Advantages of the Corning Optical Fiber Manufacturing Process

CORNING

Optical Fiber

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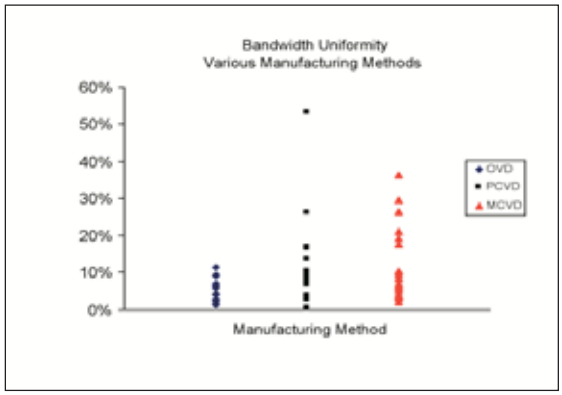
Corning-invented technologies are the foundation for all glass fiber manufacturing processes used in the world today. After several years of studying various techniques for manufacturing optical fiber, including outside vapor deposition (OVD) and inside vapor deposition (IVD), Corning selected the OVD process to manufacture optical fiber because of its process consistency, superior quality, greater ability to scale to large volumes, and independence from requiring a third party supply of key components (such as the quartz tubes required for IVD manufacturing).

Corning's OVD Process Produces Superior Quality

One of the most important advantages of the OVD process vs. IVD surrounds **bandwidth uniformity**. Variability in the fiber manufacturing process, specifically in forming the core region can lead to bandwidth variability in the full length of the fiber. This is a problem since most manufacturing measurements, such as those made during the Modified Chemical Vapor Deposition (MCVD) process, are made on the full fiber lengths (up to 17.6 km), while the application of the fiber in network links is usually less than 2 km. Given the difference between the measured fiber length and application fiber length, it is very important to understand how the bandwidth measured during manufacture relates to the bandwidth of the fiber length that is deployed. This is of particular concern in the MCVD method since there are process conditions such as higher thermal conductivity of the glass than the deposited chemicals and geometry variations in supplied third-party tubes that make it prone to axial bandwidth non-uniformities.

BW Uniformity of OVD and IVD
Figure 1



In a recent study at our Center for Fiber-Optic Testing (CFT), we measured a number of high-bandwidth 50/125 µm fibers, all with Effective Modal Bandwidth (EMB) between 950 and 4000 MHz·km, made from both the IVD and OVD manufacturing processes. The study involved measuring both the full 8.2 km length (as manufactured) and 4.1 km halves of the original fibers in order to gather a very accurate measurement of the consistency of the EMB value along the entire fiber length. These measurements revealed an average of 13% difference in EMB value between the 4.1 km halves for MCVD produced fibers compared to a 3% average difference for Corning's OVD produced fibers – see Figure 1. Typical application lengths for multimode network systems can vary from 100 m to 550 m. Therefore, a wide variance in the actual EMB value of the fiber compared to what might be specified for an IVD manufactured fiber poses significant system risk in high-performance multimode fiber applications.

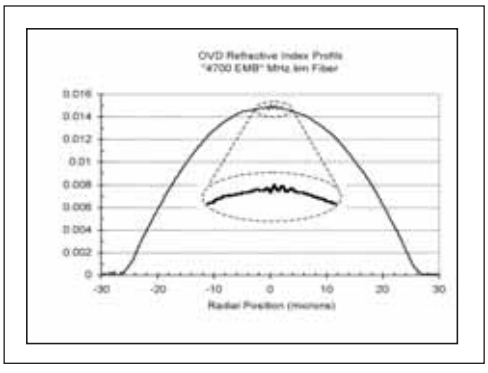
Despite significant data to the contrary, IVD fiber manufacturers have often claimed that their manufacturing processes are superior to those of Corning's chosen OVD process for producing multimode fibers. One typical argument focuses on perceived "centerline dips" in the refractive index profile (RIP) of multimode fibers. Their claim is that these profile errors can impact the bandwidth, or transmission capability of the fiber. Corning's laser-optimized™ fibers use a centerline etching process which is very effective in achieving centerline profile control. A recent review of Corning produced and competitor's IVD produced multimode fibers shows that Corning's OVD process produces outstanding centerline profile control which is proven to be superior to the IVD process – see Figure 2.

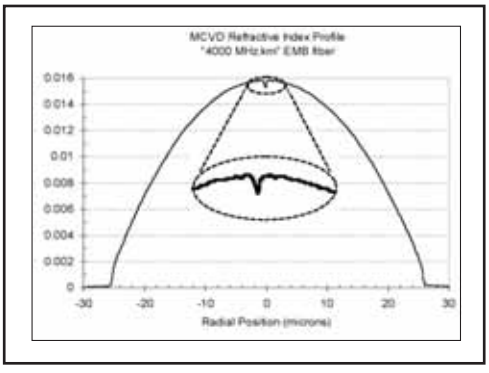
Recent claims from some cablers have focused on limited testing performed in 2004. This testing compared Corning's fiber with an IVD manufactured multimode fiber. The experiment concluded that the IVD process produced a higher quality 10 Gb/s, 50 µm multimode optical fiber (i.e. OM3 fiber). This conclusion is not accurate because the experiment compared a 550 m, 10 Gb/s product from a prominent IVD manufacturer with Corning's InfiniCor® SX+ fiber, a product designed and specified for 10 Gb/s performance over 300 meters, using one transmitter/receiver combination. We are very confident that a comparison of similar products over a broad range of transmitters and receivers would produce at least similar, if not superior results for Corning's InfiniCor® fiber products.

Refractive index profile comparison of OVD and IVD manufacturing processes
Figure 2

OVD Process
Produces higher bandwidth values with smoother and more uniform graded index profiles.

MCVD Process
More prone to centerline dips following the hole closure due to the intense heat and time required to collapse the centerline hole.





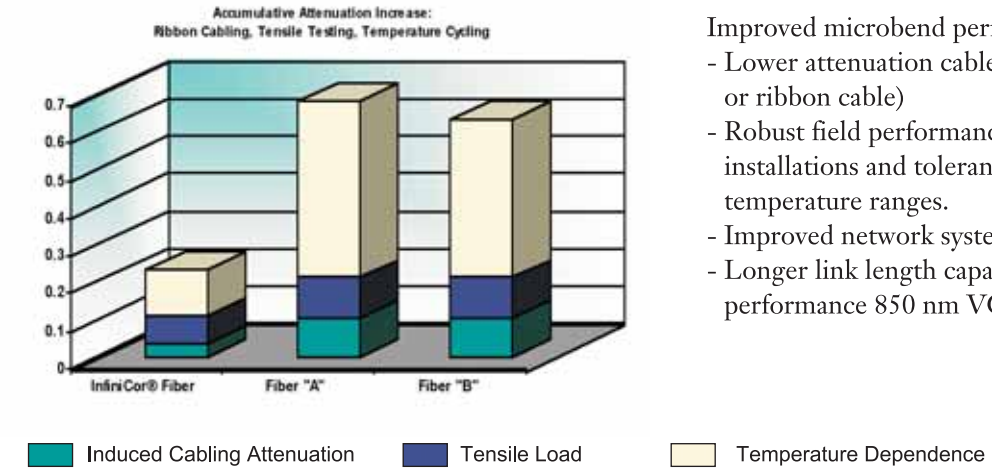
Rigorous functionality testing conducted at Corning's Center for Fiber-Optic Testing, the world's leading fiber testing facility, demonstrated that Corning's InfiniCor® fiber products meet or exceed all industry standards. For InfiniCor® eSX+ fiber functionality testing, >1500 combinations of fibers, transmitters and receivers were tested for bit error ratio, intersymbol interference, power penalty, and peak to peak jitter to prove that the product will reliably perform in high performance systems. We can find no evidence that other fiber manufacturers have conducted even one-tenth the amount of **system testing** that has been performed on InfiniCor® fibers.

Corning's CPC® Coating Produces Increased Robustness

Corning's CPC® coating enables a fiber with the **greatest resilience to environmental conditions** such as temperature cycling, often experienced in campus networks and unregulated duct environments.

Corning performed a competitive study of ribbon cable design containing new microbend performance coatings from 2 other major multimode fiber manufacturers. The results shown in Figure 3 demonstrate that the cumulative positive impact of the CPC® coating is dramatic.

Coating robustness comparison of fiber manufacturers
Figure 3



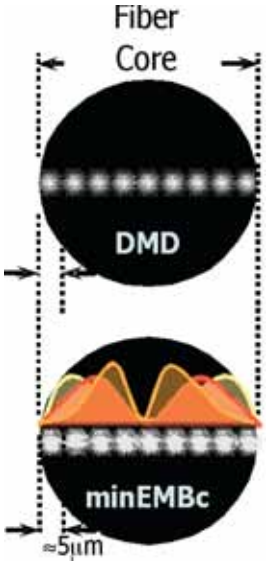
Improved microbend performance enables:
- Lower attenuation cables (even tight-buffered or ribbon cable)
- Robust field performance, important for cable installations and tolerance to extreme temperature ranges.
- Improved network system margin
- Longer link length capability in higher-performance 850 nm VCSEL based networks

Corning's MinEMB$_c$ Measurements Ensure System Performance

Multimode fiber is the most complex fiber type to characterize for system performance. With Corning's InfiniCor® laser-optimized™ fibers customers receive true bandwidth measurements like no other multimode fibers in the industry. Every single meter of InfiniCor® fiber is measured; there is no sampling or outsourcing, or reliance upon antiquated overfilled launch (OFL) bandwidth metrics, like other fiber manufacturers promote.

- Corning has developed the industry's highest-technology metrics for measuring system bandwidth, minEMB$_c$, and is the only fiber manufacturer to explicitly define and specify which metric and value will be measured for each fiber.
- Other fiber manufacturers use the "normalized DMD mask" measurement method to characterize their fibers. This technique produces a simple "pass/fail" result which does not provide the customer with a true bandwidth value upon which to base or predict system performance.
- Corning's measurement goes beyond the minimum standards required by "normalized DMD mask" approach. **MinEMBc ensures system bandwidth performance** by characterizing the performance of the fiber with all possible standards-compliant lasers and adopting the lowest bandwidth value. Tight DMD control is a given for InfiniCor® fibers.

DMD & minEMBc measurement methods
Figure 4

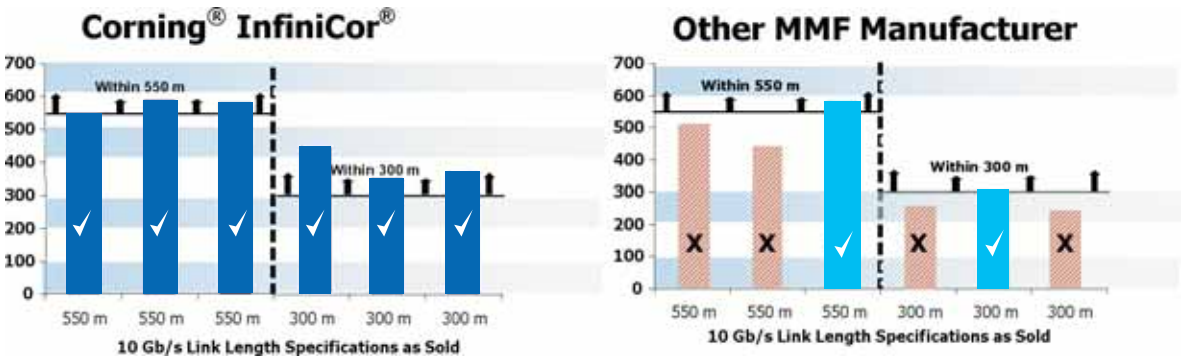


Corning's Integrity Provides a Measure of Trust

Quality has been Corning's focus for over 150 years and we continue to invest in our manufacturing processes to look for continuous quality improvement opportunities and implement quality architectures, such as TQM and Six Sigma principles. Corning provides its customers outstanding, high-quality products and leading customer service.

When it comes to multimode fiber, bandwidth is the single most important attribute for determining the functional performance of the product. Throughout its 30+ years of optical fiber manufacturing, Corning has **never had a single field return for MMF bandwidth failure – ever**. Unfortunately for the industry, consistent, reliable system performance is not assured with all multimode fiber manufacturers.

10 Gb/s Link Lengths Specifications vs. Actual Capability
Figure 5



Recent CFT system testing performed on Corning® InfiniCor® SX+ and eSX+ fibers and another leading fiber manufacturer's equivalently branded products demonstrates that not all fibers are equivalent. As shown in Figure 5, all of the InfiniCor® fibers met and often exceeded the minimum link length against which the fibers were sold for 10 Gb/s system performance. With the other fiber manufacturer, four out of six tested fibers did not produce the 10 Gb/s link length performance to which the fibers were sold. This highlights the importance of purchasing multimode fiber from a long-standing, experienced manufacturer with industry-leading quality, process and measurements capability.

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