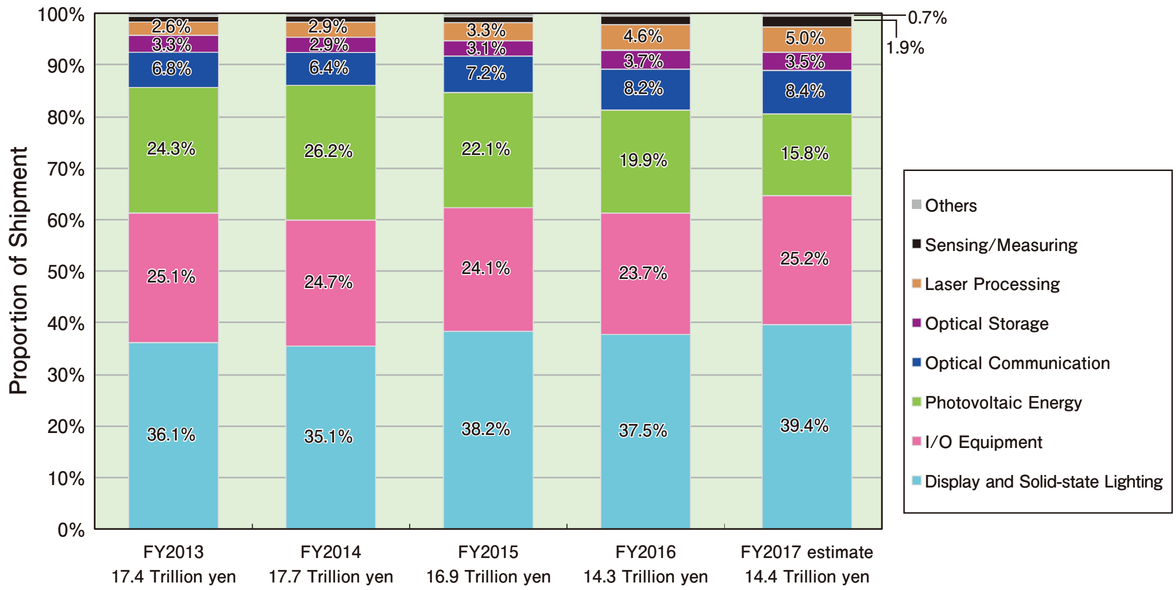


Fig.3 Proportion of Shipment by Product Field

(2) Proportion and Contribution to Total Shipment by Field

Fig. 3 shows the changes in the proportion of the total shipments of optoelectronics products by field over the five years from FY 2013 (actual results) until FY 2017 (estimate), while Fig. 4 shows the changes in the contribution of each product field to the increase/decrease in the total shipments.

From the proportion by field (Fig. 3), we can see that, the photovoltaic energy field switched places with the input/output equipment field in shares and leapt into second position in FY 2014 due to the rapid growth from FY2011.

However, the input/output equipment field returned to second place due to the decline in the share of the photovoltaic energy field in FY 2015.

In FY 2016, the share of the display and solid-state lighting field and the input/output equipment field decreased while the share of the photovoltaic energy field continued its rapid decline.

In FY 2017, the share of the display and solid-state lighting field and the input/output equipment field is likely to increase, but the share of the photovoltaic energy field is estimated to further decrease.

The contribution to the increase/decrease in the total shipments by field (Fig. 4) shows that the photovoltaic energy field recorded strong positive growth, and the display and solid-state lighting, optical communication, laser/optical processing, and sensing and measuring fields inverted to positive in FY 2013.

In FY 2014, the display and solid-state lighting, photovoltaic energy, laser/optical processing, and sensing and measuring fields maintained

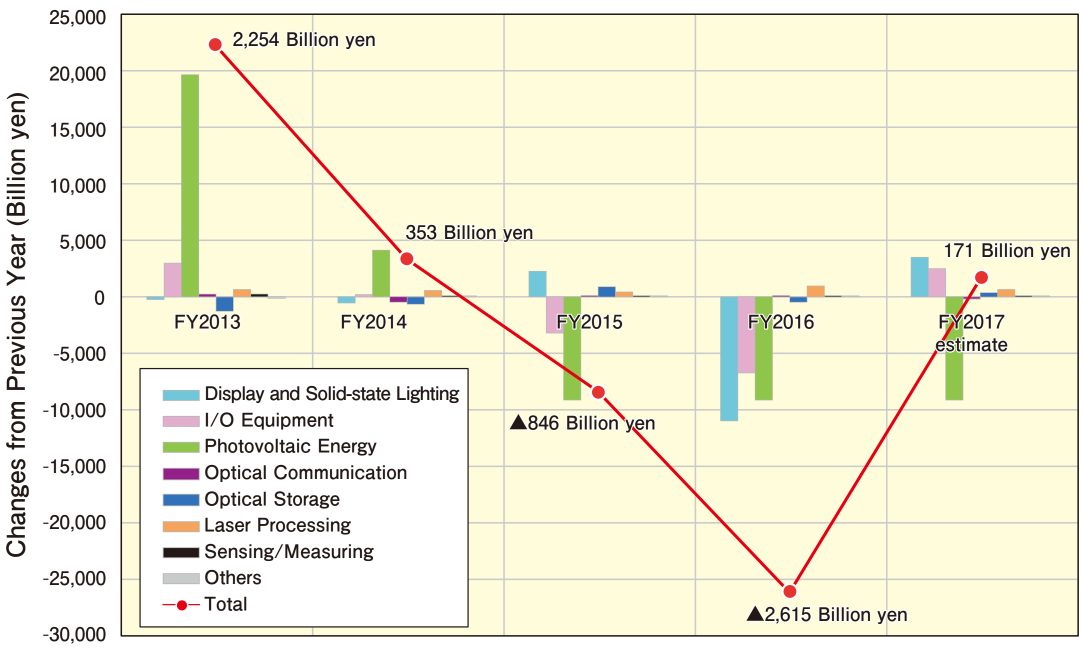
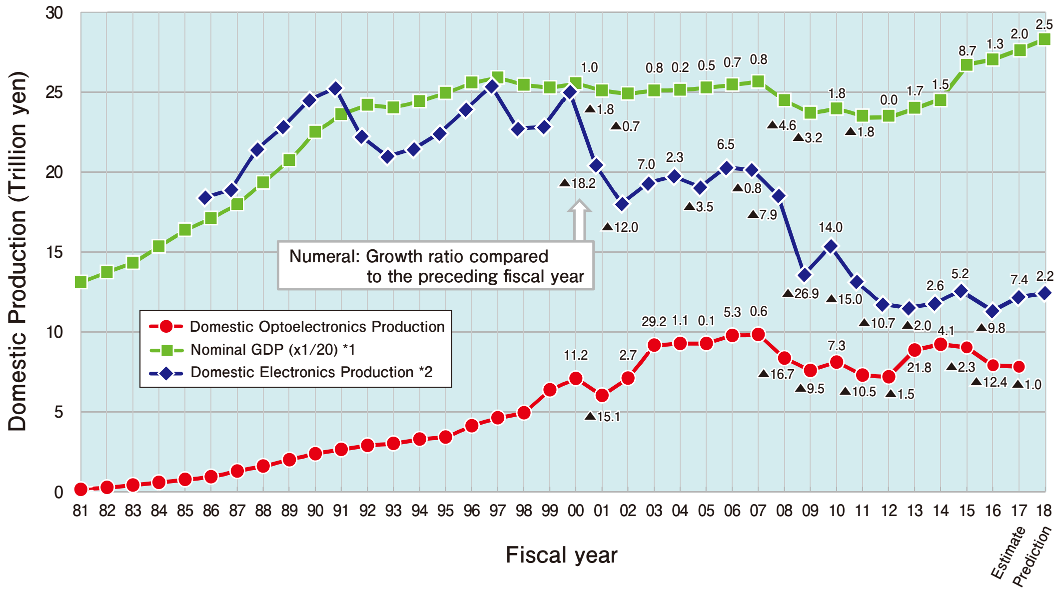


Fig.4 Contribution to Changes in Total Shipment by Product Field



*1 "Fiscal 2018 Economic Outlook and Basic Stance for Economic and Fiscal Management" (Jan. 2018) [Cabinet Decision]
*2 "Production Forecasts for the Global Electronics and Information Technology Industries," JEITA, Dec. 19, 2017

Fig.5 Domestic Optoelectronics Production, Nominal GDP, and Domestic Electronics Production

positive growth but the other three fields turned negative. In particular, growth was substantially inhibited in the photovoltaic energy field.

In FY 2015, the display and solid-state lighting, laser/optical processing, and sensing and measuring fields maintained positive growth but the optical communication, optical storage, and input/output equipment fields remained negative. In particular, the growth in photovoltaic energy decreased significantly.

In FY 2016, only the laser/optical processing and sensing and measuring fields achieved positive growth. The photovoltaic energy, display and solid-state lighting, and input/output equipment fields recorded substantially negative growth.

In FY 2017, positive growth is expected except for in the optical communication and photovoltaic energy fields. The growth of the entire industry is likely to remain steady.

2.5 Trends in Domestic Production for the Optoelectronics Industry

(1) Changes in Domestic Production for the Optoelectronics Industry

Fig. 5 shows the changes in domestic production from FY 1980 to FY 2017 alongside nominal GDP (one-twentieth of the actual value) and the domestic output of the electronics industry.

Output for the optoelectronics industry was around 80 billion yen in

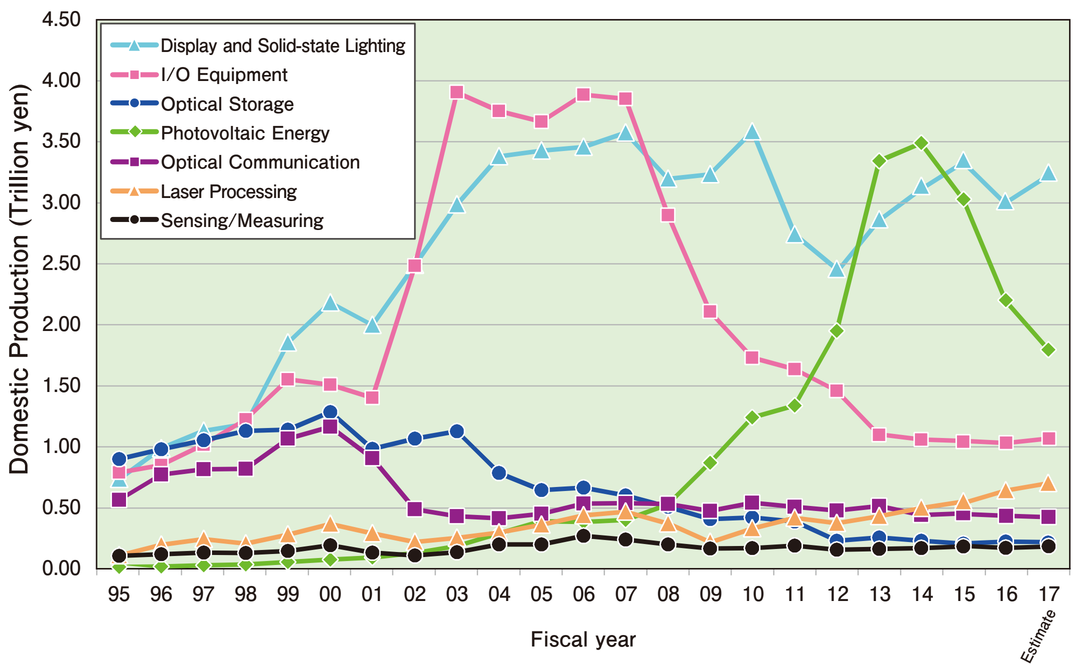


Fig.6 Domestic Optoelectronics Production by Field

FY 1980, when our survey on domestic production value started. It grew in the 1980s in line with Japan's economic growth. In 1991, it accounted for a tenth of the domestic production value of the electronics industry, and consistently maintained a positive growth trend, exceeding the 7 trillion yen level in FY 2000. Affected by the recession following the dot-com bust, 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 has since been greatly affected by the macro economy, showing changes linked to GDP and the electronics industry. It grew slowly until FY 2007, but thereafter experienced two consecutive years of negative growth, being affected by the global financial recession from FY 2008 to FY 2009. The partial recovery trend seen in FY 2010 lost steam, and again turned negative in FY 2011 to FY 2012. In FY 2013, however, the economy recovered on the back of Abenomics, as indicated by the 1.7% nominal GDP growth, and the domestic production value for the entire optoelectronics industry grew substantially (21.8%) for the first time in years due to the increase in capital investment and general consumption. In FY 2014, production also increased by 4.1% compared to FY 2013.

In FY 2015, production decreased by 2.3% for the first time in three years due to the significant decrease in the photovoltaic energy field.

In FY 2016, five fields, including photovoltaic energy, recorded negative growth, with a significant decrease of 12.4%.

In FY 2017, five fields, including display and solid-state lighting, are estimated to compensate for negative growth in the optical communication and photovoltaic energy fields, resulting in flat growth.

Fig.6 shows the changes in domestic production of optoelectronics products for each field (seven fields, excluding "Others") over the 23 years from FY 1995 (actual results) to FY 2017 (estimate).

During the 1990s, there was favorable growth in the display, input/output equipment, optical communications, and optical storage fields, with domestic production for each increasing to over 1 trillion yen in the year 2000. The laser/optical processing, sensing and measuring, and photovoltaic energy fields also performed favorably in the 1990s, although the production value was less than 500 billion yen. However, developments in each field showed significant differences after the dot-com bubble burst in 2001.

There was not much of a decline in the input/output equipment field in FY 2001, and it remained steady from FY 2002 onwards. However, it started showing negative growth from FY 2008 onwards. Although it had finally started showing signs of bottoming out in FY 2011, by FY 2012 and even in FY 2013 it followed a path of negative growth. In FY 2014, however, the trend stayed almost flat.

The display and 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 display devices in the two years from FY 2011 decreased by almost 80%. On the other hand, the solid-state lighting field attained a three-digit growth rate in FY 2011 and double-digit growth in FY 2012. Although the values for FY 2013 are not comparable with values from the previous year because of the changes in the aggregation method, production itself steadily increased until FY 2015. Despite the significant decrease due to the decrease in the demand for TV sets and falling price, etc. in FY 2016, solid-state lighting is estimated to increase moderately in FY 2017 due to the growing awareness of energy conservation. The field as a whole is estimated to remain steady, with the growth of 4K TV sets due to replacement for the Tokyo Olympic and Paralympic Games and the release of organic EL TV sets.

The photovoltaic energy field had been leading the growth in the optoelectronics industry since FY 2008. In particular, since the introduction of Feed in Tariffs (FITs) in July 2012, production for the power industry grew substantially, and this field accounted for the largest share of the domestic production value in FY 2013. However, the growth rate dropped sharply in FY 2014, resulting in a significant decrease in FY 2015 and FY 2016. Production is estimated to continue to decrease significantly in FY 2017.

The optical storage field is continuing its prolonged decline. It fell below 250 billion yen in FY 2012 (−40.4%) but rebounded to significantly increase by 17.1% in FY 2013. It reversed to a decline of −9.8% in FY 2014, remained steady with an increase of 0.6% in FY 2015, and decreased again in FY 2016 by 7.1%. It is estimated to remain flat with a 0.3% decrease in FY 2017.

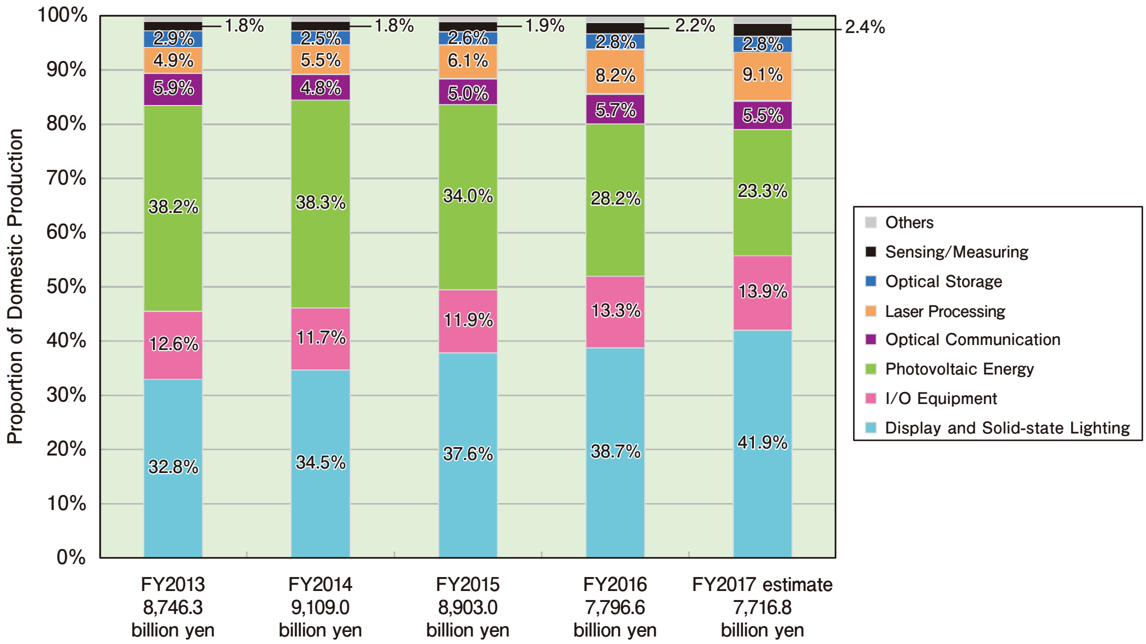


Fig.7 Proportion of Domestic Optoelectronics Production by Field

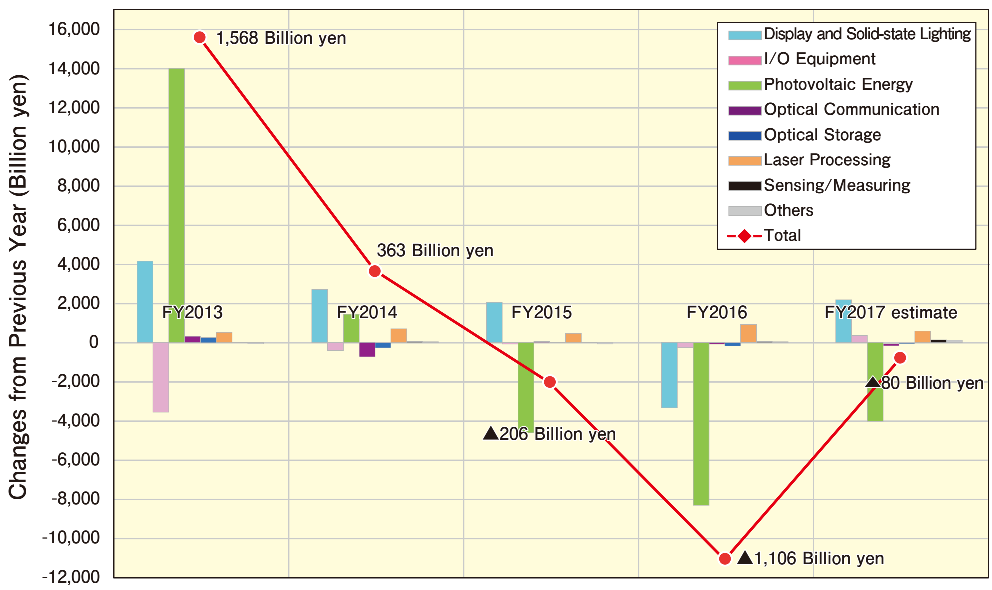


Fig.8 Contribution to Changes in Domestic Production by Field

Optical communications, laser/optical processing, and sensing and measuring, which mainly focus on the domestic market, are easily influenced by domestic economic conditions and capital investments and reflect the trends in the economic conditions, grew substantially in FY 2013. In FY 2014, the laser/optical processing field and the sensing and measuring field grew significantly by 16.6% and 19.2%, respectively. These two fields showed a similar trend in FY 2015 and onwards.

Optical communications had a 2.9% rate of growth in FY 2014 due to underperformance in trunk and metro lines, etc. In FY 2015, optical transmission equipment/system was negative, but components were strong, resulting in an overall increase of 1.9%. It remained almost flat at −1.2% in FY 2016 and is estimated to decrease slightly by 3.8% in FY 2017.

(2) Proportion and Contribution to Domestic Production by Field

Fig. 7 shows the changes in the proportion of the domestic production for each field of optoelectronics products over the five years from FY 2013 (actual results) until FY 2017 (estimate), while Fig. 8 shows the changes in the contribution of each product field to the increase/decrease in domestic production.

Looking at Fig. 7, which shows the proportion by field, it is found that three fields (display and solid-state lighting, input/output equipment, and photovoltaic energy) account for approximately 80% of the whole.

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, but its share decreased substantially after FY 2015.

In the display and solid-state lighting field, solid-state lighting has continued to grow rapidly due to the growing awareness of energy conservation despite the decline in the display field. In FY 2015, the proportion of the display and solid-state lighting field returned to the top position due to the decrease in the photovoltaic energy field. Although production of the display and solid-state lighting field substantially decreased in FY 2016, the field held onto the top share due to a considerable decrease in the photovoltaic energy field, and is likely to increase its share with increasing production in FY 2017.

The input/output equipment field seemed to hit a bottom after declining due to the slump in the market for devices such as digital cameras and camera mobile phones, and is estimated to increase its share by 2.2 points from FY 2014 to FY 2017.

Regarding the contribution of each field (Fig. 8) to domestic production, the photovoltaic energy field showed a strong positive contribution and only the input/output equipment field was negative in FY 2013.

In FY 2014, no field stood out, but the display and solid-state lighting, photovoltaic energy, laser/optical processing, and sensing and measuring fields achieved positive growth while the three other fields recorded negative growth.

Since FY 2015, the photovoltaic energy field has dragged down overall growth.

Particularly in FY 2016, when five fields other than the laser/optical processing field and the sensing and measuring field recorded negative growth, the entire optoelectronics industry recorded a decrease of about 1.1 trillion yen.

In FY 2017, the negative growth of the industry is estimated to remain at the level of about 80 billion yen as the display and solid-state lighting and input/output equipment fields turned positive while the decrease in the photovoltaic energy field shrank.

Technological Strategy Development

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 numerous 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 its technology.

Starting in FY 2011, OITDA developed the "Optoelectronics Technology Roadmap Toward the 2030s" as its five-year plan for the five selected technological fields of information processing photonics, safety and security photonics, optical user interfaces, optical communications, and optical processing/measurement to broadly show the future vision for optoelectronics technology in the 2030s. From FY 2016, we introduced a new approach in the strategy development in which we clarify how optoelectronics technology can contribute to specific fields of application, rather than to each technological field, as the goal of the activity. In FY 2016, as the first year of the new initiative, we selected automotive photonics as our theme and investigated strategies and a technological roadmap for developing optoelectronics technology in automated driving. For FY 2017, we studied a strategy on optoelectronics technology toward the age of AI (artificial intelligence) and IoT (Internet of Things), with the aim of clarifying how optoelectronics technology can contribute to AI and IoT, which have been undergoing rapid technological development and been used increasingly in industrial applications in recent years.

2. Optoelectronics Technology Required for the Age of AI/IoT

As the first step of our study, we envisaged the future society in the age of AI and IoT and shared our understanding that the rapid expansion of IoT and advancement of AI will require the:

- sensing and collection of diverse types of information at the edge,
- transfer and consolidation of the various kinds and vast amounts of information between the edge and the cloud via optical networks, and
- learning and deduction processing using vast amounts of information by AI on the cloud side.

Based on this understanding, we discussed what kind of optoelectronics technology is required and how optoelectronics technology can contribute to implement these processes at high speeds and with low power consumption, and categorized the technologies and required performance parameters into (1) optoelectronics technology at the edge, (2) optoelectronics technology in the cloud, and (3) optical transport network technology, as shown in Fig. 9 We also discussed (4) photoelectronic integration technology as a fundamental technology for implementing the abovementioned technologies.

2.1 Optoelectronics Technology at the Edge

Sensors that gather diverse types of data from the surrounding environment at the edge play a very important part in automated driving, medical diagnosis, disaster prevention, smart manufacturing, etc.

One of the most important sensors using optoelectronics technologies is the image sensor. With the remarkable technological advancement of CMOS image sensors in recent years, substantial improvements have been made for higher definition and higher sensitivity. In automated driving, it is crucial to accurately grasp surrounding traffic conditions, including other vehicles, pedestrians, and road signs, meaning that the roles that image sensors must play will increase. In light of the ongoing advancement of in-vehicle cameras toward higher definition, image sensors that have definition higher than 8K may become essential in the future. In the security field, for instance, higher definition is necessary to track a specific person in a crowd. Monitoring cameras may have 8K or higher definition in the future.

For automated driving at night and medical diagnosis, it seems useful to obtain information on wavelength spectra other than normal visible light. At night, obtaining infrared light together with an image is expected to prevent accidents that may otherwise occur when a pedestrian rushes out into the street. It is also anticipated that a wide variety of vital information obtained from infrared light data would help medical diagnosis. These kinds of multi-spectrum image sensors will become extremely important.

Sensors that obtain non-image information simultaneously with image data are likely to play increasingly important roles. In the area of automated driving, R&D on optical radars that can obtain more accurate distance information is being intensified. The integration of distance sensors with image sensors becomes important in the area of security as well. For example, Apple's iPhone X® has put into practical use personal authentication that combines a distance sensor using a surface-emitting laser array and an image sensor. Furthermore, obtaining data, such as sound and distortion, together with image data is expected to

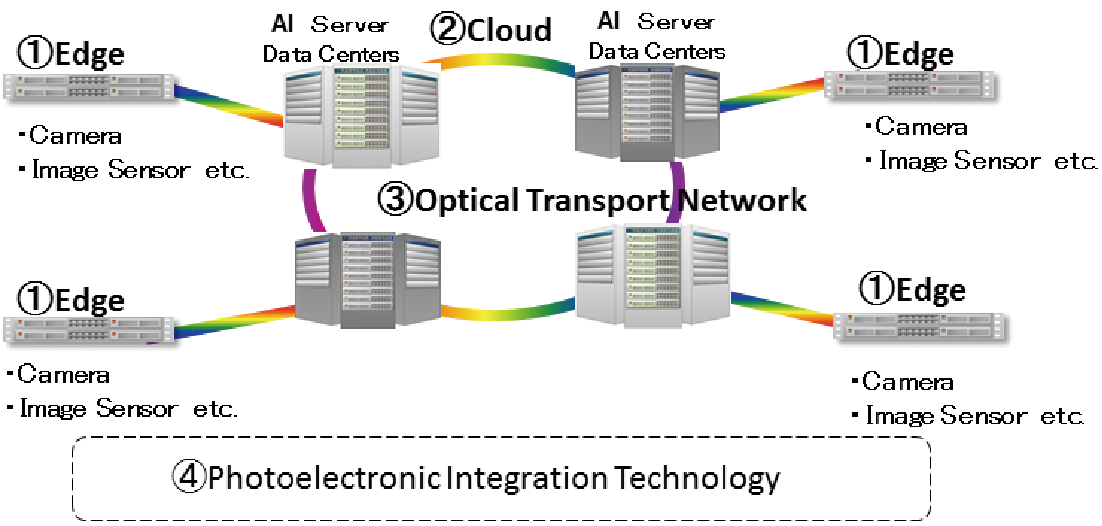


Fig.9 Conceptual image of the edge, cloud, and optical network

enable us to identify aging parts of infrastructure, such as bridges and tunnels, and detect abnormalities at factories. Multi-sensor cameras that integrate diverse sensors with high-definition image sensors may achieve sensing beyond human perception and may open up new areas of application when combined with AI technology.

Depending on the area of application, AI deduction processing is also required at the edge. For example, automated driving, which requires low latency, cannot rely on cloud-based deduction processing.

Furthermore, as mentioned earlier, automated driving in the future will use 8K or higher definition video. Normally, video data is reduced in size with image compression when transmitted, but automated driving, in which low latency is crucial, requires transmission of uncompressed video data. When transmitting uncompressed video data of 8K or higher definition, transmission speed of around 100 Gbps is required. Therefore, in-vehicle data transmission that needs optical transmission between multiple cameras and an AI unit requires technology for optical input/output interfacing of 100 Gbps or greater transmission capacity. In medical applications, similar high-speed optical interfacing is needed for low-latency transmission of 8K images for telemedicine.

2.2 Optoelectronics Technology in the Cloud

Clouds require large-scale AI learning based on the large amounts of information obtained at the edge. To facilitate high-speed learning using large amounts of information, parallel learning is essential. To exchange parameters updated through learning at each AI server, networks that connect server racks at high speeds are necessary. However, electric switches require an extremely large amount of power. Considering that the performance improvement of large-scale integrated circuits (LSI) according to Moore's law can no longer be expected in the future, the performance improvement in electric switches is likely to slow down. Therefore, to realize the large-scale parallel processing in clouds, the roles of switches using optoelectronics technology will become important.

Additionally, the transmission of large-scale data sets for learning and learned parameters will require ultrahigh-speed interfaces. However, as mentioned above, it is also difficult to secure a communication band of 100 Gbps or greater with electric interfaces, as the rate of improvement of LSI performance is likely to plateau. With no prospect for dramatic improvements in the performance of electric interfaces, their replacement with optical interfaces is necessary. It is desired that research will advance the implementation of optical interfaces on LSI using silicon photonics technology, which has been advancing to a remarkable degree in recent years. If optical interfaces could achieve bandwidths of 10 to 100 Tbps per chip, it would be a major technological innovation.

Optoelectronics technology is also expected to play an important role in the search for new computing architecture in the post-Moore age. If it becomes possible to provide high-speed power-saving optical interfaces for LSI that surpass electric interfaces, new architecture that carries on computing while transferring data between computing units, each of which is adapted to a specific type of processing, may be put into practical use. Realization of the architecture would bring about a considerable change in computing technology. Meanwhile, as proposals on new methods of computing that take advantage of optical characteristics, such as optical arithmetic operations and optical deep learning, are increasing, optoelectronics technology is expected to contribute in the search for new computing methods surpassing conventional arithmetic operation using CMOS circuits.

2.3 Optical Transport Network Technology between Edge and Cloud

In the age of AI and IoT, enormous amounts of information sensed at the edge, including high-definition video data, will be transferred to AI servers and data centers on the cloud side. As the number of IoT devices increases in the future, the volume of machine-to-machine (M2M) traffic, which does not require human intervention, is expected to increase a thousandfold, meaning that network transmission capacity must increase by a thousandfold or greater. Backbone transmission capacity, which is currently about 10 Tbps, must be tens of Pbps in the future. Access network transmission capacity must be sped up from today's one to several Gbps to several Tbps, which requires the advancement of optoelectronics technology, including spatial multiplexing optical transmission technology, multi-dimensional modulation and demodulation technology, error correction/digital signal processing technology, and technology for highly integrated optical transmitter and receiver modules. Additionally, as 5G wireless networks will be put into practical use in the future, optical wireless integrated access technology and network virtualization technology will become extremely important.

2.4 Photoelectronic Integration Technology

Ultrahigh-speed interfaces at edge and cloud, ultrahigh-speed optical transmission between edge and cloud, and high performance sensors at the edge require advanced photoelectronic integrated circuit technology as their foundation. In particular, integration density of photonic integrated circuits using silicon photonics technology doubles every year, meaning that it is becoming possible to create more complicated photonic integrated circuits by silicon photonics. Further, as technology for fabricating photonic integrated circuits integrally with electronic circuits necessary for operating the photonic integrated circuits and three-dimensional mounting technology become possible, integral design of photonic circuits and electronic circuits will become essential in the future.

Currently, in Europe and the United States, the unified environment for design and operation analysis of photoelectronic integrated circuits are being put in place and the fabless model using common fabrication facilities for production is being established. Like LSI, integral design will inevitably become the standard for design and production of photoelectronic integrated circuits. Thus, in the age of AI and IoT, it is necessary to establish a design flow that uses a common design environment for device design and circuit design, analyzes device operation through device/process simulators and circuit simulators, and re-designs to satisfy the desired performance. It will also become important to establish a fabless model in which a design rule checker verifies the design data if there are any problems in production before the design data is smoothly transferred to fabrication facilities for production. By establishing a platform for the design and production of photoelectronic integrated circuits, advanced optoelectronics technologies and devices required in the age of AI and IoT can be realized.

3. Proposals

(1) Optoelectronics technology at the Edge

A combination of high-definition multi-sensor cameras that have sensing functions surpassing the human five senses with AI will open up new areas of application. In automated driving, ultrahigh-speed optical interfaces must be achieved to transfer high-definition video data to an AI unit in the same edge node with low latency.

(2) Optoelectronics technology in the Cloud

To achieve information processing functions required for AI learning, it is necessary to provide LSI with optical interfaces that are high speed, large capacity, and power saving. Additionally, in achieving network functions required for parallel processing during AI learning, high-speed, high-port-count and low-power consumption optical switch technology is crucial. Furthermore, the search for new computing architecture following the end of Moore's law and research into new arithmetic operation method using optoelectronics technology will also become important.

(3) Optical transport network technology between Edge and Cloud

Expanding the bandwidth for optical transmission with multiplexing technology and digital technology is necessary. Additionally, the combination and integration of optical communication with 5G and other wireless networks both in hardware and software will become important.

(4) Photoelectronic integration technology

As foundational technology to realize various optoelectronics technologies and devices, photoelectronic integration technology, such as silicon photonics, becomes increasingly important.

In the future, a fabless model in which design and production are separated will be the standard for optical integrated circuits. Therefore, it is crucial to develop the design environment, the test environment, and the educational environment for photoelectronic integrated circuits in an integrated manner.

Standardization

1. Introduction

Standardization has been one of OITDA's major activities since its establishment, and has been promoted broadly across the optoelectronics industry. OITDA's 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 (JIS, OITDA standards, and Technical papers), OITDA is also working on international standardization such as IEC and ISO through field-specific meetings in order to respond quickly to the fast-changing industrial structure.

Outlined below are the results and trends of OITDA's international standardization activities at IEC TC 86 "Fibre optics" and TC 76 "Optical radiation safety and laser equipment" and at ISO TC 172/SC 9 "Laser and electro-optical systems" in FY 2017, as well as OITDA's activities in two international standardization projects commissioned by the Ministry of Economy, Trade and Industry: "International standardization on EMC characteristic evaluation, etc. of the high-speed in-vehicle Ethernet physical layer" and "International standardization on reliability, etc. of narrow-pitch multi-fiber optic connectors."

2. Fibre Optics (IEC TC 86)

IEC/TC 86 held its annual meeting for FY 2017 in conjunction with the IEC 81st General Meeting in Vladivostok, which was held in October 2017. Each working group held an interim meeting as needed in spring.

2.1 Fibre Optic Test Equipment Calibration (IEC TC 86/WG 4)

IEC/TC 86/WG 4 (Fibre optic test equipment calibration) under IEC/TC 86 held the Vladivostok meeting in Russia in October 2017.

The Vladivostok meeting discussed comments from the respective countries on the 2nd CD (committee draft), which was circulated in advance, for the standardization of calibration of wavelength/optical frequency measurement instruments (IEC 62129-3 Ed.1.0). Regarding the document, an NP (new work item proposal) from Japan was agreed at the Kwangju meeting in 2015, and Japan has been serving as the project leader. The policy for handling comments from the respective countries on the 2nd CD was discussed at the Optical Measurement Instruments Standardization Meeting, approved at the IEC TC 86 domestic committee, and then submitted to the Vladivostok meeting, where it was decided to modify the 2nd CD based on the comments from the respective countries and prepare a CDV (committee draft for vote) for the official CDV publication in spring 2018. Regarding the revision of existing documents, the meeting discussed revising calibration of fibre-optic power meters (IEC 61315 Ed.3.0) and agreed to publish a CDV document. With regard to calibration of optical fibre geometry test sets, it was reported that an IS (international standard) was published in July 2017.

2.2 Fibres and Cables (IEC TC 86/SC 86A)

IEC/TC 86/SC 86A, which has been working on the standardization of optical fibres and cables, held a meeting in Vladivostok, Russia in October 2017.

2.2.1 Fibres and Associated Measuring Methods (IEC TC 86/SC 86A/WG 1)

At the IEC SC 86A/WG 1 Vladivostok meeting in Russia, Japan proposed, with regard to the issue of making the provision on loss of cabling in IEC 60793-2-50 (Product specifications - Sectional specification for class B single-mode fibres) conform to ITU-T, that a note on the increase of loss due to cabling be added. Regarding IEC 60793-2-40 (Product specifications - Sectional specification for category A4 multimode fibres), changing "NA" in the automobile application category was proposed and agreement was reached to move toward CD preparation.

Japan offered a new proposal on JIS C 6837 (all plastic multimode optical fibres). It was agreed to add it to the A4 category of IEC 60793-2-40. Japan became the project leader and the preparation of a draft revision started.

2.2.2 Cables (IEC TC 86/SC 86A/WG 3)

At the IEC SC 86A/WG 3 Vladivostok meeting in Russia, Japan proposed that the in-conduit freezing test method be added to the cable external freezing test methods in IEC 60794-1-22 (Generic specification - Basic optical cable test procedures - Environmental test methods). After additional reporting on the results of experiments, the meeting agreed to add the proposed test method, and move it forward to the IEC 60794-1-215 NWP stage. Regarding IEC 60794-1-23 (Generic specification - Basic optical cable test procedures - Cable element test methods), the FDIS was not approved as a result of negative voting that Japan called for. Japan explained the background and it was agreed to return it to the CD stage for discussion

2.3 Fibre Optic Interconnecting Devices and Passive Components (IEC TC 86/SC 86B)

IEC/TC 86/SC 86B, which has been working on the standardization of fibre optic interconnecting devices and passive components, held meetings in Kona, U.S.A. in April and Vladivostok, Russia in October 2017.

2.3.1 Standard Tests and Measurement Methods for Fibre Optic Interconnecting Devices and Passive Components (IEC TC 86/SC 86B/WG 4)

The IEC 61300 series provides standards related to tests and measurement methods (WG 4), and specifies tests and measurement methods for fibre optic interconnecting devices and passive components. Regarding measurement methods for fibre optic passive components, revised versions of the documents IEC 61300-3-7 (Examinations and measurements - Wavelength dependence of attenuation and return loss of single mode components) and IEC 61300-3-21 (Examinations and measurements - Switching time) are under discussion.

It was also proposed that a new standard for measurement of switching reproducibility be established under the IEC 61300 series.

2.3.2 Standards and Specifications for Fibre Optic Interconnecting Devices and Related Components (IEC TC 86/SC 86B/WG 6)

With regard to fibre optic interconnecting devices (WG 6), IEC 61754-4-1 related to simplified receptacle (F16 type) and IEC 61754-6-1 related to simplified receptacle (F17 type) were replaced with IEC 61754-4-100 and IEC 61754-6-100, respectively, to avoid the overlap between component numbers.

An international standard related to interfaces of F13-type fibre optic interconnecting devices, IEC 61754-7 used to specify fibre optic interconnecting devices with one row or two rows of fibre. With the addition of provisions on interfaces with fibre optic transceivers, IEC 61754-7-1, Ed.1 about interfaces for type MPO family of connectors with one row of fibre and IEC 61754-7-2, Ed.1 about the standard interfaces for type MPO family of connectors with two rows of fibre were published.

2.3.3 Standards and Specifications for Fibre Optic Passive Components (IEC TC 86/SC 86B/WG 7)

As of February 2018, documents related to fibre optic passive components (WG 7) under circulation are: IEC 63032 (Fibre optic tuneable bandpass filters - Generic specification), IEC 60869-1 (Fibre optic passive power control devices: ED5), IEC 61753-1 (Performance standard: ED2), and IEC 62005-9-4 (High power qualification of passive optical components for environmental category C).

For these documents, Japan provided support, which included revising IEC 60869-1 (Fibre optic passive power control devices - Generic specification) and providing comments on circulation document IEC 63032 (Fibre optic tuneable bandpass filters - Generic specification). Per the request of IEC, Japan also conducted a market survey on tunable bandpass filters.

2.4 Fibre Optic Systems and Active Devices (IEC TC 86/SC 86C)

IEC/TC 86/SC 86C, which has worked on standardization of fibre optic systems and active devices, held meetings in San Luis Obispo, U.S.A. in March and in Vladivostok, Russia in October 2017.

2.4.1 Fibre Optic Communications Systems and Subsystems (IEC TC 86/SC 86C/WG 1)

IEC/TC 86/SC 86C/WG 1, which deals with standardization of the physical layer of fibre optic communications systems and subsystems, is establishing fibre optic system design guidelines and standardizing test methods for fibre optic systems (systems in general, digital systems, fibre optic cable facilities and optical links). To more aggressively put forward proposals on technologies in which Japan is leading to IEC, Japan participated in two standardization discussions of IEC/TC 86/SC 86C/WG 1, one in San Luis Obispo and the other in Vladivostok. Fibre optic communication subsystems - Part 1: Generic specification (IEC 61281-1), which was revised with Japan serving as the project leader, was published after the handling of comments received during the CDV circulation.

2.4.2 Fibre Optic Sensors (IEC TC 86/SC 86C/WG 2)

(1) Discussions at IEC meetings

IEC/TC 86/SC 86C/WG 2 is working on standardization documents for fibre optic sensors that are expected to be introduced aggressively. This fiscal year, meetings were held in San Luis Obispo, U.S.A. in March and Vladivostok, Russia to revise IEC 61757 (Fibre optic sensors: Generic specification) and fully discuss the IEC document proposed by Japan (IEC 61757-4-3 Fibre optic sensors Part4-2: Optical current sensors based on the polarimetric method). European countries and the United States are about to submit NPs (IEC 61757-1-2 Fibre optic sensors Part1-2 Strain sensing -Distributed sensing and IEC 61757-3-2 Fibre optic sensors Part3-2: Acoustic sensing using distributed sensing).

(2) Status of optical current sensors (61757-4-3)

Regarding IEC 61757-4-3 (Fibre optic sensors Part4-2: Optical current sensors based on the polarimetric method), which Japan proposed to TC 86/SC 86C/WG 2, IEC/TC 38 (Instrument transformers) pointed out an overlap of contents. In response, it was decided to insist that TC 86 has priority because TC 38 published IEC 60044-8 (which refers to current sensors in its scope) in 2002 while TC 86 published IEC 61757-1 (which refers to fibre optic current sensors in its scope) earlier, in 1998. A liaison will be established to continue discussions between the two parties. To wait until the issue is solved with TC 38, discussion continues by postponing circulation of IEC 61757-4-3 CD to June 2, 2018, one year behind schedule.

2.4.3 Optical Amplifiers (IEC TC 86/SC 86C/WG 3)

IEC/SC 86C/WG 3 led the survey on international standardization related to optical amplifiers, while working with the IEC/TC 86 domestic committee to review the following at the IEC/SC 86C/WG 3 meetings in San Luis Obispo and Vladivostok:

- Revision of IEC 61290-1-1 Ed.4 (Power and gain parameters - Optical spectrum analyzer method) with the addition of SOA gain ripple evaluation items: Proposed and discussed a CD about adding SOA gain ripple measurement. A modified draft will be discussed at the next meeting.
- IEC 61290-1-2 Ed.2 (Power and gain parameters - Electrical spectrum analyzer method): The project leader proposed a five-year reconfirmation, but Japan pointed out the need to consider consistency with the umbrella document. SD discussion will be held at the next meeting.
- Publication of IEC/TR 61290-4-3 Ed.2 (Power transient parameters - Single channel optical amplifiers in output power control): Discussion on the CDV comments was completed. After circulating the RVC (result of voting on CDV), the FDIS (final draft international standard) was circulated.
- IEC 61290-10-5 Ed.1 (Multichannel parameters - Distributed Raman amplifier gain and noise figure): SD discussion was held and a three-year extension was decided.
- IEC 61291-4 Ed.3 (Multichannel applications - Performance specification template): SD discussion was held and a three-year extension was decided.
- Revision of IEC/TR 61292-3 Ed.2 (Technical report - Optical amplifiers - Classification, characteristics and applications): Japan insisted on taking charge of revision, and it was agreed. A revision proposal that deletes EWDA, which is not put into practical use, from the existing document, moves PDFA and TDFA to the Annex, and adds array amplifiers and spatial multiplexing amplifiers will be explained at the next meeting.
- Revision of IEC/TR 61292-4 Ed.3 (Technical report - Optical amplifiers - Maximum permissible optical power for the damage-free and safe use of optical amplifiers): It was proposed that the document be revised by reflecting the revision of IEC 60825-1 on safety of laser products, but a three-year extension of the existing document's SD (stability date) was agreed with the goal of revising the document after the planned revision of IEC 60825-2 is completed.
- Publication of IEC/TR 61292-8 Ed.1 (Technical report - Optical Amplifiers - High-power amplifiers): Discussion on CD comments was completed. To move forward to the 2nd CD or DTR (draft technical report).
- Revision of IEC/TR 61292-9 Ed.2 (Optical amplifiers - Semiconductor optical amplifiers (SOAs)): DTR circulation and discussion on comments were completed. To be published in December 2017.

Discussions on new documents on ROPA (remote optically pumped amplifier), optical amplifiers for spatial multiplexing optical fibre transmission and other new optical amplification technologies, wide-band optical amplifier (C+L-band, O-band), pluggable amplifier (XFP, CFP), burst-mode EDFA, etc. started. There is a policy to prepare a document on ROPA.

2.4.4 Fibre Optic Active Components and Devices (IEC TC 86/SC 86C/WG 4)

SC 86C/WG 4 deals with fibre optic active components and devices in general, excluding optical fibre amplifiers. At the Vladivostok meeting in October 2017, it was decided to move the PIC (photonic integrated circuit), which Japan proposed in 2015, forward to CDV circulation on package interface standard and to CD circulation for performance standard. Preparations for standardization have been steadily made. It is anticipated to lead PIC-related standardization globally after 2018.

The SOA gain ripple measurement method, on which WG 4 and WG 3 have held coordinated discussions at the IEC/SC 86C domestic committee since FY 2015, was proposed and agreed at the IEC/SC 86C/WG 3-WG 4 joint meeting held in Frankfurt in October 2016. Documents are being prepared to propose a new measurement method within FY 2018. Activities to make an international standard, including ensuring consistency with conventional methods and clarifying the scope of application, will be made through cooperation with related parties.

2.4.5 Dynamic Modules and Devices (IEC TC 86/SC 86C/WG 5)

IEC standard documents reviewed this fiscal year include: Dynamic modules - General and guidance (IEC 62343), Performance standards - General conditions (IEC 62343-1), Reliability qualification test template (IEC 62343-2-1), Performance specification templates - Wavelength selective switches (WSS) (IEC 62343-3-3), Performance specification templates – Multicast optical switches (MCOS) (IEC 62343-3-4), and Test methods - 1 x N fixed-grid WSS - Dynamic crosstalk measurement (IEC 62343-5-2).

At the IEC San Luis Obispo meeting in March 2017, documents on MCOS performance specification templates and WSS dynamic crosstalk measurement test methods were discussed and a policy for preparing general conditions documents on reliability qualification test template and performance standards were discussed.

At the IEC Vladivostok meeting in October 2017, discussions on two documents continued while Japan presented an NP on the reliability qualification test template, for which agreement to move forward to NP circulation was achieved. With the goal of aligning the content of the dynamic module reliability qualification test with recent industry survey results, it was proposed to revise the Annex of Performance standards - General conditions. The need for revision was acknowledged and it was agreed to move the modified draft forward to CD circulation.

3. Optical Radiation Safety and Laser Equipment (IEC TC 76)

This fiscal year, IEC/TC 76 held a meeting in Milan, Italy in October. Regarding JWG, related TCs other than TC 76 are discussing documents. The following outlines the status of discussions on standard documents at each WG, primarily at the Milan meeting.

3.1 Optical Radiation Safety (IEC TC 76/WG 1)

The policy for IEC 60825-1 (Safety of laser products - Equipment classification and requirements) Ed.3, which was published in 2014, was to publish an ISH (interpretation sheet) instead of reflecting technical comments received at the CDV stage. This fiscal year, after FDIS circulation of two documents, ISH1 (radiation of multiple wavelengths, radiation from extended sources; non-uniform, non-circular or multiple apparent sources: related to 4.3) and ISH2 (conventional lamp replacement: related to 4.4), the two ISHs were published in December.

To supplement IEC 60825-1 Ed.3, a project was launched to work on virtual protective housing (where sensors detect human access to the beam to reduce exposure risks) and on moving platform (where the position of the measurement aperture surrounding a mobile object, including laser equipment, changes depending on the speed).

3.2 Laser Radiation Measurement (IEC TC 76/WG 3)

Discussion on action items continued, with the goal of revising IEC/TR 60825-13 Ed.2 (Measurements for classification of laser products) in FY 2018. WG 3 aims to complete a draft that includes new items, such as a policy on failure analysis, for RR (review report) and CD circulation.

3.3 Safety of Medical Laser Equipment (IEC TC 76/WG 4)

Regarding the Ed.4 Project, which aims to add requirements for class 1C to IEC 60601-2-22 (Particular requirements for basic safety and essential performance of surgical, cosmetic, therapeutic and diagnostic laser equipment), CDV was circulated. To expedite IS, it was decided to review Japan's proposal that interlock mechanism evaluation methods be modified when preparing Ed.5.

IEC/TR 60825-8 (Guidelines for the safe use of laser beams on humans) has a lot in common with IEC/TR 62471-3 (Guidelines for the safe use of intense pulsed light source equipment on humans), and therefore the latter will be abolished and integrated into the former. Regarding the revision of IEC/TR 60825-8 Ed.3, approval was received to start a project at the Milan meeting and WG 4 is reviewing the draft.

Discussion on ISO/TR 22463, which is related to eye damage risk associated with treatment of the upper eyelid using laser or intense pulsed light (IPL) source equipment, was carried out jointly with IEC/TC 76/JWG 12 (see 3.10).

3.4 Safety of Fibre and Free Space Optical Communications Systems (IEC TC 76/WG 5)

Japan, as the project leader of IEC 60825-2 and IEC 60825-12, is leading revision efforts.

RVC circulation of IEC 60825-12 (Safety of free space optical communication systems used for transmission of information) Ed.2 was conducted, and the draft for FDIS circulation was sent to the TC 76 secretary. WG 5 is discussing the content of the supplement to Ed.2.

A policy to circulate the CD of IEC 60825-2 (Safety of optical fibre communication systems) Ed.4 and discuss comments from the respective countries at the Milan meeting for the 2nd CD circulation was finalized. The results were circulated as a CC (compilation of comments on CD). The proposal to set the measurement condition 2 (magnifying lens observation condition) to the measurement distance of 14 mm and aperture stop diameter of 3.5 mm in the full spectrum was approved. The proposal to set the MPE (of the skin) upper limit to C7 (where wavelength dependence is exponential) was still under discussion at WG 5 to reach consensus. Meanwhile, regarding the current version of IEC 60825-2 (Ed.3), ISH2 FDIS circulation to confirm that the upper limit of C7 is 8 started. With regard to the safety of laser products in high-power optical fibre communication systems, JWG (joint working group) 10 was established under IEC/TC 86 to promote a cooperative relationship with TC 86.

3.5 High Power Lasers (IEC TC 76/WG 7)

Comments received during CDV circulation of IEC 60825-4 (Safety of laser products - Laser guards) Ed.3 were discussed, and many technical comments made by Japan on Annex D were adopted. After unifying the style of the CDV, an FDIS will be circulated.

With regard to IEC 60825-18 (Guided beam delivery systems), the number of experts did not reach the specified number at the time of last year's NP circulation, so NP circulation was carried out again this fiscal year. A total of five experts got together to start a project.

3.6 Development and Maintenance of Basic Standards (IEC TC 76/WG 8)

The revised draft of IEC/TR 60825-3 (Guidance for laser displays and shows) Ed.3 was discussed at the Milan meeting. It was decided that the applicable scope of this standard be class 3B or above outside the scope of IEC 60825-1 4.4. The draft will be edited by taking into account the comments received at the meeting and a CD will be circulated.

The DTR of IEC/TR 60825-5 (Manufacturer's checklist for IEC 60825-1) Ed.3 was circulated, and comments were reviewed at the Milan meeting. There were requests to distribute IEC/TR 60825-5, which is a checklist, as an editable file. Whether such a file can be distributed or not is being confirmed with the IEC Central Office.

The CD draft of IEC/TR 60825-14 (Safety of laser products - A user's guide) was reviewed at the Milan meeting. Its consistency with IEC 60825-1 Ed.3 ISH1 was confirmed and appropriate information on protective eyewear from the ISO draft was added. A CD reflecting the comments will be circulated.

In relation to the EU Directive issued in February 2014 on the safety requirements for consumer laser products, safety standards for consumer laser products that were to be published by the European Committee for Electrotechnical Standardization (CENELEC) was introduced. The draft European standard allows consumer laser products of Class 2 or below, excluding toys for children, while requiring a manufacturers' risk assessment for Classes 1M, 2M, and 3R. The safety standards were to be published by December 2017, but publication is behind schedule.

3.7 Non Coherent Sources (IEC TC 76/WG 9)

The 3rd CD of IEC/TR 62471-4 (Photobiological safety of lamps and lamp systems: measuring methods) Ed.1 was circulated, but the content overlap with IEC 62471-1 was not resolved. According to the convenor's judgment that the IEC 62471-1 side should determine the division of measurement-related contents, discussion on IEC/TR 62471-4 was suspended. IEC 62471-6 (Photobiological safety of ultraviolet lamp products), which was subject to NP again due to a shortage of experts, was approved and the CD draft was discussed at the Milan meeting. Japan pointed out that a wide range of UV lamp products were to be covered but not defined. The lower limit of the applicable scope of wavelength was changed from 180 nm to 200 nm.

3.8 IEC 62471-1 Special Joint TC (JTC 5)

Since April 2013, CIE Div.2 and Div.6 and the joint TC of IEC/TC 34 and TC 76 (JTC 5) have been revising CIE S009/IEC 62471 (Photobiological safety of lamps and lamp systems) for republication as CIE S009/IEC 62471-1. This fiscal year, the CD was discussed at the Jeju meeting in October and the Milan meeting in November.

The Jeju meeting discussed the policy of removing general lighting service (GLS) from the applicable scope of IEC 62471-1 to be covered in the revised version of IEC 62471-2, but the Milan meeting decided that there should be no specification to "exclude GLS" and that differentiation should be made under the measurement conditions. Regarding GLS, coordination with IEC/TC 34 is also needed.

While discussions on measurement distance continued, several experts have different intentions with regard to separating the 1 m condition and 200 mm condition, etc., so that discussion remained chaotic.

An agreement is being made to follow the discussion and voting procedures in line with CIE operational rules and to make a proposal to IEC/TC 76 at the FDIS stage.

3.9 Safety of Lasers and Laser Equipment in an Industrial Materials Processing Environment (IEC TC 76/JWG 10)

JWG 10, as a JWG with ISO/TC 172/SC 9/JWG 3, is discussing standards of the ISO/IEC 11553 series.

With regard to ISO/IEC 11553-1 (Safety of machinery - Laser processing machines – Part 1: General safety requirements) and ISO/IEC 11553-2 (Part 2: Safety requirements for hand-held laser processing devices), the machinery safety consultant of Comité Européen de Normalisation (CEN) provided many technical comments on the Ed.2 CDV circulation, with the result that the convenor and the project leader had an ad hoc meeting. The agreed draft was discussed at the Milan meeting, and the FDIS reflecting the discussion will be circulated. Currently, however, there is no project leader familiar with hand-held laser processing devices regarding ISO/IEC 11553-2.

3.10 Eye and Face Protection against Laser Radiation (IEC TC 76/JWG 12)

Activities are underway as the JWG with ISO/TC 94/SC 6/JWG 1. A review is being conducted at the ISO meeting, and web meetings are held as appropriate. The documents in the WD stage are circulated based on the ISO numbers.

Regarding ISO/IEC 19818 (Eye and face protection - Protection against laser radiation - requirements and test methods) Ed.1, the WD (N76) was discussed at the Milan meeting. As the laser resistance class (RC) can be confused with laser classification, it was decided to read RC as "laser resistance category." Four symbols and divisions used for RC categorization were decided: C for "continuous–0.1 s," P for "under 0.1 s–10 µs or higher," Q for "under 10 µs–1 ns or higher," and U for "under 1 ns" (pulse width in parentheses). As resistance data of protective eyewear for type U laser was not sufficient, type U laser testing would not be included in the requirements but the test results would be compiled as an annex (reference). In relation to that, round robin tests will be conducted, but mutual comparison is unlikely to be easy because of differences in specifications between organizations.

The DTR of ISO/TR 22463 (Patient/client eye protectors for protection against laser/intense light source (ILS) equipment used on humans for cosmetic and medical applications - Guidance for selection and use) was discussed at the Milan meeting. The 2nd DTR reflecting the discussion will be circulated.

4. Laser and Electro-Optical Systems (ISO/TC 172/SC 9)

This meeting compiles domestic opinions and reflects Japan's proposals on the international standards proposed by ISO/TC 172/SC 9, which is in charge of preparing international standards on lasers.

This fiscal year, the domestic meeting, with a new additional member, was held in August 2017 and in March 2018 to deliberate on international meeting strategy.

For three days from September 20 to 22, 2017, an international meeting was held at the National Institute of Standards and Technology (NIST) in Boulder, U.S.A., with a total of 21 participants from four countries: four from France, seven from Germany, three from the U.S.A., and seven from Japan. Discussions and decisions at the international meeting were as follows:

4.1 Plenary

- The Chairman (Germany) proposed to change the name of ISO/TC 172/SC 9 from Electro-optical systems to Laser and electro-optical systems. It was decided to seek approval of TC 172.
- WG 7's convenor (Japan), who served in the role for years, resigned and a new convenor (Japan) was selected.
- One person from Germany and one person from Japan were selected as liaisons for IEC/TC 62/SC 62D (Electromedical equipment).
- One person from Japan was selected as a liaison for IEC/TC 47/SC 47E (Discrete semiconductor devices).
- The next meeting in 2018 will be held in France. The meeting in 2019 and meeting in 2020 will be held in China and the Americas, respectively.

4.2 Terminology and Test Methods for Lasers (ISO/TC 172/ SC 9 WG 1)

- ISO/PWI 22247 (Effective numerical aperture of laser-lenses in the field of laser beam forming – Definition and verification procedure): It was decided to work on it as an NP and a project leader (PL) was selected.
- ISO/CD 19986 (Lasers and laser-related equipment - Test method for angle resolved scattering): It was decided to circulate a CD (committee draft) after a web meeting. As the draft tended to explain specifications regarding IOF (German) equipment, it was decided to change the draft to provide a more general description.
- ISO/AW21254-1, -2, and -3 (Laser and laser-related equipment – Test methods for laser-induced damage threshold Parts 1, 2, and 3): A person from Germany was selected as the project leader. How to revise Part 1 and 2 was discussed. Regarding raster scan, in particular, it was decided to collect the respective companies' procedures in order to summarize the procedures. The project leader of Part 3 proposed evaluation procedures and it was decided to conduct a round robin test in the United States following the proposed procedures.
- ISO/WD 11551 (Optical and Photonics – Lasers and laser-related equipment – Test method for absorptance of optical laser components):

A test report was introduced. It was decided to consider standardization within a limited scope and work on a WD (working draft).

- ISO/DIS 17915 (Optics and photonics – Measurement method of semiconductor laser for sensing): Transition from TS (technical specifications) to IS (international standard) was approved. It was decided to discuss comments received from the respective countries and move on to the FDIS (final draft international standard) stage by the end of the year.

4.3 Laser Systems for Medical Applications (ISO/TC 172/ SC 9 WG 4)

- ISO/DIS 11990 (Lasers and laser-related equipment – Determination of laser resistance of tracheal tube and tracheal cuffs): It was decided to move forward to the FDIS stage.
- ISO/PWI 22248 (Laser and laser-related equipment – Test methods for laser-induced damage threshold – Classification of medical laser delivery and application systems): Based on the discussion at a joint meeting with WG 1, it was decided to move forward to the NP stage.

4.4 Electro-Optical Systems other than Lasers (ISO/TC 172/SC 9 WG 7)

(1) ISO/AWI 11807-1 and -2 (Integrated optics – Vocabulary – Part 1: Basic terms and symbols) (Part 2: Terms used in classification), ISO/AWI 14881 (Integrated optics – Interfaces – Parameters relevant to coupling properties)

- The secretary introduced and demonstrated the ISO/IEC terminology search system.
- It was found that the use of the system can facilitate development efforts, with the result that the information was given to the group members.
- Because of a correspondence to the IEC/TC 86 SC terminology, it was decided to coordinate with the IEC side by holding a meeting with IEC in April 2018 in Milan (Italy).
- It was decided to move forward to the WD stage by the end of January 2018 and to the CD stage by the end of June 2018, but in fact the work is behind schedule.
- A working group meeting was held in Mishima in January 2018 to prepare a WD.

4.5 ISO Standards Voted On and Published

This fiscal year, seven projects were subject to voting (DIS [draft international standard]: 5, FDIS: 1, CIB [committee internal balloting]: 1), and the following two were published as ISO standards.

- ISO 11554:2017 (Optics and photonics -- Lasers and laser-related equipment -- Test methods for laser beam power, energy and temporal characteristics)
- ISO/TR 20811:2017 (Optics and photonics -- Lasers and laser-related equipment -- Laser-induced molecular contamination testing)

5. International Standardization on Evaluation of EMC and related Characteristics of High-Speed In-Vehicle Ethernet Physical Layer (V Pro 3)

5.1 Objective

Increasing the capacity of in-vehicle communications is expected for advanced driving support systems and automated driving. In-vehicle Ethernet standards with an enhanced real-time property and fail-safe property are required to be highly reliable for the communication backbone connecting backbone units of self-driving vehicles and for sensor networks. Particularly with regard to EMC, reliable in-vehicle communication systems will become possible by combining communication boards with superior EMC characteristics and fiber optic harnesses that do not generate and are not subject to electromagnetic noise. This project proposes coordination between EMC standards for communication chips and communication boards and standards for fiber optic harnesses while leading the development of optical communication standards

5.2 Activities and results of this fiscal year

The following (1) through (4) were conducted as international standardization activities.

(1) Developing IEC and ISO standards

Worked with standardization organizations and related organizations to prepare drafts and provide proposals on: (1) 1 Gbps in-vehicle optical Ethernet communication standards (ISO 21111-3), (2) 1 Gbps in-vehicle optical Ethernet component standards (ISO 21111-4), (3) multi-giga in-vehicle Ethernet (ISO 21111-X), (4) EMC evaluation of transceivers - Ethernet transceivers (IEC 62228-5), (5) Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - General and guidance (IEC 61300-1), and (6) Optical fibres - Product specifications - Sectional specification for category A4 multimode fibres (IEC 60793-2-40).

Table 3 summarizes the progress made in this fiscal year and the future schedule.

(2) EMC-based prototyping and operation verification of in-vehicle optical communication systems

Prototyped and verified communication chips, communication boards, and other components to lead the development of in-vehicle Ethernet standards.

(3) Building in-vehicle LAN simulators and systems

Built an optical communication simulator implementing the developed standards to facilitate the dissemination of the standards and communication systems. Reflected the MPD communication model that should be developed to build the simulator in the standards. Demonstrated and verified EMC resistance and effectiveness of high-speed sensor networks by using actual vehicles.

(4) Dissemination activities at IEEE, etc.

Participated in IEEE's standardization activities related to in-vehicle Ethernet, and promoted technical discussions and advocated the standards at academic conferences and standardization meetings attended by in-vehicle communication engineers from carmakers.

6. International Standardization on Reliability of Narrow-Pitch Multi-Fiber Optic Connectors (NP Pro)

6.1 Objective

With the advance of cloud computing in recent years, the volume of data processed and the communication volume at data centers are increasing, which poses an issue around controlling power consumption. To address the issue, high-density optical interconnect is being applied to servers and routers at data centers around the globe. To bring about high-density optical interconnect, this project works on the international standardization of narrow-pitch multi-fiber optic connectors to which optical fibers that are narrower than conventional optical fibers are applied. With the goal of registering an NP (New work item Preposal) by FY 2019, the project will propose one draft international standard NP on narrow-pitch multi-fiber optic connectors to IEC/TC 86.

6.2 Progress in this fiscal year

In this fiscal year, as the first year of the three-year plan, conducted technical review based on experiments on insertion loss of prototype connectors for international standardization of narrow-pitch multi-fiber optic connectors, and proposed the content of the new standard to IEC/TC 86 in October 2017. Progress made in this fiscal year is as follows:

(1) Established an international standardization proposal committee on reliability of narrow-pitch multi-fiber optic connectors in order to standardize draft specifications of narrow-pitch multi-fiber optic connectors with the same outer dimension as MT ferrule, guide pin

Table 3　Progress of international standardization

Standard No.	Proposed to	Ultimate goal (–FY 2019)	Results in FY 2017	Future schedule
ISO 21111-3	ISO/TC 22/ SC 31/WG 3	Document publication	Division of the document at the WD preparation stage was decided. A reconstructed WD was prepared, and registration of the CD was approved.	Discuss the CD to prepare a DIS by the end of FY 2018.
ISO 21111-4	ISO/TC 22/ SC 31/WG 10	Document publication	Document development activity was carried out to move to the CD voting process.	Summarize the CD voting results, hold F2F meeting in May 2018, and prepare DIS in July 2018.
ISO 21111-X	ISO/TC 22/ SC 32/WG 10	Committee draft registration approval	Transmission characteristics and mode characteristics of multi-mode optical fibers were evaluated and issues related to in-vehicle installation were confirmed.	Confirm optical harness characteristics for the in-vehicle environment, and submit new work item proposals.
IEC 62228-5	IEC/TC 47/ SC 47A/WG 9	Circulation of committee draft for vote	Questions were posed and a survey was conducted on Germany's notice of an NP. The proposal was provided in January 2018.	Review the NP from Germany in April 2018. Continue review of the proposal to reflect Japan's opinion.
IEC 61300-1	IEC/TC 86/ SC 86B/WG 4	Registration of draft international standard	As the draft revision of 61300-1 was merged into 61300-3-53, it was decided to reflect the draft revision in 61300-3-53. The revision was approved at the WG 4 meeting.	Submit a draft to the SC 86B interim meeting in April 2018. After NP approval, start official revision efforts.
IEC 60793-2-40	IEC/TC 86/ SC 86A/WG 1	Circulation of committee draft for vote	A revision proposal was presented. Approval was given for the proposal to be integrated with the addition of a separately proposed new subcategory into a task.	Prepare a CD and submit it to be discussed at the WG 1 meeting in April 2018.
IEEE 802.3ch (adding optical fiber to the scope)	IEEE802.3 Multi-Giga Automotive Ethernet PHY Study Group	Establishing a forum to discuss multi-giga in-vehicle optical Ethernet standard	In response to the rejection of the multi-giga in-vehicle optical Ethernet standard at the meeting in July, information collection and lobbying activities were continued with a view to submitting a new proposal in the next fiscal year.	Provide a CFI proposal on the 10-G in-vehicle Ethernet standard at a meeting in March 2019.

diameter of 0.55 mm, optical fiber pitch of 125 μm, and up to 32 fibers (1 line).

(2) At the IEC/TC 86 presentation session and TC 86 FOCI (Fibre Optic Common Interest), held on October 8 in Vladivostok, made a presentation on the direction of and need for developing narrow-pitch optical connectors and proposed that standardization efforts be divided between SC 86A, SC 86B, and JWG 9 in the future. The proposal was discussed.

(3) Simulated random insertion loss by using single mode optical fiber with outer diameter of 80 μm and 24-fiber narrow-pitch ferrule, and reviewed the relationship between ferrule accuracy and insertion loss of narrow-pitch multi-fiber optic connectors. Conducted technical review based on experiments on insertion loss of prototype connectors.

(4) Carried out discussions on standardization of narrow-pitch multi-fiber optic connectors at the IEC SM and MM Optical Interface Task Group Meeting, and conducted a technical survey on optical interconnect at the international academic conference of SPIE Photonics West to gain knowledge for future NP submission to IEC.

Educational and Public Relations Activities

1. FY 2017 Symposium on the Optoelectronics Industry and Technology

The FY 2017 Symposium on the Optoelectronics Industry and Technology was held at the Rihga Royal Hotel Tokyo on Wednesday, February 7, 2018. The event was jointly sponsored by OITDA and the Photonics Electronics Technology Research Association (PETRA), with support from the Ministry of Economy, Trade and Industry.

While there has been rapid progress in the utilization of AI, IoT, and Big Data in recent years, the development of optoelectronics technology is expected to drive innovation that will lead Japanese industry and society forward. Optoelectronics technology is also predicted to provide fundamental support to the coming AI, IoT, and Big Data society.

The symposium attracted around 300 participants. Under the theme of "Photonics Technologies Underpinning the AI/IoT Era", experts from various fields gave presentations on AI-oriented supercomputers, machine learning platforms, "trillion IoT," the strategy for photonics technology for the AI/IoT era, and development of a compact silicon photonics transceiver applicable to AI/IoT, and the future vision of Japan's optoelectronics industry and technology was actively discussed.

2. InterOpto 2017

InterOpto 2017, an international exhibition of cutting-edge optoelectronics technology, was held at Makuhari Messe for three days from Wednesday, October 4 to Friday, October 6, with support and cooperation from the Ministry of Economy, Trade and Industry and many other organizations.

The event this year was held concurrently with CEATEC JAPAN 2017 as well as LED JAPAN 2017, BioOpto Japan 2017, LaserTech 2017, and MEMS Sensing & Network System 2017, in an effort to showcase all the latest technologies and products ranging from device components to the hottest IoT, AI, and automotive applications together, so that visitors could gather information more efficiently and effectively, while opportunities for collaboration between exhibitors were dramatically increased.

Covering a wide range of exhibition categories, including laser/light sources, optical devices/modules, materials, optical equipment/instruments, and services/software related to the optoelectronics industry, InterOpto exhibited a broad range of technologies from optoelectronics-related materials to optical application systems.

InterOpto alone featured 106 booths set up by 86 exhibitors from in and outside Japan, including optoelectronics manufacturers and trading companies. The total number of exhibitors and booths for the five exhibitions excluding CEATEC was 269 and 292, respectively. As tickets for each exhibition included admission to the others, many CEATEC visitors dropped by the other exhibitions, with the bustling exhibition halls holding several times as many visitors as last year.

A "Notable Optoelectronics Technology and Special Exhibit Zone" was set up in the Exhibition Hall. In this zone, eight companies recommended by the working groups of OITDA's Optoelectronics

Table 4　FY 2017 Symposium on the Optoelectronics Industry and Technology

10:00 − 10:05	Opening Remarks	Mr. Yasuhisa Odani President / Vice Chairman, OITDA
10:05 − 10:15	Guest Greeting	Mr. Tatsuji Narita Director, IT Industry Division, Commerce and Information Policy Bureau, METI
10:15 − 11:15	Keynote Speech: Supercomputer TSUBAME3 and ABCI (AI-Based Bridging Cloud Infrastructure), and Photonics Technology for Them	Dr. Satoshi Matsuoka Professor, Global Scientific Information and Computing Center, Tokyo Institute of Technology
11:15 − 12:00	Google's Easy to Use Machine Learning	Mr. Kazunori Sato Staff Developer Advocate, Cloud Platform, Google
13:00 − 13:45	Trillion IoT, Edge Computing and Their Standardization	Dr. Taizo Kinoshita Board of Directors, New Generation M2M Consortium
13:45 − 14:30	Photonics Technology Strategies for AI / IoT Era	Dr. Mitsuru Takenaka Associate Professor, Department of Electrical Engineering and Information Systems, The University of Tokyo
14:45 − 15:30	"Optical I/O Core" Small Optical Transceiver and New Optical Market	Mr. Tomoyuki Fujita CEO, AIO Core Co., Ltd.
15:30 − 16:15	Integrated Photonics-Electronics Convergence System Technology − Compact and Large Capacity Optical Interconnect between CPUs	Dr. Shigeaki Sekiguchi Photonics Electronics Technology Research Association (PETRA)
16:20 − 17:00	Award ceremony for the 33rd Kenjiro Sakurai Memorial Prize	
17:00 − 19:00	Get-together	

Technology Trend Committee exhibited their technologies and products. A Notable Optoelectronics Technology Seminar was also held for two days from October 5 to 6 at the seminar site in the Exhibition Hall.

In the Seminar Room of the International Conference Hall, a special lecture titled "Recent Advances and Applications of VCSEL Integrated Photonics" was presented by Prof. Fumio Koyama from the Laboratory for Future Interdisciplinary Research of Science and Technology at the Tokyo Institute of Technology, and seminars on technological trends in seven optoelectronics technology fields were held on October 5. On October 6, Mr. Toshimitsu Kawano of Beckoff Automation gave a special talk titled "Industry 4.0: Introducing an Industrial IoT and Business Model," and seminars on optoelectronics industry trends in seven product fields and overview trends were presented. These seminars attracted large audiences and stimulated exchanges of opinions among audience members.

3. 33rd Kenjiro Sakurai Memorial Prize

The Kenjiro Sakurai prize was established as a memorial to the late Dr. Kenjiro Sakurai, a former director of OITDA who played a major role in developing the optoelectronics industry. Its purpose is to promote the technological development of the industry. The prize has been given out 32 times to 24 individuals and 37 groups, for a total of 147 awardees.

This year, the Kenjiro Sakurai Memorial Prize was awarded to two groups out of 14 applications for their pioneering achievements in the optoelectronics industry and technology since 2007.

One prize was awarded to Dr. Hakaru Mizoguchi, Dr. Junichi Fujimoto, and Dr. Koji Kakizaki of Gigaphoton Inc. and Prof. Shuntaro Watanabe of the Tokyo University of Science for their "Development and implementation of high power ArF excimer laser for semiconductor lithography." The other prize was awarded to Dr. Mitsuru Sugawara, Mr. Keizo Takemasa, and Dr. Kenichi Nishi of QD Laser, Inc. for their "Development and practical use of high-temperature semiconductor quantum dot lasers."

Dr. Mizoguchi and his colleagues at Gigaphoton have worked on the development and implementation of light sources for semiconductor lithography for many years. They achieved the world's first injection lock technology for deep ultraviolet light source lithography, and succeeded in developing a high-power ArF excimer laser for semiconductor lithography achieving the world's top-level efficiency, high output power, tunable output power, and high beam stability. The technological development resulted in a number of wins, including helping Gigaphoton attain a major market share for global excimer lasers for semiconductor lithography, and significantly contributed to the global development of semiconductor manufacturing and Japan's optoelectronics industry.

Dr. Sugawara and his team at QD Laser have developed crystal growth technology to form 10 nm self-assembled semiconductor quantum dots in a multilayer configuration with high density and high uniformity. In doing so, they achieved characteristics that had been expected from quantum dot semiconductor lasers, such as low threshold current characteristics, high temperature operation characteristics, and high tolerance to optical feedback, and promoted technological development for the practical use and mass production of quantum dot lasers, which has led to applications in a wide variety of areas, including 1.3 μm band optical communications, light sources for optical interconnect, and sensing under high-temperature environments. The development, practical use, and mass production of quantum dot lasers represent a significant contribution by the optoelectronics industry to the development of an IoT society where everything is networked.

The award ceremony was held on February 7, 2018 following the FY 2017 Symposium on the Optoelectronics Industry and Technology. At the ceremony, Prof. Yasuhiko Arakawa (The University of Tokyo) who is the chairperson of the Kenjiro Sakurai Memorial Prize Committee, reported on the selection process and results. This was followed by the presentation of certificates, medals, and extra prizes to the awardees.

Awardees of the 33rd Kenjiro Sakurai Memorial Prize
Back row, from left: Dr. Nishi, Dr. Fujimoto, Dr. Kakizaki
Front row, from left: Mr. Takemasa, Dr. Sugawara, Dr. Mizoguchi, Prof. Watanabe

Supporting Members

(As of March 31, 2018)

[Chemistry]

Fujifilm Corporation

Mitsubishi Chemical Corporation

Nissan Chemical Industries, Ltd.

Shin-Etsu Chemical Co., Ltd.

Sumitomo Bakelite Co., Ltd.

Yamamoto Kogaku Co., Ltd.

[Glass & Ceramics]

Asahi Glass Co., Ltd.

Corning International K.K.

Nippon Sheet Glass Co., Ltd.

Sumitomo Osaka Cement Co., Ltd.

Technical Co., Ltd.

Toyo Seikan Group Holdings, Ltd.

[Electric Wire & Cable]

Fujikura Ltd.

Fujikura Dia Cable Ltd.

Furukawa Electric Co., Ltd.

Okano Electric Wire Co., Ltd.

Sumitomo Electric Industries, Ltd.

SWCC Showa Holdings Co., Ltd.

[Electronics & Electronic Appliances]

Anritsu Corporation

Enplas Laboratories Inc.

Fujitsu Limited

Hamamatsu Photonics K.K.

Hirose Electric Co., Ltd.

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Honda Tsushin Kogyo Co., Ltd.

Huawei Technologies Japan K.K.

Japan Aviation Electronics Industry, Ltd.

Kyocera Corporation

Macom Japan Limited

Mitsubishi Electric Corporation

Murata Mfg. Co., Ltd.

NEC Corporation

NTT Electronics Corporation

Oclaro Japan, Inc.

Oki Electric Industry Co., Ltd.

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Rohm Co., Ltd.

Santec Corporation

Sanwa Denki Kogyo Co., Ltd.

Sharp Corporation

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Taiyo Yuden Co., Ltd.

Toshiba Corporation

Tyco Electronics Japan G.K.

Ushio Inc.

Yamaichi Electronics Co., Ltd.

Yamamura Photonics Co., Ltd.

Yokogawa Electric Corporation

[Precision Instrument]

Canon Inc.

Konica Minolta, Inc.

Nikon Corporation

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Ricoh Company, Ltd.

Seiko Instruments Inc.

Seikoh Giken Co., Ltd.

Sigma Koki Co., Ltd.

Suruga Seiki Co., Ltd.

Topcon Corporation

[Commercial & Advertisement]

Hakuto Co., Ltd.

JTB Communication Design, Inc.

Marubun Corporation

The Optronics Co., Ltd.

[Electric Power]

Central Research Institute of Electric Power Industry

[Other Manufacturing]

Adamant Namiki Precision Jewel Co., Ltd.

Dai Nippon Printing Co., Ltd.

Iwasaki Electric Co., Ltd.

Optoquest Co., Ltd.

[Others]

Granopt Ltd.

Institute for Laser Technology

Japan Optomechatronics Association

KDDI Research Inc.

Nippon Telegraph and Telephon Corporation

NTT Advanced Technology Corporation

Photonics Electronics Technology Research Association

INTERNATIONAL OPTOELECTRONICS EXHIBITION 2019

InterOpto® 2019

10.16 wed - 18 fri 2019

Makuhari Messe, Japan

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