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Nippon Telegraph and Telephone Corporation
NTT Advanced Technology Corporation

Field assembly technology for optical connectors - Newly developed instant adhesive and portable high-speed polisher allows quick and economical field assembly of optical connectors -

Nippon Telegraph and Telephone Corporation (hereafter NTT; Head Office: Chiyoda-ku, Tokyo; President: Norio Wada) has developed a field assembly technology for optical connectors that is both quick and economical. Until now this assembly had been impossible to accomplish outside a factory. This new technology is being promoted through "Comprehensive Commercialization Functions[*1]", which started to promote the commercialization of prominent research achievements in July 2003. NTT Advanced Technology Corporation (hereafter NTT-AT; headquarters: Shinjuku-ku, Tokyo; president: Kimio Tazaki) will begin to market this technology on March 10th, 2004.

This product consists of an instant adhesive and a portable high-speed polisher. This combination can be used to assemble an optical connector with conventional low cost parts very quickly (1/5 the time needed with the conventional method) even on a construction site without a power supply. The flexible use of optical wiring will become more widespread through the use of field assembled connectors than could be possible with the conventional splicing technique.

This portable high-speed polisher can also be used for re-polishing existing connectors. It can revive damaged connectors or increase return loss with low reflection PC polishing.

Development Background

When constructing FTTH systems or installing intra-office LAN wiring, we need to attach connectors to optical fiber cables. A ferrule[*2] bonding process and a polishing process are needed when we assemble these optical connectors. Epoxy adhesive[*3] is used with the conventional method and it takes 10 to 30 minutes to fix the ferrule in place. It also requires about 10 minutes to polish the ferrule endface with high-level production control. With the conventional method, batch processing can reduce unit cost, but this requires an electrically powered curing heater and large polishers. We cannot employ this method in the field.

When building an FTTH system, a splicing[*4] technique is used to attach a pre-assembled connector in the field. An easily assembled connector, which consists of a polished ferrule end with a short fiber, and a splicing mechanism is also used. Both methods increase the cost and insertion loss because they need an additional splicing point.

We have developed a field assembly technique for MU connectors[*5], which are used in NTT's intra-office equipment for FTTH systems. We hope to extend the application of MU connectors to customer premises.

Key Technical Points
This product consists of instant adhesive, an assembly tool that is easy to operate, and a portable high-speed polisher (Fig. 1).
(1) Instant adhesive
A fiber is dipped in curing agent and then inserted in the ferrule, which is coated with the adhesive. The newly developed instant adhesive can fix the ferrule in place within 1 minute. The adhesive can be consistently applied every time because it is packed in a one-time-use disposable package.
(2) Assembly tool
The assembly tool consists of a ferrule holder, an adhesive coating vessel, and a fiber insertion guide. This tool can coat the ferrule with a fixed quantity of adhesive. It is important that curing always takes place under identical conditions. It is also easy to insert the fiber using the fiber insertion guide.
(3) Portable high-speed polisher
This polisher has a polishing sheet that can be rotated slowly and revolved quickly. It can polish with high-speed and excellent accuracy using the whole area of the polishing sheet. Ultra low reflection PC polishing is achieved with a three-stage polishing procedure (90 seconds total). The polisher can be used anywhere because of its small size, light weight and dry battery operation.

This product can assemble an optical connector plug in about 5 minutes with the same cost, performance, and reliability as a factory assembled connector (Fig. 2).

Application areas
The application areas of this product are as follows;
- Intra-office optical fiber wiring for LAN
- Customer premises for FTTH systems

The portable high-speed polisher can also be used for the following purposes;
- Reviving a damaged connector (deeply stained and/or severely scratched)
- Re-polishing a PC connector (return loss*6 of 25 dB) to realize a low-reflection PC polishing*7 connector (return loss of over 50 dB)

Future progress
This product will be sold from March 10th, 2004 by NTT Advanced Technology Corporation for use with MU connectors. We plan to expand the application fields of this technology to, for example, SC connectors*8.

Glossary
*1) Comprehensive Commercialization Functions
The "Comprehensive Producer Function" is a formalized methodology for promoting business projects based on excellent research and development achievements. It is directed by managers (known as "producers") who have been assigned the responsibility of cooperating with other companies both inside and outside the NTT Group. NTT is planning to use its Comprehensive Producer Function to promote business projects that emerge from the various achievements realized by its research and development efforts.

*2) Ferrule
In an optical fiber connector, an optical fiber is fixed with adhesive in the center

capillary of a precisely manufactured cylindrical rod known as a "ferrule", and then polished to form a round end surface. The most important element in a single-mode optical fiber connector is the ferrule itself. The ferrule requires high dimensional precision (sub-micron order) in terms both of roundness and the eccentricity of the center capillary in relation to the outer diameter. Most conventional ferrules are made of zirconia ceramics.

*3) Epoxy adhesive
This is a two-part epoxy system especially designed for bonding metal, glass, and ceramics. Thermally curable epoxy adhesives have been used for bonding optical fibers to ceramic ferrules during the fabrication of optical fiber connectors.

*4) Splicing
A splice can be loosely defined as a non-separable joint. Two optical fibers can be spliced by arc-fusion or the mechanical alignment of fiber cores. Refractive index matching material (gel) is usually used between the fiber ends in non-fusion splices.

*5) MU-type optical connector
This connector was developed at NTT Photonics Laboratories and put into service by NTT in 1993. The MU connector system can be used as a plug-in type optical connector for unit connection between a back-panel and a package, and as a simplified receptacle type connector for optical modules. The packaging density of this connector is four times that of an SC-type connector. NTT decided to use MU-type connectors in their optical communication systems in November 1999.

*6) Return loss
An essential characteristic of optical connectors is the reflection or return loss at the connection interface between fiber cores. The return loss (dB) is defined as the ratio of the reflected optical power to the total propagating optical power. A return loss of 50 dB corresponds to a ratio of 1/100,000.

*7) Low-reflection PC polishing (PC: Physical Contact)
The physical contact (PC) polishing technique produces spherical convex polished fiber ends in optical fiber connectors. These spherical ends can eliminate the light reflected from connectors without the use of index-matching material. However, the return loss for a conventional PC connector was limited to about 30 dB because a thin damaged layer was produced by the fiber endface polishing process. The low-reflection PC polishing technique can suppress the generation of this damaged layer and realize spherical convex polished fiber ends with an average return loss of > 40 dB.
This technique is known as, for example, AdPC, SPC, and UPC. Most of the fiber ends of conventional optical connectors are now processed with the low-reflection PC polishing technique.

*8) SC-type optical connector
The SC connector was developed by NTT Laboratories in 1986. Its features include ease of operation as a result of its unique push-pull coupling mechanism, high levels of performance, and low cost. The SC connector is the first optical connector to employ a zirconia ferrule. In terms of optical connectors, the SC connector has the largest share of the world market at 70%.

-Figure 1 Assembly process of our technique

-Figure 2 Optical characteristics of MU-type fiber-optic connector assembled with our technique

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