All-solid, hetero-material, microstructured optical fibers for non-linear light conversion

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ABSTRACT

The investigations on all-optical computers and artificial optical neural networks [1] has posed an increasing demand for novel and fast non-linear all optical components for light manipulation (switching/gating) and generation. In addition, the boom of fiber lasers intensifies the need for in-fiber, non-linear wavelength conversion components of high conversion efficiency. In this work, a new type of an all-solid, hetero-material, microstructured optical fiber is demonstrated, with inherent light conversion, and all-optical switching capabilities.

This hybrid all-solid, microstructured optical fiber uses a silica glass scaffold, infiltrated with a highly non-linear organic material, while supporting a twofold wavelength dependent guidance mechanism, and prominent second harmonic generation (SHG) capabilities [2]. A silica glass microstructured optical fiber was infiltrated with molten 2-methyl 4-nitroaniline (MNA) [3] for creating the hetero-material all-solid optical fiber, with the MNA material exhibiting a great refractive index dispersion, manifested by an Abbe number lower than ~3. This all-solid, hetero-material optical fiber was characterized over a broad wavelength range, revealing that a transition from photonic bandgap guidance to modified total internal reflection propagation occurs from short to longer wavelengths, as imposed by the Abbe number of MNA. Moreover, this hybrid optical fiber was pumped at 1064nm (the modified total reflection regime) for achieving second harmonic at 532nm (the photonic band gap guidance regime). The efficiency of the light conversion process is dependent upon the microstructure of the solidified MNA inside the optical fiber capillaries. Post processing by means of thermal annealing was shown to suppress losses and simultaneously improve SHG performance.

Further investigations into the optimization of this hybrid optical fiber performance led to the post-fabrication application of electric field poling. Different poling conditions, namely temperature, and electric field intensity were applied, resulting in different transmittance and second harmonic generation performance. The origins of these differences were also investigated by means of backscattered signal examination of the MNA capillaries as a function of pump light polarization. Results showed that crystallinity and orientation of the MNA filled capillaries surrounding the optical fiber core play dominant role in both SHG efficiency and modal characteristics of the hetero-material optical fibers. Additionally, it was shown that for optical fibers with similar MNA crystalline orientation, SHG output light intensity can be a function of pump light polarization, enabling handy phase-matching process, as well as, prospects for all optical switching and filtering applications.

REFERENCES

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