International Comparisons of Optical Fiber Power Measurements*

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We discuss the results of optical fiber power meter (OFPM) measurements at 1310 nm and 1550 nm made by NIST and seven national measurement institutes (NMIs). We also describe transfer standards and the associated uncertainties. The comparisons show a reasonably good agreement between the participating laboratories, with relative differences that are within the standard (*k*=1) combined uncertainties.

INTRODUCTION

In our previous work we have reported international comparisons of optical fiber power with several NMIs [1-7] at 1310 nm and 1550 nm. In this paper we present new measurement results from National Institute of Metrology (NIM-China) and summarize previous fiber-based power measurements.

For OFPM calibrations, the NIST primary standard is the cryogenic radiometer [8], which has an expanded measurement uncertainty of absolute optical power of 2 parts in 10^4. NIST reference standards are calibrated against the primary standard by the use of collimated (free field) beams, but are typically used with divergent beams characteristic of laser light exiting an optical fiber.

TRANSFER STANDARDS

We used two germanium (Ge) trap-based detectors [1-6] and one commercial optical power meter [7] in the comparisons. The transfer standards may be broadly described as "trap detectors" [9]. In the present case, our trap detectors, known as the "4×trap", are two Ge photodiodes and a spherical mirror. It has been shown in [10] that such a configuration provides a uniform response over a wide field of view and therefore requires no correction for beam geometry. This design increases the coupling efficiency for larger values of numerical apertures [11].

The transfer standards were calibrated at the participating laboratories against their reference standards at approximately 100 µW.

We employed a direct-substitution method for the measurements. NIST's measurement system is described in detail in [12].

RESULTS

We present the results of the responsivity comparisons and their associated standard combined uncertainties (as error bars, *k*=1) in Fig. 1. The standard uncertainties for the optical power measurements were evaluated in accordance with the International Organization for Standardization Guide to the Expression of Uncertainty in Measurement [13]. Fig. 1 shows the relative difference (expressed in percent compared to the measurement of the National Institute of Standards and Technology (NIST-USA)) at two laser wavelengths of 1310 nm (blue) and 1550 nm (purple) among seven NMIs: (1) National Physical Laboratory (NPL-UK), (2) All-Russian Research Institute for Optophysical Measurements (VNIIOFI-Russia), (3) Physikalisch-Technische Bundesanstalt (PTB-Germany), (4) National Metrology Institute of Japan/National Institute of Advanced Industrial Science and Technology (NMIJ/AIST-Japan), (5) Federal Office of Metrology (METAS-Switzerland), (6) Centro Nacional de Metrología (CENAM-Mexico), and (7) National Institute of Metrology (NIM-China). The comparisons show a reasonably good agreement between the participating laboratories, with relative differences that are within the standard (*k*=1) combined uncertainties.

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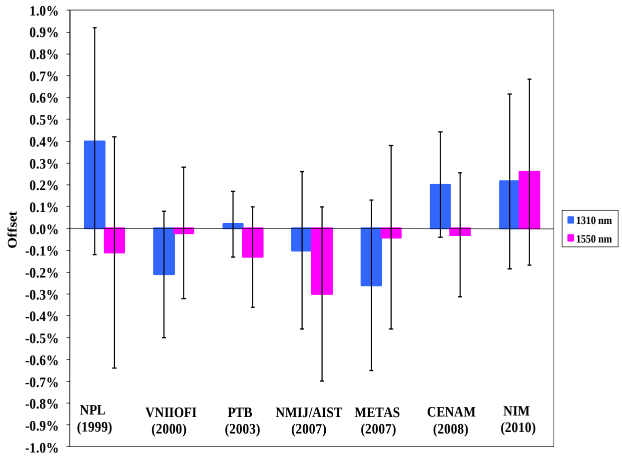

Figure 1. International comparison results (1999-2010; *k*=1). NIST results are represented by a horizontal line with an offset of 0%.

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