Mode-field diameter of single-mode optical fiber by far-field scanning: addendum

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OCIS codes: 060.0060, 060.2270, 060.2300, 060.2430, 050.1960, 120.3940, 120.4800.

In my earlier paper,[1] I did not discuss the effect of changing wavelength on the measured value of mode-field diameter w. I performed the necessary measurements with tunable diode lasers in the neighborhoods of 1.31 and 1.55 μm.

Figure 1 shows the results of the measurements at the wavelengths 1.28–1.34 μm and 1.52–1.58 μm. The points are experimental data, and the lines are least-squares lines of best fit. For mathematical convenience, these lines can be represented by

$$w(\lambda - \lambda_0) = w(0) + b(\lambda - \lambda_0), \qquad (1)$$

where $\lambda - \lambda_0$ is the difference between the actual wavelength λ and the nominal wavelength λ_0 (either 1.31 or 1.55 μm), $w(\lambda - \lambda_0)$ is the mode-field diameter measured at wavelength λ, $w(0)$ is the mode-field diameter measured at wavelength λ_0, and b is the slope of the line of best fit. The value of b is (4.64 ± 0.08) μm/μm in the wavelength region around 1.31 μm and (5.35 ± 0.07) μm/μm in the wavelength region around 1.55 μm. These uncertainties are stated with a coverage factor of $k = 1$ (one standard deviation). The uncertainty of the wavelength measurements is less than 0.1 nm and therefore does not affect the measurement significantly. The numbers are germane to the fiber used for the Standard Reference Material only; other fibers with different index profiles are apt to show different dependences on wavelength.

For comparison with Standard Reference Material 2513,[1] the National Institute of Standards and Technology recommends that mode-field diameter measurements be carried out at the nominal wavelength of 1.31 or 1.55 μm. If that is not possible, we recommend using a laser whose wavelength λ is within 30 nm of the nominal wavelength λ_0 and correcting the resulting mode-field diameter by subtracting the value $b(\lambda - \lambda_0)$. This value is 30% less than what we would get by assuming that the mode-field diameter is proportional to wavelength. Effecting this correction will incur an additional component of uncertainty:

$$u_b|\lambda - \lambda_0|, \qquad (2)$$

where u_b is the standard uncertainty of slope b and the coverage factor is $k = 1$. This component of uncertainty must be added in quadrature with all the other components to determine the combined standard uncertainty.

If, for example, $\lambda_0 = 1.31$ μm and $\lambda - \lambda_0 = 20$ nm, then the correction $b(\lambda - \lambda_0)$ is 92 nm, or 1% of the mode-field diameter. The corresponding component of uncertainty is less than 2 nm. It has a negligible effect on the combined standard uncertainty of Ref. 1.

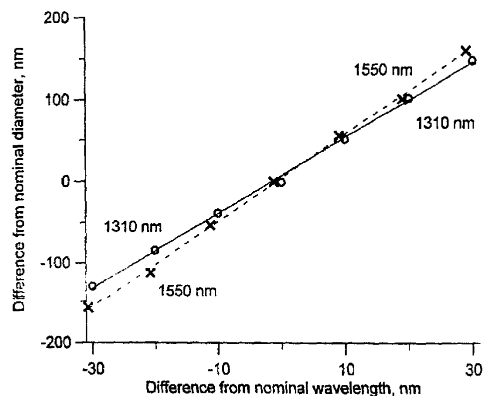

Fig. 1. Measured mode-field diameter as a function of wavelength in the neighborhoods of 1.31 and 1.55 μm.

Many thanks to Jack Wang of the Statistical Engineering Division for help with the uncertainty analysis and to Gordon Day of the Optoelectronics Division for elucidating the problem. Contribution of the National Institute of Standards and Technology, not subject to copyright.

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Received 24 September 1998.

References

1. M. Young, "Mode-field diameter of single-mode optical fiber by far-field scanning," Appl. Opt. **37**, 5605–5619 (1998).