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V-GROOVES FOR FIBER OPTIC ASSEMBLIES: INCREASING THE DESIGN WINDOWS FOR COMPONENT MANUFACTURERS

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The fiber V-groove array (FVA or FAU) is a deceptively simple device used in key components such as transceivers, wavelength selective switches and splitters within the datacenter architecture. It is used for accurately connecting arrays of optical fibers to other optical components in order to manipulate light using high precision micro-electromechanical systems (MEMs) technology, prisms and gratings, often partially in a free space configuration. Due to the high degree of manipulation (in both frequency and space), accurate location of both the end facet of the fiber and the exit angle of the light is required across the entire array.

Historically, designers have been limited in terms of V-groove shape and pitch by a combination of the host material and the material processing technology. In this white paper, we discuss some of the benefits of Optoscribe's unique laser inscription technology for V-groove fabrication, discussing where tolerancing and shape optimization can support the optical design engineer overcome some of the limitations of traditional manufacturing techniques.

From first principals, a minor misalignment of a fiber core will have a significant cumulative impact on the optical loss budget of the component. Figure 1 (left) shows the calculated coupling loss of two fibers when their cores are misaligned by a small fraction – a 0.05 dB loss can be easily incurred with a core-to-core mismatch in one axis of ~0.5 μm.

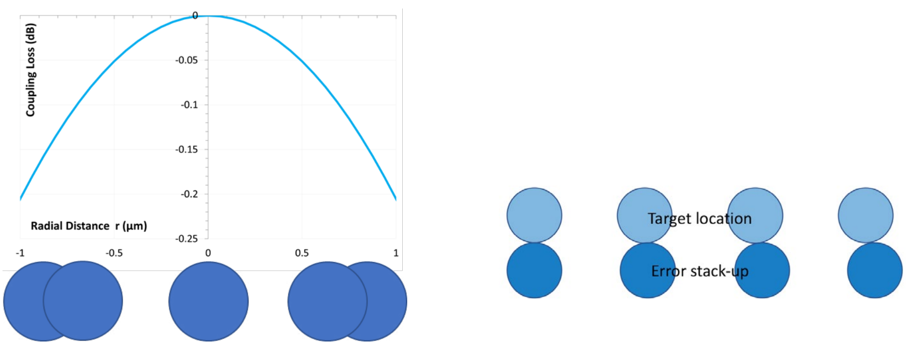

Figure 1: *Left: Coupling loss with respect to fiber core offset. Right: Fiber stack-up error*

Increasing fiber channel count adds a further degree of potential loss as stacking errors can be introduced to the system. Technologies that mechanically align and fix multiple fibers to a high degree of precision and accuracy both individually and with respect to each other are required. For example, in Figure 1 (right), over 4 channels, the 0.5 μm core pitch mismatch could potentially result in the 4th fiber being 2 μm away from the optimal location, resulting in a minimum loss of ~0.8 dB.

By using V-groove technology a fiber can be aligned along six axes using a relatively simple groove, cap and epoxy configuration as shown in Figure 2. By fabricating multiple grooves on a single substrate, arrays can be manufactured to address high channel count requirements seen in the most advanced transceivers and switches, e.g., DR4 and DR8 configurations.

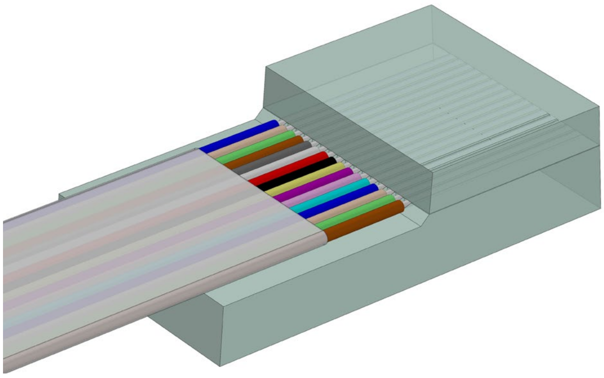

Figure 2: *Image of fiber V-groove component*

Optical V-grooves are a well-established technology in a variety of materials from silicon and ceramics to a range of glass types. There are a wide variety of V-groove manufacturing techniques ranging from lithography to mechanical cutting, each with their own attributes including surface quality, tolerance, design flexibility and cost.

Optoscribe's laser-induced selective etching method is a two-stage microstructuring process, wherein subsurface 3D shapes can be rapidly patterned and then preferentially etched. With this high-speed, high-precision, and highly scalable technique, high-density, bespoke configurations of V-groove arrays can be produced. The process can be used on different glass types targeting two main application areas, specifically SiPh with borosilicate glasses and silica-based configurations with fused silica glass.

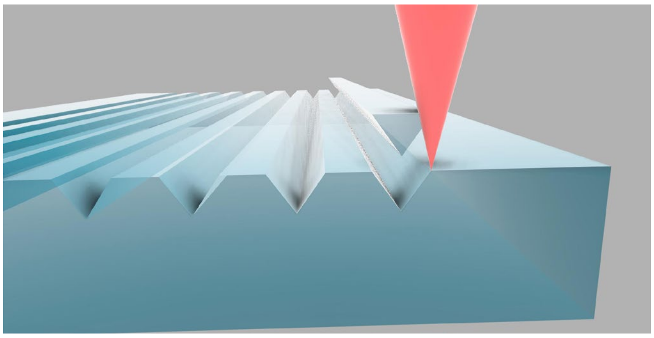

Figure 3: *Schematic of high-speed laser writing*

The V-groove profiles achievable by Optoscribe's technology are broad, as limitations such as material crystal planes or mechanical tool-piece shape are removed. Shapes with defined radius of curvatures at the apex, specific angles on the sidewalls and pitch changes across the array (Figure 4) can be readily achieved. Alignment marks and fiducials with references to accurately located sidewalls can easily be achieved using the laser inscription technology at Optoscibe, supporting assembly processes.

Figure 4: *Example V-groove shapes*

Design engineers at Optoscribe work with clients to develop bespoke V-groove array designs for laser manufacture of unique complex components. The laser inscription process is rapid, capable of manufacturing large numbers of devices annually and, with the etch process technology transferred from volume semiconductor processing, high volume, low cost, bespoke designs can be readily delivered.

The Optoscribe 3D laser inscription technology is unique for V-groove manufacturing as it allows the optical engineer high precision design freedom in all axes. Due to the nature of the processing, novel shaped V-grooves and features are repeatable, precise, and accurate across the entire component every time.

About Optoscribe Ltd

Optoscribe designs and manufactures 3D glass-based optical components for the telecommunications and data communications markets. Using its innovative laser direct-write technology, Optoscribe's bespoke solutions address market challenges such as bandwidth, speed, density and channel count.

Optoscribe's product portfolio includes precision fiber alignment arrays, fiber-to-fiber interconnects, multicore fiber fanouts, photonic lanterns, transceiver photonic integration platforms, SiPh coupling solutions, and Optical Sub-Assemblies.

For more information, visit: www.optoscribe.com

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