Single Mode – Multimode Infrared Optical Switching based on Phase Change Materials Cored Optical Fibers

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Phase-change materials (PCMs), which typically consist of chalcogenide elements, have drawn large interests due to switchable optical properties [1]. Their wide applications have been introduced in the field of plasmonics such as mid-infrared antenna resonance tuning using germanium antimony telluride (GST) [2] or more recently in the field of optical fibers by implementing a photonic neuron in gallium lanthanum sulphide oxide (Ga:La:S:O or short GLSO) micro fibers [3].

Here we report a new application of PCMs in the field of optical fibers namely, monomode/multimode optical switching by using PCMs cored step index optical fibers. Because of a large shift of refractive index (for example, $\Delta n \sim 2.5$ for GST at 1.5 μm) when changing between amorphous states and crystalline states in mid-infrared regime, the PCMs cored fibers will become a monomode/multimode switching platform, if the core diameter is designed around the cut-off condition at the amorphous state. In our particular work, the amorphous GST cored silica clad fiber reaches the cut-off condition at the core diameter of around 400 nm as can be seen in Fig. 1a. Hence, when fixing the core diameter at 400 nm and illuminating optical pulses from the side to induce phase change within the nanocore (inset of Fig.1c) to bring the material into the crystalline state and thus achieve a greater core refractive index, the fiber will be switched from single mode to multimode as shown in Fig. 1b. Because the refractive index n of amorphous GST is around 2 at 1.5 μm, only a small shift of n (~0.1) is required to switch the fiber to multimode operation. We present in Fig.1c a boundary curve in which only the fibers having cored refractive index and radius in the region below this curve can support single mode operation. This graph helps to design further fibers with various types of PCMs for monomode/multimode switching purposes.

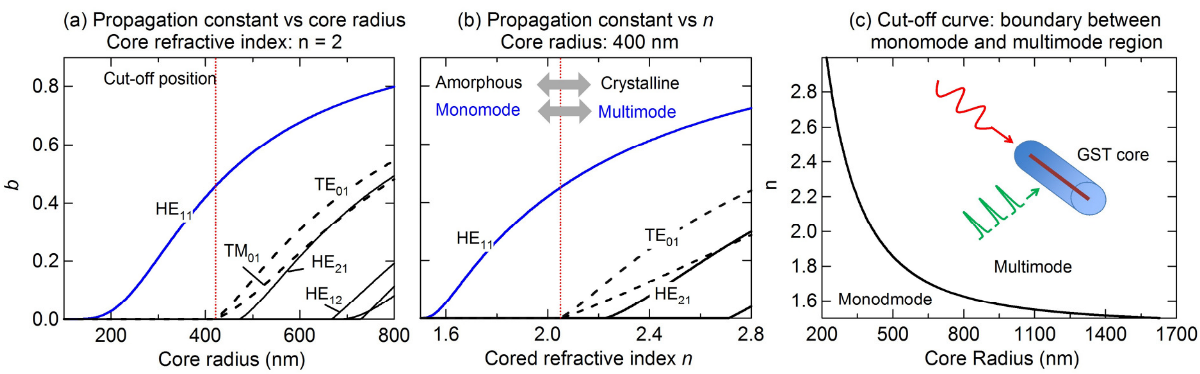

Fig. 1 Normalized propagation constant as a function of core radius when core refractive index is fixed to 2 (a) and as a function of core refractive index when core radius is fixed to 400 nm (b) for a few low-order fiber modes. (c) Cut-off curve defines boundary between monomode and multimode region.

In conclusion, a new concept of single mode/multimode optical switching realized by implementing phase change materials into the fiber core is presented. This paves the way to different optical fiber designs using PCMs that are not only limited to monomode/multimode switching but can be extended to mode selection and sensing application.

References

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978-1-4673-7475-0/15/$31.00 ©2015 IEEE