Evanescent field control in a dynamic waveguide composed of gelatin coated few-layer fiber

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1. Introduction

Manipulation and precise control of propagation and modal characteristics is crucial for designing and performance optimization of several fiber-optic devices [1]. This necessitates to the origin and advent many specialty optical fibers namely, photonic crystal fiber (PCF), photonic bandgap fibers, hybrid fiber *etc.* owing to the design flexibility offered in such waveguide structures. In addition to this, responsive liquid infiltration (thermo-optic, nematic) of micro-holes/air-holes of PCF also emerged as a promising technique for obtaining tunable fiber devices. However, limitations exist in the dynamic range of tunability, difficulty in selective infiltration through capillary action, high absorption losses of liquid around operating wavelength. Thinking in this line, in this work, a novel approach of obtaining a dynamic few-layer fiber (FLF) is proposed such that the outer cladding (third layer) composed of a hygroscopic material (e.g. gelatin) can be designed to control the propagation of core and leaky cladding modes to a large extent through the ambient relative humidity (RH) [2].

2. Theory and Experimental Results

We discuss our analysis and experimental results of modal propagation in a dynamic RI-profile few-layer fiber (see Fig. 1) with a focus to controllable evanescent field across the interfaces. As a first step, we analyze the dispersion curves identifying the cut-off properties of FLF to pinpoint the influence of RH as the control parameter. Next the propagation and modal characteristics of FLF is investigated in such a dynamic RI-profile waveguide by systematically varying the RI-profile resulting from changing surrounding humidity. This clearly revealed the tailorability as mapped through estimating the fractional power in the core, cladding and coating regions. The significant change in the RI (1.33–1.5) for RH variation, fast response, ease of availability and low hysteresis have made our choice of gelatin as the coating material a unique one. In our experimental fiber-optic circuit, a selected length of conventional SMF is chemically etched and coated with gelatin to realize an FLF. The field excitation coefficients of the cladding/coating modes from the first SMF, multimode propagation within the FLF segment and overlap of the

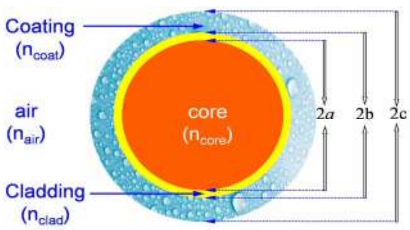

Fig. 1: Schematic diagram for transverse cross-section of the proposed few layer fiber.

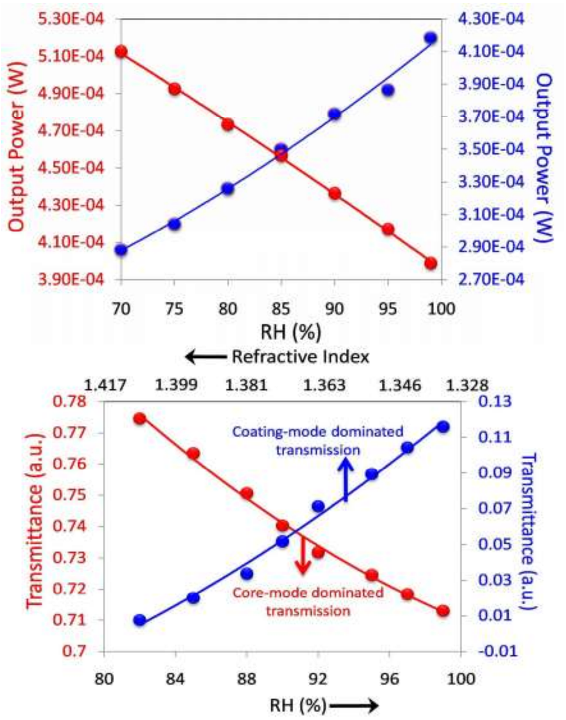

Fig. 2: Transmission characteristics of in-house fabricated SFS structure (weekly etched – red curve, deeply etched—blue curve) with as a function of ambient humidity (a) Experimental observation (b) Theoretical prediction.

superposed field at the FLFs rear-end with the final SMF is also computed and analyzed [3]. A series of carefully prepared SFS (SMF-FLF-SMF) structures are then placed in an air-sealed humidity chamber to study their transmission characteristics as a function of humidity. Using FLF with small residual-cladding width and coating width ~1 μm, a moderate change (~ – 1.6 dBm) in transmitted power is observed for RH variation from 80– 99 % (see Fig. 2). However, an optimized FLF geometry with deep-etched core (core diameter ~ 7 μm) and coating width ~1 μm shows a *remarkable change* in the output power (~ – 30 dBm) for a range of RH from 80–99 %. This maximized sensitivity owes to the efficient excitation of the higher -order coating-modes from the fundamental mode of SMF at the steep SMF–FLF transition region. These results are new and will be useful to designing devices based on evanescent field control.

References

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