Dual Clad HPCF for Laser Power Delivery
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Introduction:
Optical fibers with a glass core, glass clad and a secondary hard polymer clad, known as Dual Clad fibers, have been successfully used for years for laser power delivery in minimally invasive medical treatments, such as laser lithotripsy. The dual clad is capable of delivering increased laser power compared to regular single clad hard polymer clad silica optical fiber (HPCF) that has a glass core and polymer cladding. This is because the glass is much more heat resistant than the polymer that forms the cladding in the single clad HPCF. The dual clad has a secondary polymer clad that confines some of the cladding mode light in the fiber, which otherwise might escape under bend conditions. As a result, the dual clad offers improved performance in medical procedures where the fiber often experiences tight bends.

Specifications:
The fiber consists of a low –OH synthetic silica core, with a depressed index silica clad layer surrounded by a polymer-based low index secondary cladding layer. Beyond the clad layer, the fiber is jacketed with an extruded bio-compatible and sterilizable polymer, such as ETFE (Tedlar®) or Nylon for mechanical and environmental protection. The fiber operates at wavelengths ranging from 450 to 2100nm. A high –OH version is also available for UV and visible wavelengths. The fiber operates at temperatures up to 125°C.

Polymicro offers a series of standard dual clads with 0.22NA for the primary waveguide. Standard fiber comes with blue colored Tedlar® jacket and a proof test rating of 100ksi. Non-standard dual clads are also available with modified core/clad size, jacket material, jacket color, NA, and proof test rating.

<p>| Specifications of Standard Dual Clads (0.22NA) at Polymicro |
|---------------------------------|------|-------|------|------|</p>
<table>
<thead>
<tr>
<th>Description</th>
<th>Core</th>
<th>Primary Clad</th>
<th>Secondary Clad</th>
<th>ETFE Jacket</th>
</tr>
</thead>
<tbody>
<tr>
<td>JTFH272326356460</td>
<td>272 ± 10</td>
<td>326 ± 10</td>
<td>356 ± 8</td>
<td>460 ± 30</td>
</tr>
<tr>
<td>JTFH285060637050</td>
<td>365 ± 10</td>
<td>400 ± 8</td>
<td>425 ± 8</td>
<td>730 ± 30</td>
</tr>
<tr>
<td>JTFH1000010351400</td>
<td>550 ± 12</td>
<td>600 ± 10</td>
<td>630 ± 10</td>
<td>750 ± 30</td>
</tr>
<tr>
<td></td>
<td>940 ± 50</td>
<td>1000 ± 15</td>
<td>1035 ± 15</td>
<td>1400 ± 50</td>
</tr>
</tbody>
</table>

Fiber and Fiber Supplier Selection:
Readers experienced with design and manufacture of fiber optic assemblies know well that fiber parameters and mechanical issues not only impact the performance in practical use, but also affect the production and economic parameters (such as optical alignment and production yield). Additionally, the fiber supplier’s commitment to customer service plays a key role in the product development. The following discussions give more details.

- Fiber Geometry—Core-clad diameters, concentricity, and tolerances are key geometric parameters for consideration. Tighter tolerances are often indicative of higher quality fiber and provide ease of alignment and improved coupling of laser light into the fiber. However, excessively tight tolerances unnecessarily increase fiber cost and delay fiber production and delivery.

- Fiber Proof Test Rating - Fiber is typically proof tested in line during the fiber draw process to ensure that the fiber meets a minimum strength level in the customer’s application, where physical abuse such as
pulling, flexing, and bending is not uncommon. Estimated short term and long term minimal bend radii can be calculated based on the fiber geometry and the proof level.

Hard Polymer Secondary Clad – Quality hard polymer clad with good adhesion and surface properties provides the silica glass with needed mechanical protection, offers the fiber a clean cleave or end cut, minimizes connector pistoning, and avoids “connector pulloff” in practical use.

Extruded Jacket – A quality jacket extrusion is critical in maintaining the high strength properties of the fiber. The buffer must have good concentricity and be mechanically strippable without damage to the underlying hard polymer layer. The stripping properties may need adjustment for the specific application and termination process being used. The selection of the buffer material depends largely on the termination technique. In general if the connector is adhered directly to the jacket, then a nylon jacket is preferred due to its tighter adhesion to the polymer clad and improved epoxy bond. ETFE (Tefzel®) is the preferred choice when chemical resistance and ease of stripping is desired.

Economics – The dual clad offers good power handling capability at an economical price. Economics can be improved further in the fiber design and manufacture stages. For example, depending on operating wavelength and bending conditions in use, a more affordable base fiber preform design may be specified. Cost savings can often be achieved if increased specification tolerances are acceptable in the user’s application. In other cases, fiber specs may be tightened to improve fiber alignment and achieve improved production yields, leading to a better overall product cost offsetting possible increased fiber cost.

Fiber Supplier – For a project to succeed, it is critical to partner with a fiber supplier that has in-depth technical knowledge and experience and is known for responsive customer service. There are often several iterative steps from design to prototype to final volume production. Polymicro’s extensive project experience strongly suggests that a customer should work closely with a fiber supplier as early in the design stage as possible. The supplier should provide responsive technical and customer support. Some detailed issues rising in the product development require close cooperation to find a solution. For example, a fiber supplier may need to adjust extruded jacket properties, such as jacket stripping and tightness, to match a customer’s specific production process. The supplier may need to help the customer fine tune their production processes, such as fiber cleaving, cutting and stripping.

Summary:
The Dual Clad fiber has become a common solution for laser power delivery in minimally invasive medical applications. Fiber optical and mechanical parameters must be considered in the selection of a proper fiber. Further, it is critical for a customer to partner with a fiber supplier that has in-depth relevant technical knowledge and experience, and also is reputed for responsive customer service. A good fiber supplier-customer partnership goes beyond just a satisfactory, economic fiber optic assembly product. It is a mutually beneficial relationship lasting beyond the product life-cycle.

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