

Comparison of Low Loss and Better Performance of Fiber Bragg Gratings



Overview

We report the direct femtosecond laser inscription of type-I fiber Bragg gratings (FBGs) into the core of soft-glass ZBLAN fibers.

Key Takeaways

Fiber Bragg Gratings can be optimized either for minimal loss or enhanced performance, with trade-offs in reflectivity, mode-dependent loss, and spectral control. Low-Loss FBGs

Low-loss FBGs are designed to minimize insertion loss and mode-dependent loss (MDL), which is critical for long-haul optical communication and high-power laser systems. For example, step-index (SI) transverse profile FBGs in multi-mode fibers achieve MDL standard deviation below 0.14 dB and mode-averaged loss under 0.27 dB across the C-band, ensuring minimal signal degradation while maintaining compatibility with existing fiber systems. Similarly, femtosecond laser-written type-I FBGs in ZBLAN fibers can achieve losses below 0.5 dB/cm while maintaining temperature stability, making them suitable for mid-infrared applications. Low-loss designs prioritize signal integrity and reduced power penalties, which is essential for space-division multiplexing and high-capacity fiber links.

Better-Performance FBGs

Better-performance FBGs focus on maximizing reflectivity, coupling efficiency, and spectral control. Free-form-optimized transverse profiles in multi-mode fibers can reduce MDL STD to less than 0.11 dB and mode-averaged loss to 0.07 dB, while also improving group-delay compensation and overall system performance . In laser applications, controlling the coupling coefficient and grating length allows FBGs to reach reflectivity up to 99.98%, enhancing slope efficiency and threshold performance in all-fiber laser cavities . These designs often involve advanced fabrication techniques, such as multi-pass femtosecond laser inscription, to tailor the refractive index modulation and overlap factor for optimal performance.

Trade-Offs and Considerations

- **Low-Loss vs. High Reflectivity:** Minimizing loss may limit the maximum achievable reflectivity, while optimizing for high reflectivity can slightly increase insertion loss.
- **Fabrication Complexity:** Free-form or multi-pass laser-written FBGs offer better performance but require precise control of laser parameters, increasing fabrication complexity.
- **Application-Specific Optimization:** Low-loss FBGs are preferred for long-haul communication and sensing, whereas high-performance FBGs are critical in high-power lasers and broadband optical signal processing .
- **Spectral Flexibility:** Better-performance FBGs allow more complex spectral shaping, enabling advanced filtering, pulse shaping, and dispersion compensation.

Conclusion

Low-loss FBGs prioritize minimal signal attenuation and stability, making them ideal for long-distance transmission and sensitive sensing applications. Better-performance FBGs emphasize high reflectivity, precise spectral control, and enhanced coupling, which are crucial for high-power lasers and advanced optical signal processing. The choice between the two depends on the specific application requirements, balancing loss, reflectivity, and fabrication complexity .

Article Content

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To better distinguish between temperature and strain, some scholars have a combination of optical fiber sensors, the sensor is based

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