FBP Broad Spectrum Optical Fiber for Astronomy and Spectroscopy

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Synopsis:

A variety of applications in astronomy and spectroscopy require optical fibers that transmit light over a broad optical spectrum and demonstrate, specifically in astronomy, minimal focal ratio degradation (FRD). The broad spectrum optical fiber (FBP series) has high UV transmission near 300 nm, comparable to high –OH standard fiber, but with no water absorption peaks at about 730 nm, 950 nm and 1380 nm. It transmits light as well as low –OH standard fiber in visible and near infrared. Besides a wide operating wavelength range from 275 to 2100 nm, the FBP fiber demonstrates excellent performance with respect to FRD. Additional work is under way to further improve the fiber UV performance.

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A variety of applications in astronomy and spectroscopy require high performance optical fibers that transmit light over a broad optical spectrum and demonstrate, specifically in astronomy, minimal focal ratio degradation. An optical fiber with a broad optical spectrum is capable of transmitting a wide range of wavelengths with relative uniformity across the wavelength range. This is advantageous in spectroscopic applications since it expands the measurement range and sensitivity of the device. In many cases, it allows the spectrometer to be remotely located, connected to the analysis areas through broad spectrum optical fibers. As a result, more spectroscopic information over a greater wavelength range can be collected and analyzed.

One example is an optical fiber link between a telescope to a spectrograph at an astronomical observatory. Compared with the traditional approach of directly mounting the instrument onto the telescope, the optical fiber eliminates the need for alignment, providing a robust and easy-to-operate high quality spectroscopic measurement.

Focal ratio degradation (FRD) is also an important factor in astronomy applications and should be taken into consideration when selecting the optical fibers. FRD is a characteristic of an optical fiber in which the light enters a fiber at a specific cone angle and exits at an increased cone angle after the light propagates down the fiber. For a fixed length of fiber, a smaller increase in the cone angle means a better FRD performance. Low FRD is critical in preserving high quality images from telescopes to the spectrographs and thus is highly valued along with the broad optical spectrum coverage.

In scientific research and commercial product development, a broad spectrum optical fiber can be utilized as a light guide to uniformly transmit light across a wide wavelength range. Often this allows replacement of two or more standard optical fibers with one broad spectrum fiber, thereby reducing cost and improving reliability.

FBP Broad Spectrum Optical Fiber

The broad spectrum optical fiber discussed here is a large core multi-mode step index fiber exhibiting relatively high and flat optical transmission (low attenuation) over a broad optical spectrum from UV to near infrared. Standard large core optical fibers have either a high or low hydroxyl (-OH) content pure silica core with a doped silica cladding.
High –OH (also called “high water” or “wet”) optical fibers exhibit a fairly good transmission for the ultraviolet (UV) light spectrum, but not in the near infrared spectrum. This is due to high hydroxyls in the pure silica core absorbing heavily in the near infrared at about 730nm, 950nm, and 1380 nm. Low –OH (also called “low water” or “dry”) fibers show excellent transmission in the near infrared as a result of minimal hydroxyl content in the core. However, its UV transmission is poor plus it can often exhibit a draw induced band around 630nm.

While IR performance is limited by –OH content and the infrared absorption of silica, the UV performance of these standard fibers is limited by a combination of factors including intrinsic optical loss from Rayleigh scattering, electronic transitions in atomic structure, and non-structured –OH absorption. Additional losses in these fibers result from UV defects in the pure silica core from the breaking of strained bonds under UV irradiation producing UV absorptive centers in the glass.

Polymicro has employed a proprietary process which successfully produces a broad spectrum optical fiber (FBP series) with an operating wavelength range from 275 nm to 2100 nm. The FBP series fiber has a low -OH pure silica core with a significantly reduced content of UV defects and other UV absorption centers. This process effectively avoids the drawbacks of either of the standard fibers, while combining the benefits of both. Referring to Figure 1, the FBP series fiber exhibits high UV transmission near 300 nm, comparable to high –OH standard fiber, but with no water absorption peaks at about 730 nm, 950 nm and 1380 nm. It retains the high and flat transmission of the low –OH standard fiber, in visible and near infrared extending beyond 1200 nm.

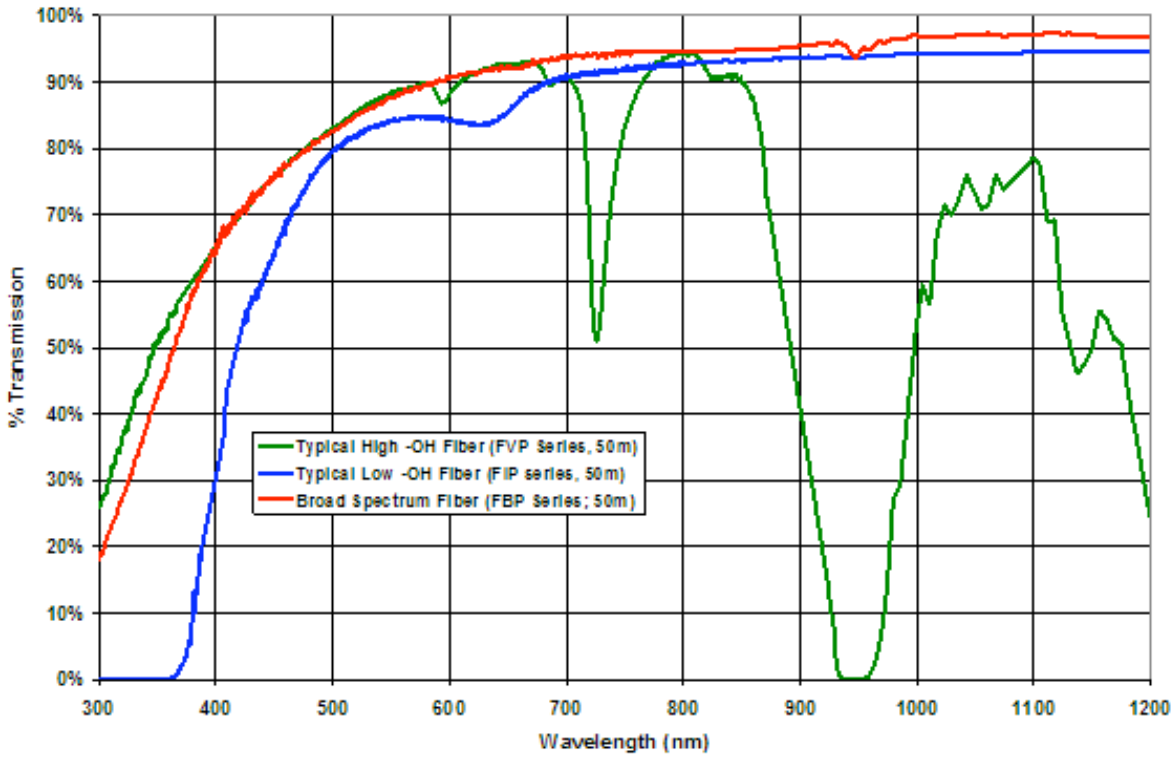

Figure 1. FBP series optical fiber demonstrating its broad optical spectrum coverage from 300 to 1200 nm. Full operational wavelength range is approximately 275 to 2100 nm.

Besides a wide operating wavelength range, the FBP series fiber demonstrates excellent performance with respect to focal ratio degradation (FRD). As a result, the FBP series fiber has been widely accepted as a high performance broad spectrum optical fiber in the astronomy and spectroscopy communities. An additional developmental effort is under way to further improve UV performance of FBP series fiber.

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Tue, 08 Jul 2008 00:12:46 GMT