Why hollow-core fiber is the next big leap in optical connectivity

app note

EXFO

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By Olivier Côté
PLM, Hollow-Core Fiber Solutions, EXFO

Introduction

Hollow-core fiber (HCF) is a breakthrough technology poised to revolutionize the telecommunications industry. With hollow-core fiber, light propagates through a central air-filled core, surrounded by a microstructured cladding, instead of through solid glass. With the latest advancement in nested antiresonant nodeless fiber (NANF), the attenuation challenges of traditional photonic bandgap fiber have been overcome.

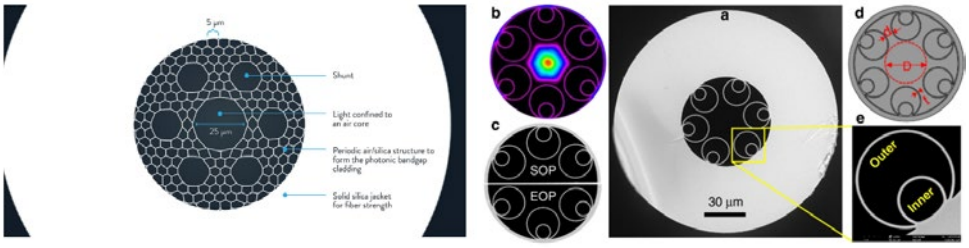

Figure 1. Comparison between photonic bandgap fiber (left) and NANF (right).

NANF maintains the key latency advantage of photonic bandgap fibers, since light travels through a medium with a refractive index close to 1.00—significantly lower than the 1.5 index of conventional ultra-low loss SMF-28 single-mode fiber. In addition, NANF achieves a lower attenuation coefficient than SMF-28, which typically exhibits attenuation about 0.16 dB/km in the ultra-low loss SMF variants. HCF is now being trialed in both field and laboratory settings, achieving record-low attenuation levels below 0.1 dB/km—marking a critical step toward real-world adoption. Some researchers anticipate that HCF could reach attenuation levels as low as 0.05 dB/km, making it a strong choice for long-distance communications. Additional benefits of HCF include minimal nonlinear effects, which allow the use of higher-power transceivers, along with inherently low chromatic and polarization mode dispersion (CD and PMD) that help extend transmission range.

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HCF is gaining traction in segments where ultra-low latency and high data rates are critical—most notably data center interconnects (DCI), high-performance computing, and specialized telecom networks. In DCI environments, where massive volumes of data move between data centers, HCF can provide a competitive edge by lowering signal delay, with the added benefit of reducing power consumption for amplification over longer spans. Beyond DCIs, emerging use cases include precision timing distribution, high-frequency financial trading, and advanced sensing applications.

EXFO developed a patent-pending method to decouple the GFE signal from the fiber trace, enabling accurate splice loss assessment.

EXFO at the core of HCF testing

As a global leader in fiber optic testing, EXFO is closely tracking the evolution of HCF technology. Our close collaborations within the industry allowed us to test our equipment on NANF HCF. These trials validated the readiness of our solutions and provided valuable data to further enhance our software capabilities. Today, EXFO offers a comprehensive portfolio of HCF-optimized test solutions, including the Hollow-Core Fiber OTDR Test Kit, which delivers precise fault location and loss measurements in scenarios where traditional OTDRs fall short. Its high dynamic range makes the hardware inherently well suited for HCF characterization.

Complementing this, the dedicated uni- and bi-directional analysis software extracts critical fiber parameters such as loss, ORL, and length. It also enables splice loss and reflectivity measurements—capabilities that required specific innovation for hollow-core fiber—making it a unique and essential tool for advancing this new fiber technology.

- **Hollow-Core Fiber OTDR Test Kit**
- **FTBx-570 – Advanced CD/PMD analyzer**
- **MaxTester 945 – Compact OLTS for field use**
- **FTBx-88810 Series – 1G-800G solution with EtherBERT test application**
- **CTP10 – Attenuation profile**
- **FTBx-5255 – Optical spectrum analyzer**

Hollow-Core Fiber OTDR Test Kit

HCF introduces two key OTDR challenges:

1. **Low rayleigh backscatter (RBS):** HCF exhibits RBS levels approximately 15 dB lower than standard singlemode glass fiber. As a result, a high-performance OTDR is required to detect return signals over long distances. EXFO's hollow-core fiber–optimized, bi-directional OTDR—with the industry's most powerful dynamic range—has proven effective in field trials for HCF characterization.
2. **Splice assessment and gas filling event (GFE):** Unlike standard SMF splices, HCF splices exhibit a distinct signature. RBS elevation on either side of the splice—known as a gas filling event—can extend for kilometers. GFEs occur when environmental gases enter the hollow core upon cutting, gradually equalizing over months. This phenomenon can obscure accurate splice loss measurements.

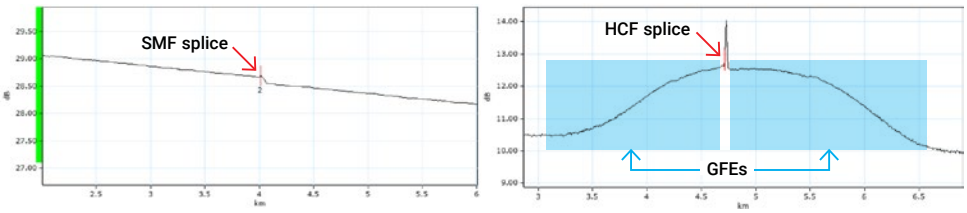

Figure 2. Comparison between SMF splice (left) and HCF splice (right) RBS signature.

To address this, EXFO developed a patent-pending method to decouple the GFE signal from the fiber trace, enabling accurate splice loss assessment. Additionally, HCF splices often exhibit reflectivity unrelated to splice loss. EXFO's analysis software captures both loss and reflectivity measurements for complete characterization.

MaxTester 945 units successfully measured fiber length, total loss, and reflectivity, and confirmed fiber continuity—making them ideal for field verification tasks.

Finally, hybrid cables combining HCF and SMF pose another challenge due to differing indices of refraction (IOR). EXFO's analysis software accounts for these variations, supporting traces with dual IORs to ensure accurate length measurements for each fiber section.

FTBx-570 – Single-ended dispersion analyzer

The FTBx-570 is inherently well suited for CD and PMD measurements on HCF. Its software already supports refractive indices as low as 1.00. For optimal results, users should enter the estimated fiber length under test to ensure the instrument identifies the correct fiber endpoint. With these settings, the FTBx-570 delivers accurate dispersion results on HCF.

MaxTester 945 – Multifunction optical loss test set (OLTS)

The MaxTester 945 was designed with enough flexibility that only minor software modifications were needed for HCF compatibility. In testing, paired MaxTester 945 units successfully measured fiber length, total loss, and reflectivity, and confirmed fiber continuity—making them ideal for field verification tasks.

FTBx-88810 Series – 1G-800G test solution

Equipped with the EtherBERT test application, the FTBx-88810 Series enables precise latency measurements—critical for validating the ultra-low delay performance of hollow-core fiber in next-generation high-speed, time-sensitive networks.

CTP10 – Attenuation profile

With EXFO's advanced CTP10 test system, you can quickly obtain accurate and reproducible spectral loss test results at an ultra-high resolution of 0.02 pm. The system covers the test range from 1240 nm to 1680 nm. The following diagram shows the results of a spectral loss test for CO_2 absorption of a typical long-distance (> 100 km) hollow-core fiber.

FTBx-5255 - Optical spectrum analyzer

As a field alternative to the CTP10, the FTBx-5255 can provide valuable insight into the attenuation profile of the installed fiber. Used in conjunction with the FLS-5834B, the FTBx-5255 can show the attenuation profile of the hollow core fiber in the C+L bands with a resolution of 0.035nm.

For more information

Hollow-Core Fiber OTDR Test Kit

FTBx-570 – Single-ended dispersion analyzer

MaxTester 945 – Fiber certifier optical loss test set (OLTS)

FTBx-88810 Series – 1G-800G test solution

CTP10 – Passive optical component testing platform

FTBx-5255 – Optical spectrum analyzer

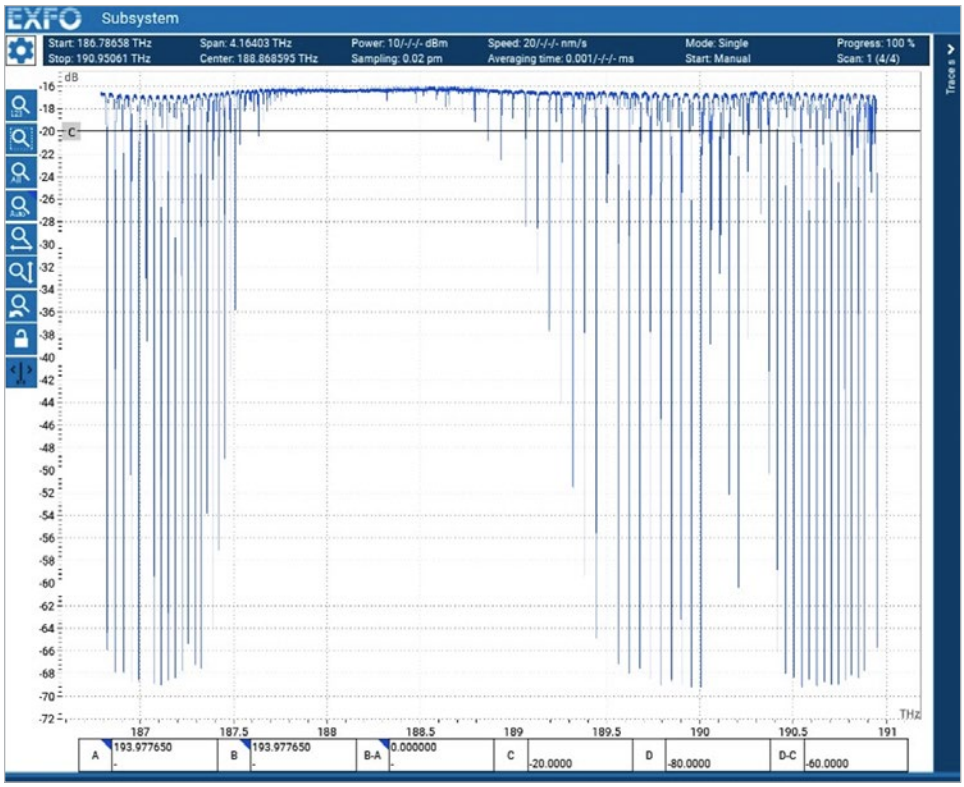

Figure 3. Spectral loss test results for CO_2 absorption of a typical long-distance HCF.

Why EXFO?

At EXFO, customer satisfaction is paramount—especially as new technologies emerge. By collaborating early with customers and partners, we ensure our solutions address real-world challenges and lead the market in usability and performance. Characterizing HCF is no small feat, but EXFO brings unmatched expertise in fiber testing ensures we get it done—delivering reliable, first-time-right results with tools trusted across the industry.

Conclusion

EXFO is proud to offer a suite of solutions for HCF testing and characterization. Whether you're in R&D, deployment, or troubleshooting, our solution are ready to help you get the most from hollow-core fiber. Contact your EXFO representative for more information or request a live demonstration—and see how EXFO can support your next HCF project with confidence and precision.