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Miniaturized fiber in-line interferometer fabricated by femtosecond laser micromachining

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An in-line fiber MZI is attractive due to its simplicity and compactness. Various types of in-line fiber MZI structures have been developed, based on interference between the fundamental core mode and the higher order cladding mode, with size of typically in the order of millimeters or centimeters, and have very small effective refractive index (RI) difference between the core mode and the cladding mode (<0.01).

This work presents a new structure of in-line fiber MZI for RI measurement with high sensitivity and precise sensing location. A MZI cavity is formed by removing part of the fiber core near the core and cladding interface, which results in splitting of the input beam into two portions, I_{in1} and I_{in2}. While I_{in1} remains traveling along the fiber core, I_{in2} has to propagate through the micro-cavity, and the interference happens when the two output beams recombine at the fiber core.

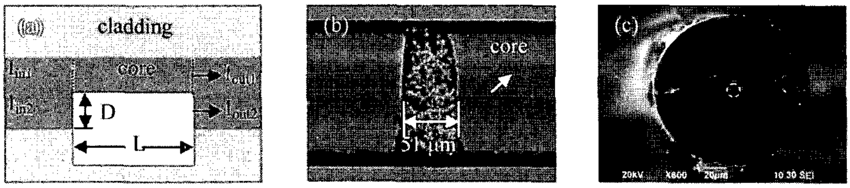

Fig. 1 In-line fiber MZI fabricated by use of femtosecond laser irradiation. (a) Schematic of the structure (top view). D represents the removed size of fiber core; L is the cavity length; I_{inm} and I_{outm}, m=1, 2, are the input and output optical intensities propagated in the fiber core and micro-cavity, respectively. (b) Optical microscopic image of the micro-cavity (side view). (c) SEM image of the micro-cavity, the dashed white circle indicates the fiber core (cross-section view)

The essential difference between our MZI and those reported previously lies in the fact that our device is based on the interference of the guided mode in the core and the unguided mode travelling through the micro-cavity. The RI difference between the two arms of the MZI is very large (> 0.10), which allows a dramatic reduction of the cavity length while maintaining a high RI sensitivity. Moreover, the position of the RI change can be precisely located due to the small size of the micro-cavity.

The interferometer created in this work exhibits a high RI sensitivity, ~-9370 nm/RIU (refractive index unit) within the RI range between 1.31 and 1.335. Moreover, a precise sensing location can be ensured owing to the small size of the interferometer. Such a fiber device has high potential in chemical and biological sensor applications.

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