Micromolded easy-assembly multi fiber connector: RibCon®

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Abstract The fabrication and the design of a new fiber connector for up to 16 single- or multimode fibers are presented. The connector features the following essential advantages: low cost fabrication by micro injection molding, easy assembly due to elastic alignment structures made possible using LIGA technology and bonding by UV-curing adhesive, and a hermaphroditic connector design in order to avoid damage of the precision part of the ferrule. The mean insertion loss is 0.35 dB with multimode fibers and as it turned out from first experiments 1.16 dB with singlemode fibers.

1 Introduction
Fiber ribbons are used to make high-density optical fiber connections. It is employed in feeder cables for optical subscriber loops, in bus cables that are used for the control of various measuring instruments and in optical backplanes, i.e. in cables for optical connection between a printed board and an equipment backpanel. In order to guarantee easy reconnection and high performance for the particular use several multifiber connectors for joining fiber ribbon cables have been developed and presented (Kobayashi et al., 1997; Kihara et al., 1996).

This paper describes the design, fabrication, and characteristics of a newly developed hermaphroditic multifiber connector for 16 fibers. The hermaphroditic connector provides one main advantage: the risk of damage of the ferrule is drastically reduced.

The essential quality criteria for such a connector is the insertion loss when two connectors are coupled. The aimed goal is an insertion loss of 0.5 dB, which means in terms of geometrical dimensions an accuracy of some few microns for multimode fibers and 0.5 μm for singlemode fibers.

2 Design for easy assembly strategy
The ferrule of the 16-multifiber connector is illustrated schematically in Fig. 1. It consists of two micro molded plastic parts: one for the alignment of fibers and guide pins with five rows of highly precise alignment structures, the other for their fixation and protection. The connector obeys international standards (IEC 1994). The centers of the fibers and of the guide pins are positioned in a line and the pitch of the fibers is 250 μm. Elastic ripples in the side walls of the alignment structures as can be seen in a SEM photograph in Fig. 2 facilitate fiber and pin insertion. They also make the connector insensitive to variations in fiber diameter. The gap between the alignment structures is 140 μm wide in the last row and is reduced successively down to 123 μm in the first row facing the opposite connector. This enables a very easy assembly and passive alignment of the fibers without the need of micro positioning. Since the front end gap is 2 μm smaller than the fiber diameter the fibers are clamped softly by the alignment structures thus allowing an easy handling during the on-going assembly.

In order to bond both parts of the connector together the upper part has a central hole, which allows insertion of adhesive. Since the remaining gaps between the fibers and the ferrule walls are of the order of single microns the adhesive is spread into the connector by capillary forces.

Because of the different diameters of fibers and pins the cross section of the connectors features two structural layers as becomes evident from Fig. 3. On a basic body a
first layer is patterned which levels the fibers and pins in order to align them vertically in one line. The height of this level is defined by the medium difference of the fiber and pin diameters, which is 287.5 μm. In a second layer the rippled alignment structures are patterned for the horizontal positioning. Figure 3 shows on its left side the connector before both parts are assembled. On the right side the indenting of both parts is indicated.

The connector is a hermaphroditic type that means that all pieces look the same, i.e. no male/female types do exist. Thus, the risk of ferrule damage is reduced to a minimum because the pins of both connectors to be coupled are inserted into an also highly precise coupling adapter as indicated in Fig. 4. If the pins damage the respective holes in the adapter due to often reconnection the adapter can be replaced easily whereas the fibers and connectors can be maintained.

3 Fabrication of the molding tool
The two parts of the connector ferrules are microinjection molded in polymer, e.g. PMMA. The injection molding tool consists of two shells. One shell forms the macroscopic or the basic body of the connector. The respective cavities are patterned directly into the shell by cavity sinking electro discharge machining (EDM). The other shell contains the microstructured mold inserts, which form the vertical and horizontal alignment structures. During molding the two half shells need to be well positioned and have to be tightly sealed.

The microstructured mold inserts are fabricated by a combination of mechanical micromachining and LIGA technology (Fahrenberg et al., 1996). The process is illustrated in Fig. 5. The first layer of the latter ferrule is micromilled into a copper substrate. Afterwards the substrate is covered with a thick layer of PMMA in which the rippled alignment structures are patterned by X-ray lithography followed by electroforming of nickel. The nickel block is released from the substrate and the mold inserts are cut to the final shape by wire-EDM. The diverse process steps are described successively more in detail.

3.1 Mechanical micromachining of the copper substrate
Copper as substrate material is suited for the treatment and patterning by diamond micromilling. The used KERN 22/16 and KERN HSPC 2216 machines provide a