Dimensional parameters of quantum communication fiber optic corrugated tubes



Overview

In this work, based on the polarization degree of freedom, we demonstrate high-fidelity (~0.) single-photon transmission and distribution of entangled photons over a 36.4 m hollow- 98 core...

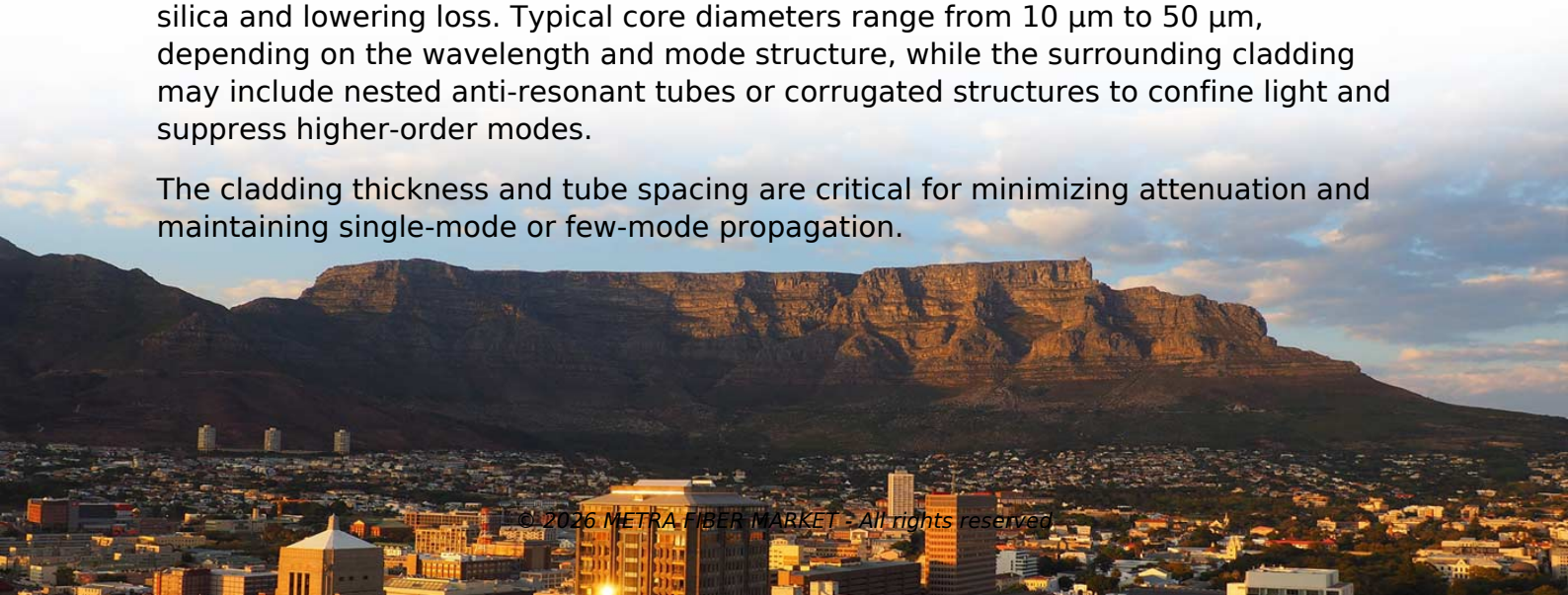
Key Takeaways

Quantum communication fibers, including corrugated or hollow-core designs, typically feature core diameters from a few microns to tens of microns, cladding structures engineered for low-loss transmission, and corrugation or anti-resonant features to minimize mode coupling and maintain high-fidelity quantum state transfer.

Core and Cladding Dimensions

Quantum communication fibers often use hollow-core or multimode fibers. Hollow-core fibers (HCFs) guide light through an air-filled core, reducing interaction with silica and lowering loss. Typical core diameters range from 10 µm to 50 µm, depending on the wavelength and mode structure, while the surrounding cladding may include nested anti-resonant tubes or corrugated structures to confine light and suppress higher-order modes.

The cladding thickness and tube spacing are critical for minimizing attenuation and maintaining single-mode or few-mode propagation.



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Corrugation and Anti-

Resonant Features

Corrugated or anti-resonant designs involve periodic variations in the cladding or tube walls, which create a photonic bandgap effect or anti-resonant reflection. These features help reduce mode coupling, scattering, and loss, enabling high-dimensional quantum state transmission over long distances. The corrugation period is typically on the order of the operating wavelength (hundreds of nanometers to a few microns), while the tube wall thickness is optimized to achieve low-loss windows at specific quantum wavelengths, such as 934 nm for quantum dots or 1550 nm for telecom signals.

Modal Properties and High-

Dimensional Transmission

For high-dimensional quantum communication, fibers are designed to support multiple spatial and polarization modes. Multimode fibers can carry 20 or more spatial–polarization modes, with modal group numbers and principal modes carefully engineered to reduce cross-talk. The fiber's orbital angular momentum (OAM) modes and LP modes are influenced by the core diameter, corrugation geometry, and refractive index profile, which together determine the fidelity and error thresholds for quantum state transfer.

Attenuation and Practical Considerations

Typical attenuation in hollow-core fibers ranges from 0. 12 dB/km to 0. 65 dB/km at quantum wavelengths, significantly lower than standard single-mode fibers at the same wavelengths.

Corrugated tube designs also allow coexistence of classical and quantum signals without introducing Raman noise, which is essential for practical quantum networks. Environmental factors such as bending, temperature, and mechanical stress can affect polarization and mode stability, so fibers are often deployed with stabilization techniques or polarization-maintaining designs.

Summary

In practice, the dimensional parameters of quantum communication corrugated fibers include: Core diameter: 10–50 μm (hollow-core or multimode)Cladding structure: Nested anti-resonant tubes or corrugated wallsCorrugation period: Hundreds of nanometers to a few micronsTube wall thickness: Optimized for low-loss windows at target wavelengthsSupported modes: Multiple spatial and polarization modes for high-dimensional quantum statesAttenuation: 0. 12–0. 65 dB/km at quantum wavelengths These parameters are carefully engineered to maximize quantum fidelity, minimize loss, and enable high-dimensional entanglement transmission over long distances, forming the backbone of practical quantum communication networks.

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