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2D HIGH PRECISION FERRULES FOR HD OPTICAL CONNECTORS

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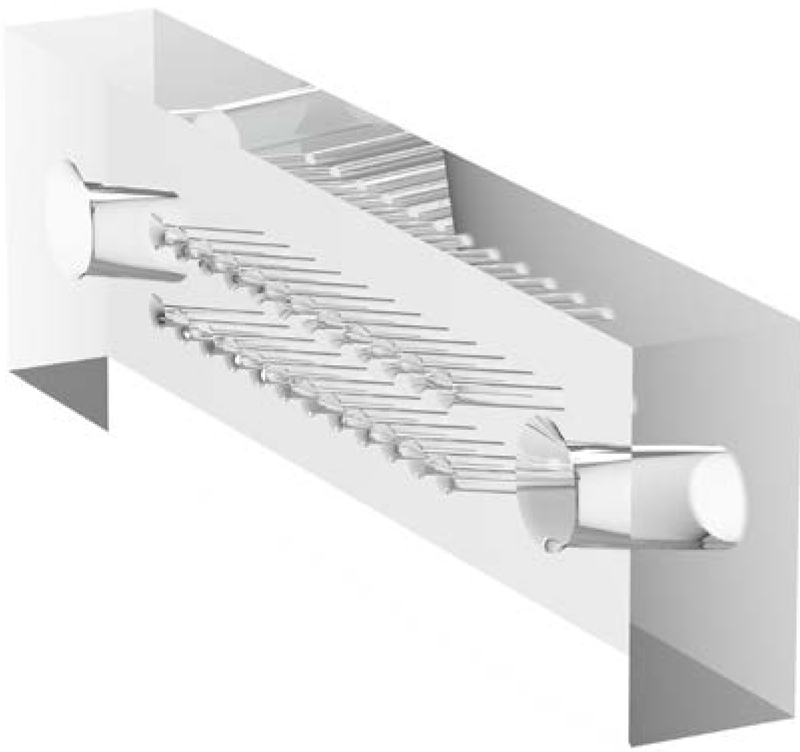
The demand for ever increasing bandwidth is driving the need for dense optical fiber connections in applications such as datacenter interconnects and optical switching nodes. Many of these high-density connections require the use of precise, tightly-toleranced fiber alignment structures to accurately position the optical ports. While many solutions exist to create low fiber count and/or one-dimensional fiber arrays, making 2D arrays of high channel count (greater than 32 channels) is more complex.

2D hole arrays to house and position arrays of fibers can be used in a wide range of applications, from multi-fiber connectors and large arrays for interfacing to optical switching hardware such as Optical Cross Connect (OXC) switches and Wavelength Selective Switches (WSS).

This paper focusses on the specific challenges and a potential solution for high-density, multi-fiber connectors requiring greater than 32 fibers.



2x12 glass MT Ferrule Insert

Moulded glass-filled polymer ferrules for single mode optical connectors have been successfully manufactured for fiber counts of up to 32 channels, with sufficient hole diameter and pitch tolerances to meet the requirements for low-loss single mode fiber alignment. However, plastic moulding processes struggle to maintain the necessary tolerances for single mode fiber alignment beyond 32 channels at the volumes required. This is in contrast with the drive for higher channel count optical fiber connectivity to meet the demands for ever increasing bandwidth.

RIE or laser processing?

The two techniques best equipped to produce tightly-toleranced 2D hole arrays for optical connectors requiring >32 fibers at scale are silicon patterning and laser-induced selective etching.

Currently popular in the industry, silicon patterning involves the same process used to manufacture silicon MEMS devices; Reactive Ion Etching (RIE) removes silicon material which is masked appropriately to form the shape of the array required.

Meanwhile, laser-induced selective etching is a novel two-stage microstructuring process in glass that uses a focussed ultrashort pulsed laser to induce subsurface material patterning, localised to the focus of the laser beam. By rapidly scanning a 3D shape within the glass, regions of enhanced etch rate are created, such that upon exposing the substrate to a wet chemical etch, the irradiated regions etch preferentially.

Both techniques offer significant advantages over rival methods, including their ability to produce high-density optical ports as well as their inherent speed and scalability. Both methods provide tight control over positional accuracy of the fiber hole center (<0.5μm tolerances) and hole diameter – important factors in reducing insertion loss and ensuring excellent 2D array performance.

Flexible frontrunner

Where silicon patterning and laser-induced selective etching primarily differ is in their adaptability – a crucial factor in a rapidly advancing industry. For example, because silicon patterning relies on existing MEMS technology and fabrication facilities, the tools used to manufacture 2D arrays can only produce standard silicon wafer thicknesses, typically 650 microns thick.

Optical connector 2D fiber arrays require thicknesses in the 2mm range to provide the mechanical rigidity and integrity to hold the optical fibers in place. Therefore, three silicon-patterned 2D arrays are often stacked and bonded together to produce the required thickness. This not only creates an additional unnecessary processing step and cost, but also introduces a potential new stack-up misalignment error. In contrast, laser-induced selective etching can be performed on substantially thicker glass substrates, such as those in the 2mm range.

Another important feature highlighting the adaptability of laser-induced selective etching is the technique's freeform control of hole shape throughout the volume of the substrate. Freeform 3D control also means the hole entrance can be modified to any desired shape. Though silicon patterning can produce a flared hole to allow simple fiber insertion, the flare must be a standard-sized cone shape. Laser-induced selective etching can yield curved or conical flares of various lengths depending on requirements.

A crucial advantage of freefrom 3D control is the ability to form holes at arbitrary angles to the surface of the glass and the opportunity to minimise back-reflections. These capabilities are not possible with silicon patterning.

Laser-induced selective etching is the only practical, commercially available process for fabricating optical fiber connector ferrules of greater than 32 channels in a single piece.

About Optoscribe Ltd

Optoscribe uses its innovative laser direct write technology to manufacture glass-based photonic components primarily for the telecommunications and data communications markets. Optoscribe's technology allows for 3D waveguide formation and 3D laser induced selective etching with unprecedented design freedom.

Optoscribe's Precision Fiber Alignment Structures (OptoArray™) and SiPh Advanced Coupling Solutions (OptoCoupler™) can solve many of the challenges associated with the drive for high density optical connections. The company is located in Livingston, UK, where it has a state-of-the-art manufacturing facility.

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