Short Coherence Length Interferometer for the Measurement of the absolute Fiber Facet Angle

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In this paper we present a Linnik white light interferometer with phase-shift technique for the characterisation of the absolute angle of the fiber facets.

Fiber optical systems showed an increasing interest in the past few years, especially in the development of fiber lasers and amplifiers as well as for high power beam delivery.

For many applications such as splicing, cleaving or polishing, the inspection of the fiber facets becomes necessary to avoid any undesired effects.

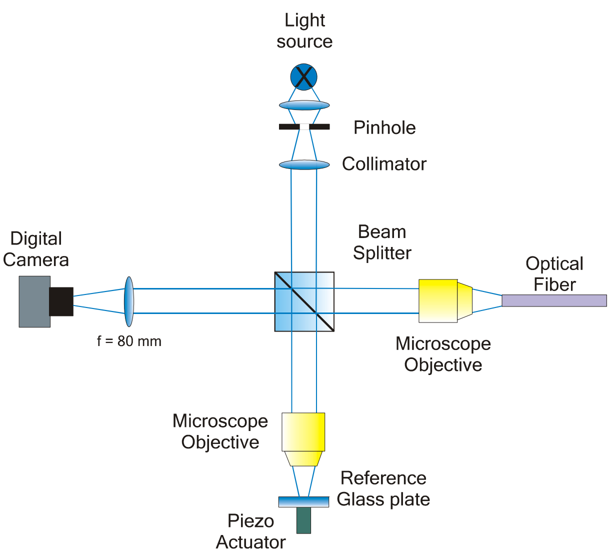

Fig. 1 *The high power LED is focused on a pinhole, thus providing sufficient lateral coherence for a good fringe visibility. The pinhole is followed by a lens that collimates the beam. A microscope objective is used to image the fiber end onto the CCD-camera. An identical objective in the reference arm images a glass reference plate, mounted on a piezo actuator enabling phase shifting, onto the same camera.*

Fig. 1 shows the setup. It is a Linnik [1] white light interferometer using phase-shifting technique for the characterisation of the absolute angle of the fiber facets. A blue high power LED emitting at 470 nm with a FWHM of 20 nm is used as a light source. A LED source combines the advantages of low cost, long lifetime and suppression of unwanted reflections from other optical interfaces.

The short coherence length of 11 µm [2] allows focusing onto the sample surface by simply maximizing the fringe contrast. With a proper alignment of the interferometer, which has to be done only once, the maximum fringe contrast coincides with sharp imaging of the fiber facet. The used microscope objectives with a N.A. of 0.25, a working distance of 10.5 mm, and a 10-fold magnification enable interferometric measurements with microscopic magnification.

The setup includes an exchangeable telescope (not shown in Fig. 1) in the camera arm which allows changing the area of interest quickly between 400 µm and 1000 µm. The lateral resolution of the interferometer is estimated to be about 1.1 µm (Rayleigh limited). An axial resolution of 6 nm (pv) and 0.8 nm (rms) is reached with the present setup [3].

The fiber facet is measured twice. Between both measurements the fiber is rotated around its axis by 180° as sketched in Fig. 2. From the two measured relative angles β and γ the absolute angle between the fiber facet and the fiber axis α is calculated by (1).

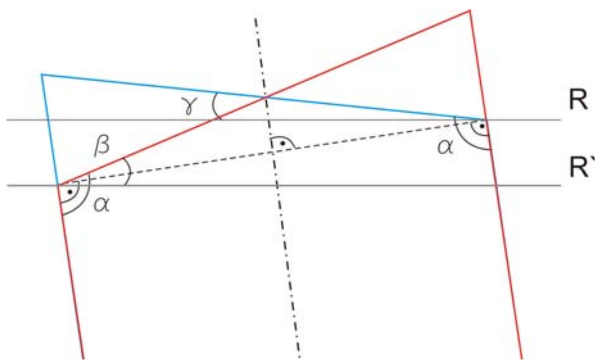

Fig. 2 *The absolute fiber angle of the fiber facet with the fiber axes is α. In the first measurement the angle γ is measured relative to the reference plane R. After an axial rotation of 180° in a second measurement the angle β relative to R' measured.*

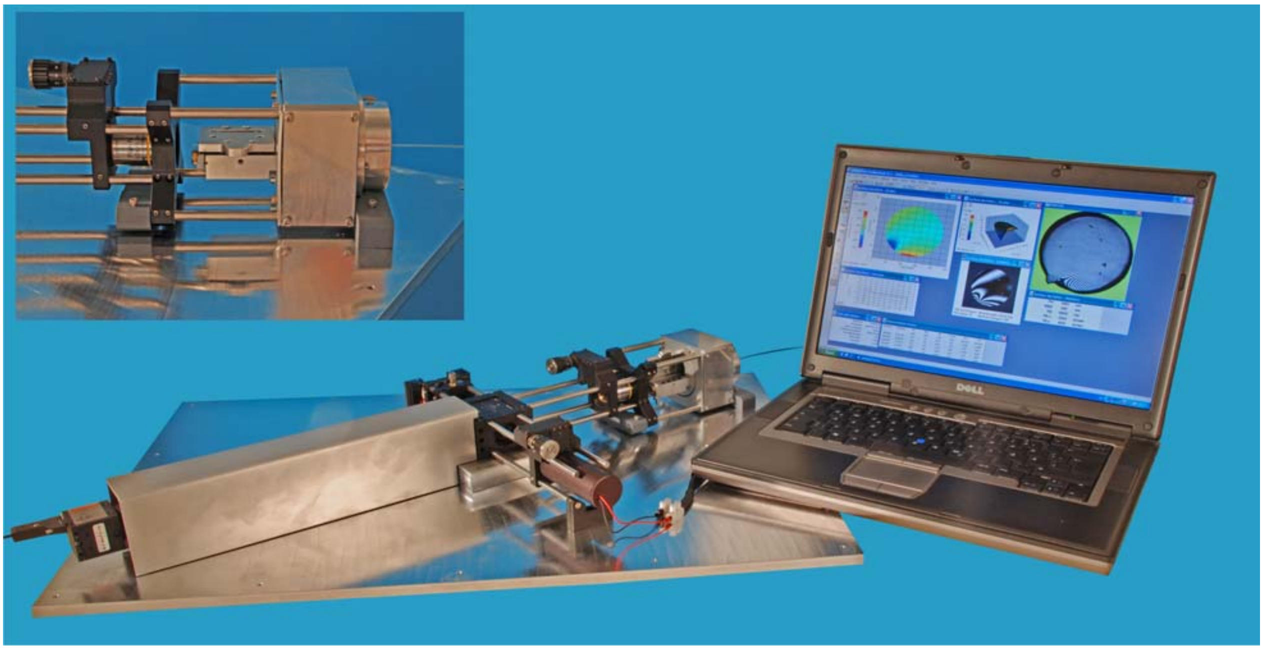

***Fig. 3** The realized Linnik interferometer with the high precise fiber rotator (upper left corner). The special analysis is fully integrated in the µShape™ Professional software.*

The new high precision fiber rotator which was specially designed for this setup allows an extremely precise axial rotation of the fiber. This holder can be seen in Fig. 3 both in the total view and as close-up in the insert. Several experiments have been performed with a very good reproducibility of 3.4 arcsecs (rms) and 11 arcsecs (pv) as can be seen in Fig.4, thus demonstrating the excellent stability of the setup.

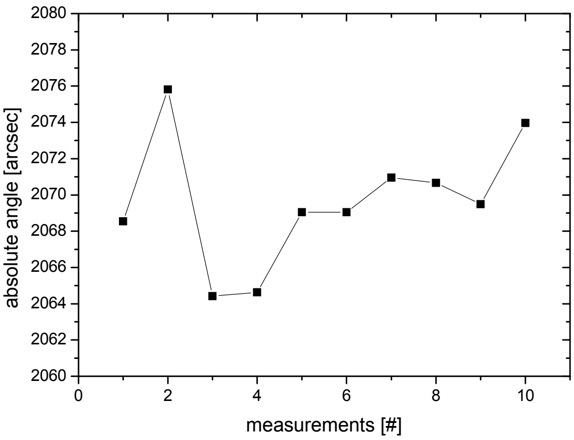

***Fig. 4** The diagram shows the measured absolute angle of the fiber facet for ten measurements. Shown is one measurement series out of three measurement series.*

Conclusion

A Linnik white light interferometer with a short coherence length was realized. In addition, a high precision fiber rotator was developed to measure the absolute angle between the fiber facet and the fiber axis of bare optical fibers by rotating the fiber by 180° and measuring the relative angle before and after the rotation. The control of the phase-shifting interferometric measurements as well as the calculation of the relative and absolute angles is performed with a modified version of the commercial interferometer software µShape™ Professional.

References

[1] D. Malacara, *Optical Shop Testing*, (John Wiley & Sons Inc 2007)

[2] M. Born, E. Wolf, *Principles of Optics*, (Cambridge University Press 1999)

[3] E. Hecht, *Optik*, (Oldenburg Verlag München Wien 2001)