Faculty of Electrical Engineering & Computer Science
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Development of Birefringence–based Optical Fiber On-line Drawing Tension Measurement.

ABSTRACT - Masterthesis

During the drawing process of an optical fiber, several drawing conditions must be continuously monitored such as fiber diameter, furnace temperature, drawing speed and bare fiber tension. Controlling of such parameters enables the achievement of the desired wave guiding properties and mechanical strength of the fiber.

The drawing tension is usually monitored either by a strain gauge mounted on the fiber, which damages or breaks the uncoated fiber at high drawing speeds; or by employing the vibrating-string method, which is susceptible to vibrational noise and instabilities in the drawing environment. Instead, a neat way to determine the tension of a silica fiber is to use its lateral optical linear birefringence induced by the tensile axial stress during the drawing process. This method employs a laser source with a defined linear state-of-polarization illuminating the fiber laterally and then measuring the azimuth-angle of the output SOP after reconversion from elliptical to linear. The result is proportional to the retardation between the two orthogonal axes, where this retardation is proportional to the applied axial tension on the fiber.

This birefringence-based method has been applied in a previous work for graded-index multi-mode fiber for a tension range less than 30 g. However, the experimental setup had a limited performance for the sideward movement of the fiber with a measurement error in tension of +7.1/-1.3 g for only ±200 µm fiber shift.

In this work, the relation between fiber's lateral birefringence and the applied axial tension is investigated theoretically, by simulation, and experimentally. The raytracing of the laser beam traversing the fiber is simulated and both retardation and azimuth-angle are calculated as function of the axial tension using the derived relation. In addition, the stability of the SOP of the laser source and its effect on the measurement are investigated, and the measurement stability is improved in a wider range of ±1000 µm for both sideward and forward fiber movements. Furthermore, the tension measurement range is extended up to 300 g to resemble real tension values used in industrial drawing processes. Finally, the developed tension measurement is applied for three types of optical fibers such as graded-index multi-mode fiber, stepindex multi-mode fiber, and single-mode fiber.