A novel all-normal dispersion photonic crystal fiber design for low-noise coherent supercontinuum generation with 1030 nm pumping

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Abstract: We present a polarization-maintaining all-normal dispersion photonic crystal fiber designed for 1030 nm femtosecond pumping, enabling ultrafast applications with supercontinuum generation spanning 750 nm–1300 nm.

Supercontinuum generation (SCG) in all-normal dispersion (ANDi) optical fibers has recently garnered significant attention due to its ability to achieve broad and flat spectral bandwidths with high brightness, coupled with excellent stability and high coherence [1–3]. Low-noise ANDi SC sources are essential for numerous applications, including optical coherence tomography (OCT), nonlinear imaging, ultrafast technologies, and dual-comb spectroscopy at the shot-noise limit [3].

In this work, we introduce a novel polarization-maintaining (PM) ANDi photonic crystal fiber (PCF) specifically designed for 1030 nm femtosecond pumping, tailored to ultrafast and widely tunable optical parametric amplifier (OPA) systems. Figure 1(a) shows a SEM image of the PCF's cross section, which features 11 rows of air holes to minimize confinement losses. The fiber's polarization-maintaining properties are achieved through the two larger central holes, an alternative approach to using conventional stress rods. [4]. By carefully optimizing the fiber pitch and hole diameters, we achieve a parabolic all-normal dispersion profile with a minimum around 1030 nm, along with low optical losses and polarization preservation, tailored to meet demanding experimental requirements. Figure 1(a) shows the measured and simulated dispersion profiles for both the fast and slow axes. Next, we pumped the fiber with an Yb:YAG CPA femtosecond laser (Model PHAROS PH1-SP-1mJ) delivering 180-fs pulses at 1034 nm, and we analyzed the output using a spectrometer. Figures 1(b) shows a false-color map plotting output spectral intensity as a function of energy, comparing experimental measurements (bottom) with numerical simulations (top). Simulations used a generalized nonlinear Schrödinger equation with no free parameters and we see very good agreement in terms of overall evolution and spectral bandwidth. Line profiles of the experimental spectra (up to 14.6 nJ - 80 kW peak power), on both linear and logarithmic scales are shown in Fig. 1(c, d). At maximum pulse energy, the PM-ANDi fiber supercontinuum spanned from 750 nm to 1300 nm, corresponding to a -5 dB bandwidth of 650 nm, demonstrating state-of-the-art performance [4].

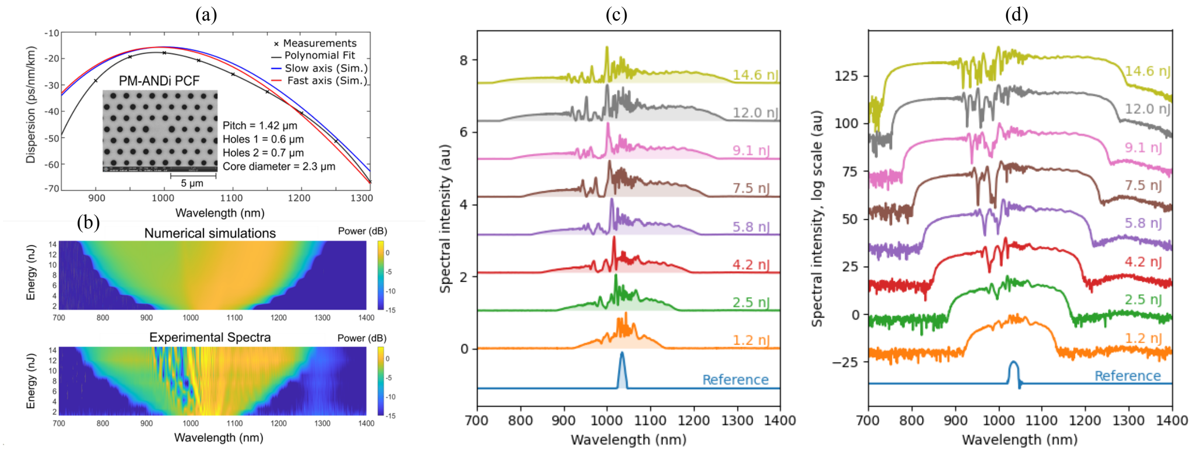

Fig. 1 (a) Group-velocity dispersion (GVD) of the fabricated PM-ANDi PCF shown in inset (SEM image). (b) Numerical and experimental SC spectra as a function of input pulse energy. (c) and (d) shows these SCG results on linear and logarithmic scales, respectively.

References

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