50 µm Optical Fiber Q&A
White Paper

Optical Fiber

CORNING

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Q1. Is 50 µm a new product?

A1. No, it is not. The 50 µm fiber was developed in 1976 and was the first optical fiber that was commonly installed. Both 50 µm and 62.5 µm fibers were used in telephony applications at the beginning of the 70's prior to commercial deployment of single-mode fiber. Currently, 50 µm is rapidly becoming the standard multimode fiber used in the Americas. In the last few years, 50 µm fiber installations have also significantly grown throughout the world as bandwidth requirements for premises applications have increased. Corning has been manufacturing 50 µm fiber for over 30 years and introduced the world's first laser-optimized™ 50 µm multimode fibers, Corning® InfiniCor® series.

Q2. Why did North America embrace 62.5 µm fibers instead of 50 µm?

A2. The evolution from 50 to 62.5 µm fibers happened when the first generation optical LAN application and standard was put in place. The primary reason for the standardization on 62.5 µm at the time was that more light could be coupled into 62.5 µm fibers (Numerical Aperture, NA = 0.275) using lower cost transceivers, Light Emitting Diodes (LED), that produce a uniform, overfilled launch condition. This made more light available to support longer link lengths with a given power budget. Besides that, 62.5 µm had better handling capabilities.

Corning® 62.5 µm multimode fiber was developed and used in long-haul systems such as AT&T's Northeast Corridor in the early 1980's as well as local telephone interoffice applications. Corning 50 µm MMF was used in long-haul (140 mb/s over 18 km) projects overseas in Germany and Italy. After the commercial introduction of Corning® single-mode fiber in long-haul projects with MCI and other operators in 1982, the far superior transmission capabilities of single-mode fiber (at the time, 400 Mb/s over 40 km) compelled operators to convert these projects to single-mode fiber such that multimode fiber is rarely used in telephony public networks today. The high price of single-mode transceivers and terminations helped multimode fiber maintain a value proposition in local, private area networks.

Overseas, applications continued to favor 50 µm fiber, but in the USA several users and applications selected 62.5 µm, since it was a Bell System standard. For example, IBM chose it for a channel extender product to increase the interconnect distance between mainframe computers.

It was then designed in to the first optical network standard, the Fiber Distributed Data Interface (FDDI) which specifies a 160/500 MHz•km bandwidth for 62.5 µm at the 1300 nm wavelength and later in to early IEEE 802.3 Ethernet standards.

Q3. What has changed?
A3. First of all, the overwhelming advantage of single-mode fiber in transmission capability drove multimode fiber in to Local Area Networks (LAN's) and out of telephony. Then, fiber geometry, connector polishing and alignment as well as LED output power have improved significantly. As a result, numerical aperture and core size are no longer considered as critical as they once were.

Also, data rate requirements have exceeded the capabilities of LEDs due to fiber chromatic dispersion. The advent of low cost gigabit laser technology – 850 nm VCSELs (Vertical Cavity Surface Emitting Lasers) – is generating more demand for higher bandwidth 50 µm multimode fibers. The low cost 850 nm 1 gigabit and 10 gigabit lasers are characterized by small spot sizes. Light is launched into a small area in the center of the core, with no need for the large acceptance angle to couple the light. This, in combination with the high bandwidth advantage of 50 µm fiber in the 850 nm window, forms a strong value proposition for using 50 µm for high performance data transmission systems.

In addition, the fiber processing and cabling technologies have improved significantly. Bare and cabled 50 µm fibers can have lower attenuation than 62.5 µm fibers.

Q4. Is 50 µm multimode fiber accepted within standards?
A4. Yes, it is. All major fiber product and application standards have specified the 50 µm fiber. Most noticeably, Ethernet (IEEE), Fibre Channel (INCITS), InfiniBand, Optical Internetworking Forum (OIF), TIA and IEC have specified high bandwidth laser optimized 50 µm multimode fiber (MMF) for high speed applications. In fact, the ITU-T has a standard for 50 µm fiber recommending G.651 but not for 62.5 µm fiber.

Figure 1 shows the evolution of popular transceivers for multimode fiber using either 850 nm or 1300 nm wavelength light sources. 850 nm is the preferred wavelength for laser based MMF applications and is positioned to be the preferred low-cost wavelength for future standard premises network transmission speeds. Standards have evolved in parallel to match the trends in transceiver technologies.

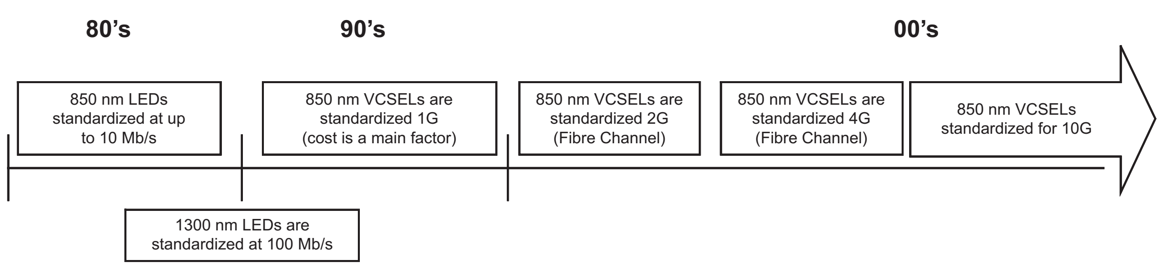

Figure 1. Multimode Fiber Light Sources – Operating Windows

Q5. Is the 50 µm multimode fiber accepted by the market place?

A5. Yes, it is. As the technology matures, more and more cable, hardware and connectivity suppliers are making 50 µm products available. The market has made a fundamental shift. In addition to the European and Japanese markets, which have been using 50 µm fibers for many years, the North American market has started mass adoption of 50 µm fibers in the last three to five years. As of 2005, approximately 50% of world-wide multimode shipments were 50 µm; approximately 30% of those shipments were OM3 fiber – fiber specifically designed for 10 Gb/s transmission at 850 nm.

Q6. Why should I consider 50 µm over 62.5 µm?

A6. The major benefit of 50 µm fiber is that it is specifically designed to produce higher bandwidth values than 62.5 µm at 850 nm, which enables the fiber to be used with lower cost 850 nm VCSEL transmitters. Standard 50 µm fiber (500/500 MHz•km bandwidth) has three times the bandwidth of standard 62.5 µm fiber (160/500 MHz•km) in the short wavelength (850 nm) operating window while some of the newer laser-based 50 µm fiber designs have 10-20 times the bandwidth of standard 62.5 µm fiber.

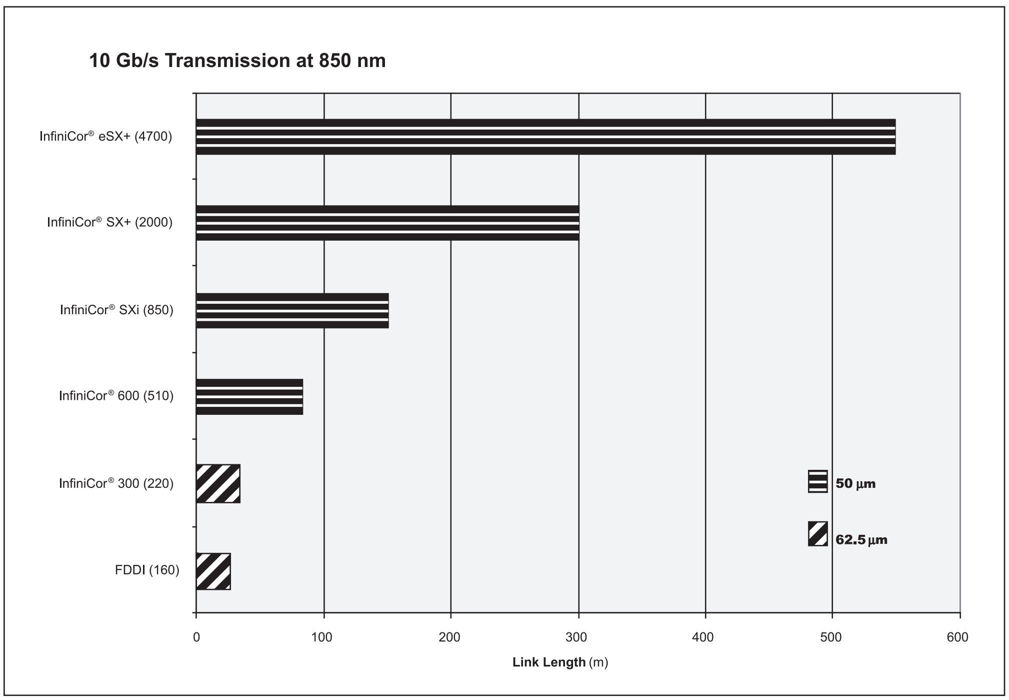

Figure 2. 10 Gb/s transmission distance at 850 nm with 50 µm and 62.5 µm fibers.

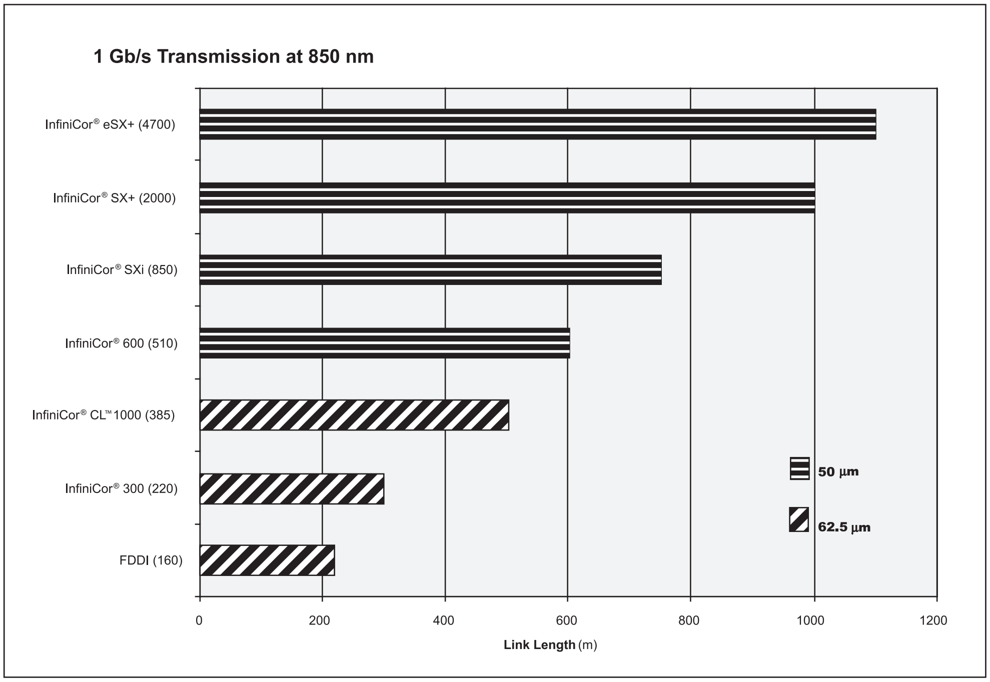

Figure 3. 1 Gb/s transmission distance at 850 nm with 50 µm and 62.5 µm fibers.

Figures 2 and 3 illustrate the comparison between the 50 µm and 62.5 µm link distances at 10 Gb/s and 1 Gb/s data rates, respectively. The numbers in the parentheses are the Effective Modal Bandwidth (EMB, MHz-Km) of the fibers at 850 nm. As shown above, 50 µm products clearly provide longer link lengths at a specific data rate or higher data rates at a certain distance. These multimode fiber products are offered by Corning as part of the InfiniCor® product line; except for FDDI fiber which is sold without the InfiniCor® fiber brand name.

Q7. What capabilities do Corning's 50 µm InfiniCor® SX+ and eSX+ fibers provide?
A7. With superior technology and profile control, Corning® 50 µm InfiniCor® SX+ and eSX+ multimode fibers revolutionize performance in local area networks (LANs), storage area networks and central office interconnects. InfiniCor® SX+ and eSX+ fibers, the newest offerings in the InfiniCor® fiber product line, are optimized for premises networks offering high performance with laser-based protocols such as 1 Gigabit Ethernet, 10 Gigabit Ethernet and Fibre Channel. They provide network managers with a low-cost serial transmission migration path from 10 Mb/s all the way to 10 Gb/s on a single fiber for bandwidth intensive applications such as information sharing and real-time streaming audio and video – at the lowest possible system cost. In addition, these fibers are positioned to support the next generation of applications at even higher speeds.

InfiniCor® SX+ and eSX+ fibers enable 10 Gb/s serial transmission up to 300 meters and 550 meters in the 850 nm wavelength window, respectively. Refer to Figures 2 and 4 for a visual comparison. While InfiniCor® SX+ fiber is optimized for LAN backbones, InfiniCor® eSX+ fiber is specifically targeted for high-end 850 nm data center and SAN applications that require additional robustness for either extra connector pairs or extended length.

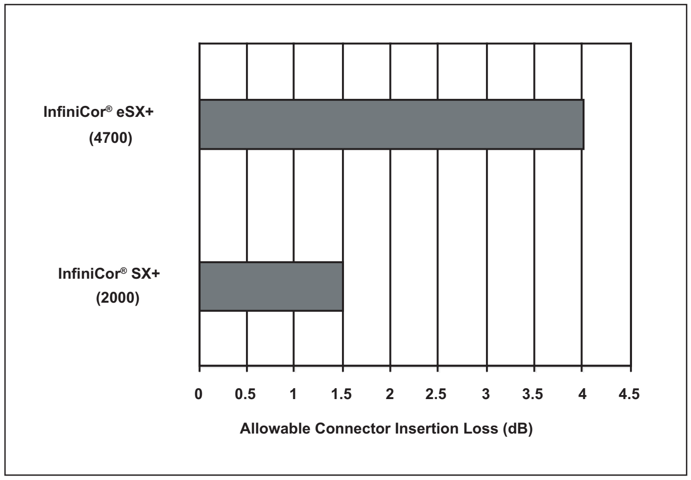

Figure 4. Allowable connector insertion loss at 10 Gb/s, 300 m.

Harnessing Corning's superior manufacturing technology, process control, and industry exclusive measurement method with the calculated Effective Modal Bandwidth metric (EMBc), the InfiniCor® line of laser-optimized 50 µm multimode fibers provide a guarantee of high bandwidth performance and low system cost when used with 10 Gb/s 850 nm VCSELs.

Q8. What is Effective Modal Bandwidth (EMB) and why is it important?

A8. EMB describes the performance of the fiber with a particular light source based on the optical power distribution it launches into the fiber. Corning uses EMBc, which is a differential mode delay (DMD) based bandwidth value that best predicts multimode system performance in high-bandwidth laser-based 1, 2, 4 and 10 Gb/s systems. Note that any bandwidth measurement that correctly predicts laser-based system performance is suitable for use in the various standards models

Laser bandwidth performance of multimode fiber is a critical attribute for ensuring optical network reliability. If the EMB from installed fibers is lower than required, the network will suffer from increased downtime, high bit-error rates (leading to high packet loss) and overall higher system costs. Since field measurements of laser bandwidth are not accurate or widely available, the best way to demonstrate field performance is via manufacturing measurements that link back into standards, such as Restricted Mode Launch bandwidth (for intermediate bandwidth Laser-Optimized systems, 1 GbE) or minimum EMBc (for high bandwidth Laser-Optimized systems, GbE & 10 GbE).

Corning® InfiniCor® optical fiber is the only Laser-Optimized™ fiber to specify laser measurement procedures with pass/fail values, to ensure laser performance with a direct laser measurement on every meter of every reel and to provide those measurements to customers as a demonstration of quality control.

Q9. What about other attributes between 50 µm & 62.5 µm fibers? How are they different?
A9. 50 µm fibers have lower bare fiber and cabled attenuation than 62.5 µm at 850 nm due to lower Germanium content in the core; they both have an identical tensile proof test specification as shown in Table 1.

Fiber Type	50 µm	62.5 µm
Maximum Bare Fiber Attenuation (dB/km)		
@ 850 nm	≤ 2.3	≤ 2.9
@1300 nm	≤ .06	≤ .06
*Common Cabeled Attenuation * (dB/km)*		
@ 850 nm	≤ 3.0	≤ 3.5
@1300 nm	≤ 1.5	≤ 1.5
Tensile Proof Test (kpsi)	≥ 100	≥ 100

* Please contact your cable manufacturer for cable attenuation specifications.

Table 1. 50 µm and 60 µm product attributes comparison.

Q10. Is 50 µm as strong as 62.5 µm?
A10. The fiber mechanical strength is determined by its surface quality and properties. Thus even though the 50 µm fiber has a smaller core diameter than 62.5 µm fiber; both fibers have identical mechanical strength properties. Specifically, 50 µm fiber has the same glass cladding diameter of 125 µm and coating diameter of 245 mm when compared to 62.5 µm fiber. Both fibers are produced using the same equipment and coating materials, therefore both fibers have the same physical strength as well as the same handling properties. See Figure 5 for a schematic drawing of an optical fiber.

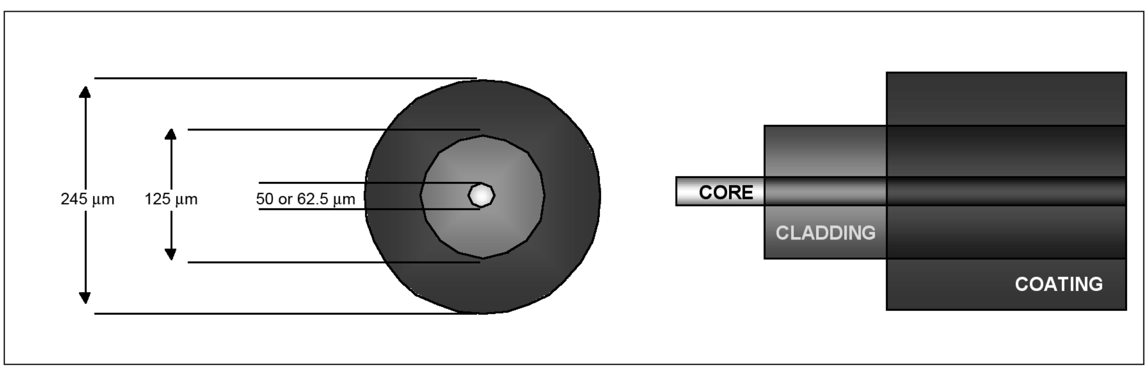

Figure 5. Optical fiber sections

Q11. Is 50 µm interoperable with 62.5 µm?
A11. Corning recommends compliance with standards by maintaining consistent core sizes within a multimode fiber cable plant. In situations where mixing core sizes is unavoidable, it is technically feasible to combine 50 µm and 62.5 µm fiber in a single link using either LED or laser sources.

Corning performed extensive physical testing and computer simulations to confirm that both fibers were interchangeable. There is a one-time attenuation loss when coupling 62.5 µm fiber into 50 µm fiber, this one-time power loss is independent of the number of connectors and fiber type changes that occur in a cable run. Refer to AN4256, Multimode Fiber in Compatibility, for further information at http://www.corning.com/docs/opticalfiber/an4256.pdf.

Mixed cable plants are not recommended and generally not encountered. The coupling loss mentioned above can severely affect the system performance. There are no standardized methods for 50 µm – 62.5 µm interoperability, nor is there a standard remedy for any system impairments that occur.

Q12. What does 50 µm cost compared to 62.5 µm?
A12. 50 µm bare fibers cost less than 62.5 µm fibers at similar performance levels. 50 µm fibers designed for use in 10 Gb/s systems cost more than standard 50 µm and 62.5 µm fibers. Fiber cable costs vary more significantly due to cable designs, manufacturing processes and distribution channels. Please contact your cable manufacturer for specific cable price information.

Q13. Where do you recommend installing 50 µm fiber?
A13. 50 µm fibers are suitable for installation in all LAN and SAN/Data Center applications. This includes backbone, riser and horizontal applications. Because of their 10 Gb/s capabilities, more 50 µm InfiniCor® SX+ and eSX+ fibers are installed in the riser and campus backbones for bandwidth aggregation. Moreover, the 50 µm InfiniCor® SX+ and eSX+ fibers are able to support the migration of speeds from 10 Mb/s to 100 Mb/s to 1 Gb/s to 10 Gb/s on the same fiber, providing the desired future proofing for all parts of the cable plant for many years to come. Conversely, 62.5 µm fibers are able to support 1 Gb/s only up to 300 m and cannot carry 10 Gb/s operation over long distances. Other than traditional LANs, 50 µm fibers are also ideally suited for data centers (storage area networks) and high-speed parallel interconnects for head ends and central offices where small foot print, cost effective parallel optical interconnections are needed. Currently 50 µm fiber is under consideration for "Fiber To The Home" (FTTH) applications.

Q14. Is Corning now recommending 50 µm instead of 62.5 µm? Should I re-cable my 62.5 µm cable plant?
A14. InfiniCor® SX+ and eSX+ (50 µm fibers) are the latest additions to Corning's world-renowned line of InfiniCor® fibers, aimed at providing the high-performance required to support the current and next generation high speed protocols. These products have been incorporated into the InfiniCor® line to provide customers with more options when building their premises networks, since they are part of the cost-effective system solution that provides significantly higher bandwidth and link length. However, Corning still supplies 62.5 µm fiber for those customers who are looking for 1 Gb/s at short distances (up to 300 m) or do not require a 10 Gb/s solution.

Corning actively encourages its customers to move to better performing 50 µm products by providing them with all the necessary technical materials to better understand the benefits of 50 µm products.

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