Cable Network Components Supporting the Infrastructures of the Optical Network

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The applications for video delivery, cloud services, etc. are becoming more diverse day by day, the communication capacity is growing year by year, and the importance of the optical access network is getting higher and higher, all of them aimed at the realization of a ubiquitous network society. The optical access network, which is an indispensable communications infrastructure in today's world, requires high speed & large capacity, high reliability, electrical power saving, and low cost. In this paper, we present the fiber optics and optical cable network components for the support of these infrastructures.

1. Introduction

In the field of optical communications products, we are working to be the premier manufacturer in the following fields: optical fiber and optical fiber cable joining technologies, fiber monitoring systems, and wavelength selective switches.

In addition, we focus on the development of optical interconnections for high-end communications equipment and supercomputers, using technology from developing various optical connectors over the years.

2. Optical fiber and Optical fiber cable joining technologies

2.1 Mechanical Splice

One of the technologies for easily joining fibers, our company continues to improve the handling and cost-competitiveness of the mechanical splice. Recently, we developed a mechanical splice connection technology that allows connection even with short remaining fiber lengths[1)] (Fig. 1). This technology allows even fiber with only about 60 mm length to be spliced, such as in aerial drop closures where fibers formerly used with dropped subscribers can be reconnected for use again down the line, and in easy establishment of small cabinets in existing small-medium residential properties. The use of Mechanical Splice technology is expected to deliver economical construction of the optical access network.

In addition, to simplify the work of connecting drop cables, we have developed the drop cable sheath grip-type mechanical splice[2)]. This is highly applicable in drop cable repair scenarios and construction of indoor optical cable wiring through small gaps in the doors and windows.

2.2 Mechanical splice-type field-installable connector

The full scale development of this field-installable connector[3)] (Fig. 2), using technology from the mechanical splice, took place during the penetration phase of the Fiber To The Home (FTTH) rollout in Japan. The drop cable grip-type field-installable mechanical splice connector[4)] was especially effective for the economical and rapid deployment of FTTH. Currently, this type of connector is also gaining traction in overseas FTTH markets.

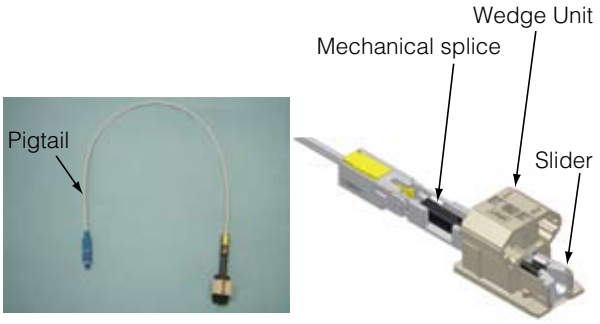

Fig. 1. Mechanical splice for short length fiber.

Fig. 2. Field-installable connector with mecanical splice.

1 Fiber Optics Network Product R&D Dept.

Abbreviations, Acronyms, and Terms.

Mechanical splice—Optical fiber splicing by clamping of aligned fiber ends together
Fiber To The Home (FTTH)—Consumer high-speed access Internet service delivered via optical fibers
Low reflectance connection—Connection which has a low value of reflected optical power
Angled Physical Contact (APC)—Connector endface with an angled and rounded contact Surface
MPO Connector—Multi-fiber Push-On Connector developed by NTT
MT Connector—Multi-fiber Transfer Connector developed by NTT
PT Connector—Photonic-Turn Connector
Trunk Cable—Backbone cables used in datacenters, etc.
10GBASE-SR—(One of the) IEEE 802.3ae specification for the 10Gigabit Ethernet standard.
OM3—ISO/IEC 11801 standard for optical multimode fiber

2.3 Splice-On field-installable connector

We are also developing the splice-on field-installable connector[5]. Fusion splicing, compared with mechanical splice and other similar fiber contact joining technologies, features low reflection performance. For this reason, use of splice-on connectors with Angled Physical Contact (APC) polish-grade ferrule endfaces[6] have spread in applications requiring low reflectance. In addition, it is thought that conventionally, the field-assembly multi-fiber connector was difficult to realize, but we have recently developed the MPO splice-on connector (Fig. 3). This technology is expected to be useful in datacenter wiring and maintenance.

2.4 Optical cabling systems

With the increasing reach of the internet and smartphone, and the demand in media delivery, datacenter construction is steadily increasing. Against this backdrop the market for wiring products within the datacenter is expanding, with a rapid penetration of optical wiring and transceiver equipment for data transmission.

Our optical cabling systems have adopted the ①Lightweight small-diameter trunk cable, ②Multi-fiber 12MPO connector bulk connection technologies, and ③Modularized high-density patch panels. For this reason we not only cater to today's 10GbE demands but also allow for a smooth transition to high speed, high capacity 40GbE and 100GbE upgrades (Fig. 4, 5, 6).

Further, with the datacenter-use optical cabling systems, all the optical connectors are pre-assembled, with only on-site connections required to complete construction of a quick-to-install and high reliability optical cabling system. In addition, wideband multimode fiber can be used to extend the transmission distance. In the case of 10GBASE-SR, a range of 300m can be attained with OM3, while 550m is possible with OM4.

In the case of cable damage or some other trouble, splice-on field-installable connectors can be utilized to quickly perform repairs for network recovery.

3. Optical network maintenance technologies

3.1 Optical fiber monitoring system

This company's Optical Fiber Monitoring System (FiMO) enables one to monitor fiber lines 24/7, allow-

Fig. 3. Field-installable connector with fusion splice.

Fig. 4. 48 core fiber Trunk cable with 12MPO connector.

ing rapid response in the event of any failure, along with the ability to perform preventive maintenance for warning signs.

The system comprises of a [Remote Test Unit], which performs testing and judges on the fiber lines, and [FiMO Server] which manages all installed Remote Test Units comprehensively via Network (Fig. 7). The [Remote Test Unit] comprises of [Optical Test Unit], which perform to test fiber lines and [Optical Fiber Selector], which selects tested fiber line. In the case of fiber line failure, the management software enable to display notifications (including location information on a map too), and also send alerts to maintenance personnel via email and other means. This optical fiber monitoring system is the first in the world to be compatible with the Passive Optical Network (PON) system, with the ability to perform line testing behind optical splitters.

The introduction effects of our system are: ①fiber line abnormalities can be found at an early stage, ② even without on-site diagnosis the situation can be judged and the rapid response is possible, ③Aging degradation of transmission loss can be visualized, allowing the performance of preventive maintenance, etc.

3.2 Optical Fiber Management System

The Optical Fiber Management System uses technology from Geographic Information Systems (GIS) and enables to manage the location and attribute information of fiber network facilities centrally on electric map.

The Fiber Management System comprises of a Server which has database, and Clients for operation. The usage state per fiber and asset management is enabled by registration of facilities and equipment of optical network such as fiber cables, closures, poles and conduits and adding circuit infomration to each fiber per section. Further, the automation of FTTH design required complicate connection management and the function making fiber connection diagram and route diagram automatically are enabled. The fault location can be displayed on the map by linking with FiMO fiber monitoring system (Fig. 8).

Fig. 5. 12MPO/LC connector module.

Fig. 6. LC adapter panel.

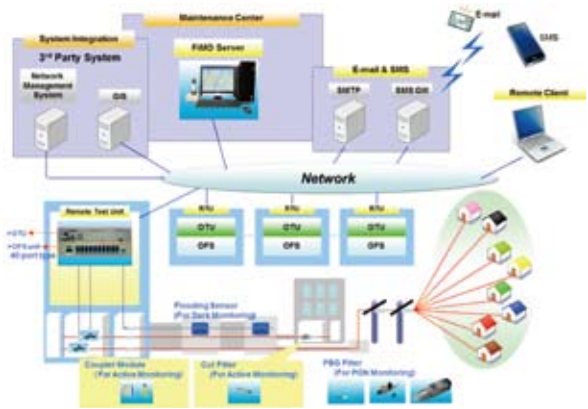

Fig. 7. Optical fiber monitoring system. (FiMO®)

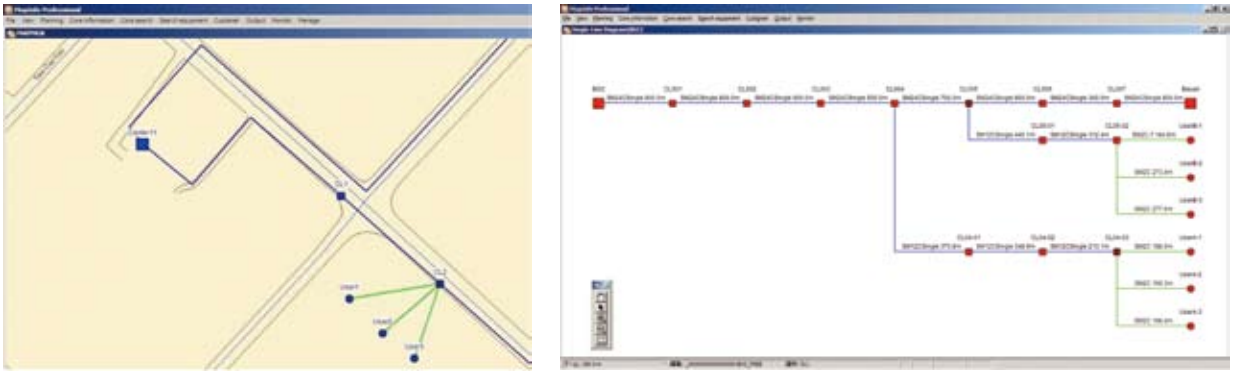

Fig. 8. Optical network database management System with geographical map.

Herebefore Optical fiber network design documentation had been drawn by CAD, excel spreadsheets and other formats and managed as library after completion of construction, which the data management tends to get more difficult over time. Our Fiber Management System can centrally manage facilities, fiber lines, connection and circuit information using GIS technology and search required information by searching function quickly. For this reason, data search at design work of change and addition to the network, as well as failure events, can be accurately and efficiently retrieved.

4. Wavelength Selective Switch

Wavelength division multiplexing, a technology which multiplexes a number of optical signals onto a single optical fiber using different wavelengths of laser light, has been progressing. In recent times, the use of the flexible Reconfigurable Optical Add-Drop Multiplexer (ROADM) is gaining in popularity. The core component in the ROADM is the Wavelength Selective Switch (WSS) (Fig. 9). We have integrated the free space optical, mechanical, circuitry and firmware design, making high-performance and high-reliability WSS products into reality. Mass production of the 1x2 WSS and 1x4 WSS has been achieved, and further development of new products is in progress (Fig 10).

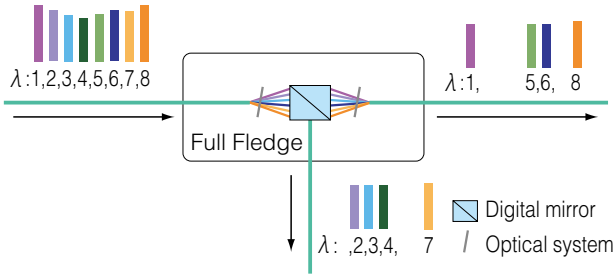

Fig.9.Conceptual diagram of the function WSS.

Fig.10.WSS housing.

5. Optical interconnections

Optical interconnections refer to the technology used in optical data transmission in-device (on-chip, chip-to-chip, board-to-board) or at short ranges between devices. Figure 11 shows a schematic diagram of optical interconnections. This technology is anticipated to solve the interconnect bottlenecks of conventional electrical wiring, and put to use in high-speed data transmissions such as in supercomputing and datacenter applications.

5.1 High fiber count connector

High fiber count connectors are used in optical interconnections. Figure 12 shows an example, the 48-fiber MPO connector. This optical connector can be connected/disconnected with an easy Push-on/Pull-off action, and packs 4 x 12-fiber ribbons into a cross-

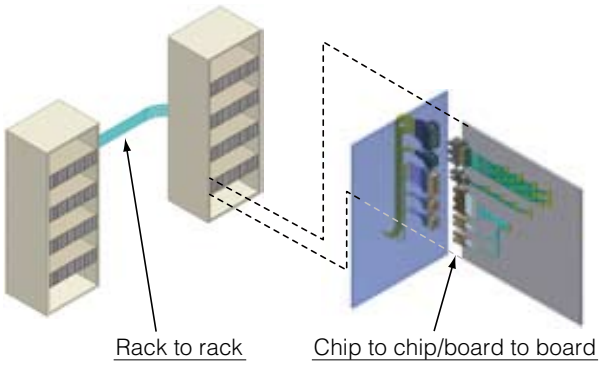

Fig. 11. Example of the application of optical inter-connection

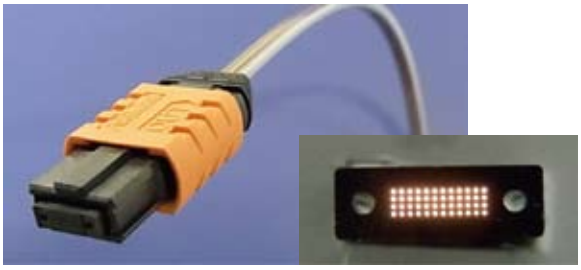

Fig.12.48-fiber MPO connector.

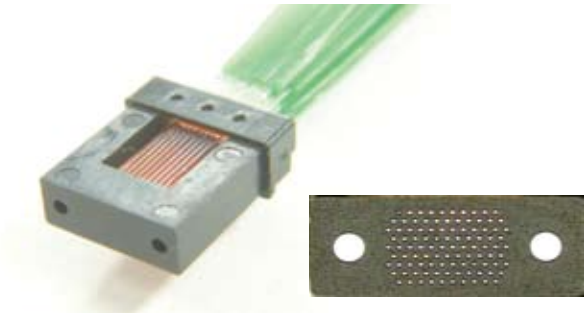

Fig.13.100-fiber MT connector.

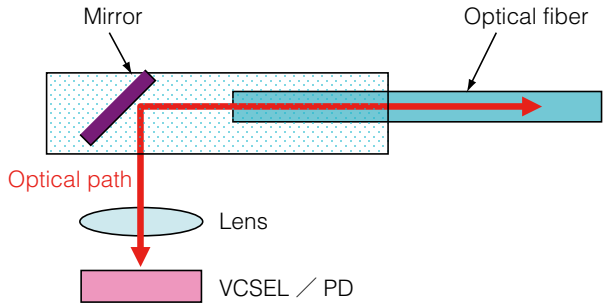

Fig.14.Principle of PT connector.

section area of 2.5 mm x 6.4 mm, using 2 guide pins for alignment. To achieve even high connection density, we are also looking into the development of a 100-fiber version using the same package[8] (Fig.13).

5.2 Photonic-turn connectors

We are developing connectors, primarily for use in optical interconnections between devices, for perpendicular mounting on the board[9]. The principle of a typical circuit board mounting type optical connector, the Photonic-Turn (PT) connector, is shown in Figure 14, and the appearance is shown in Figure 15.

The connector integrates a total internal reflection surface to redirect light perpendicularly towards the circuit board optical modules, allowing a very low profile connector. Currently we are developing a substrate-mounting type connector which utilizes total internal reflection between the optically transparent resin and the air layer (Fig.16).

6. Conclusion

We have covered the current state of the developments in optical communications components. We aim to continue contributing to the realization of a ubiquitous network society by creating world-leading products to support the optical access network.

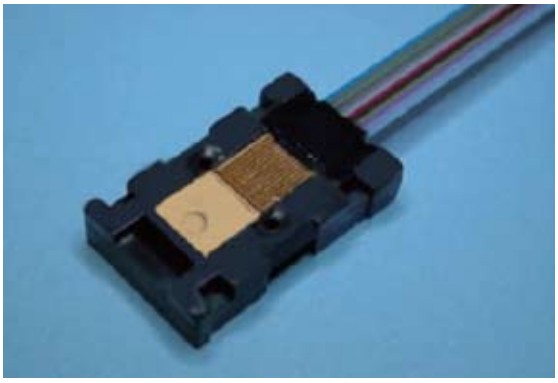

Fig.15.PT connector.

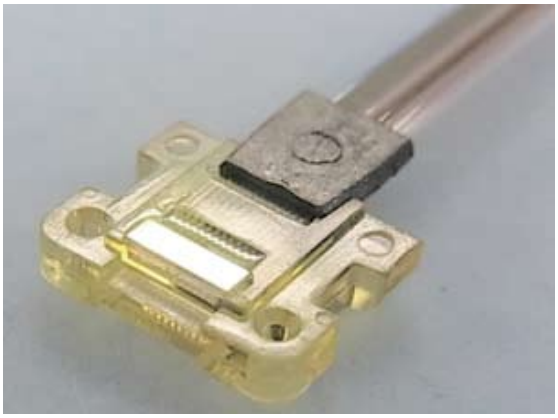

Fig.16.New type PT connector.

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