Broad spectral tuning of polarization modulation instability in ethanol-filled photonic crystal fibers

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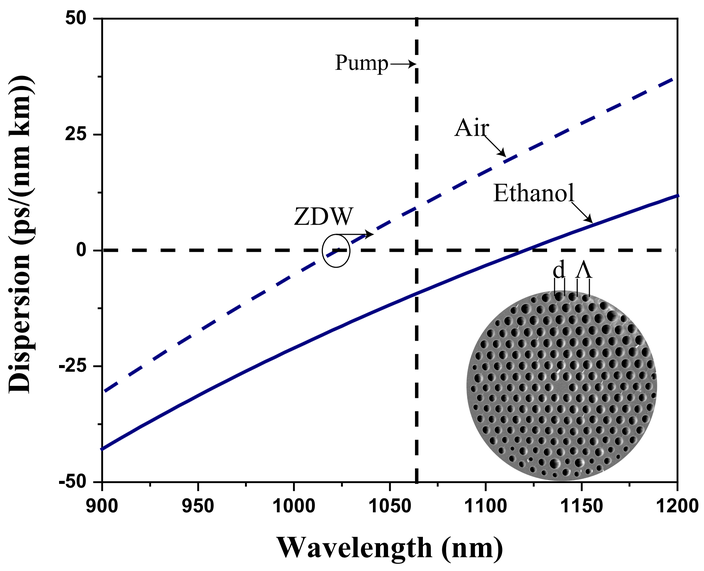
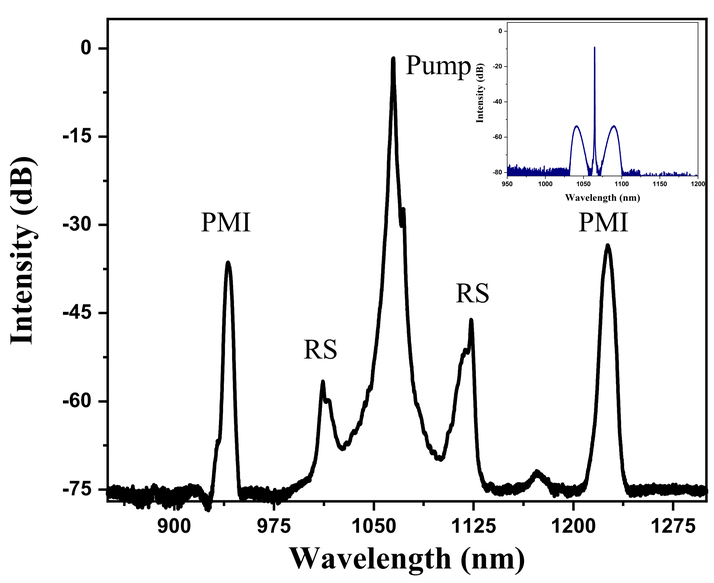
Abstract: Experimental demonstration of tuning widely spaced polarization modulation instability (PMI) bands generated by pumping in the normal dispersion near to zero dispersion wavelength (ZDW) is reported. Tunability is achieved by simultaneous dispersion and birefringence variations in ethanol filled photonic crystal fibers (PCF) through thermal heating. We designed and fabricated PCFs with appropriate characteristic to generate widely spaced PMI bands when the PCF holes are filled with ethanol and the fibers are pumped at 1064 nm. We found out in the experiments that the phase matching condition of PMI is very sensitive to small changes of dispersion and birefringence when the pump wavelength is near to ZDW, leading to large PMI wavelength shifts. In the experiments, frequency shift of 26.7 THz is attained and correspond to wavelength tuning range from 1226 nm to 1378 nm for Stokes band and 940 nm to 867 nm for anti-Stokes band.

Ethanol-filled fiber

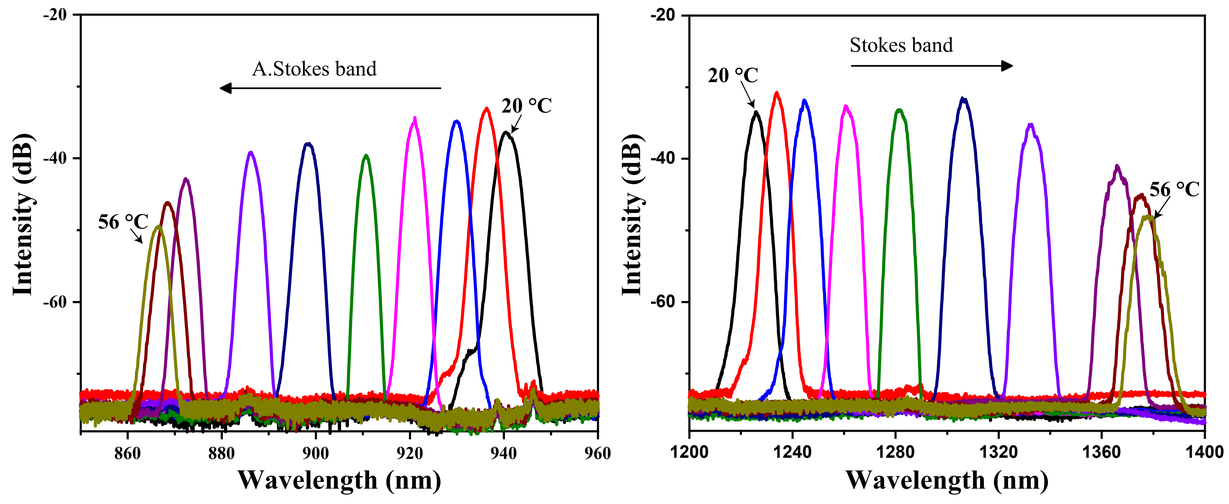


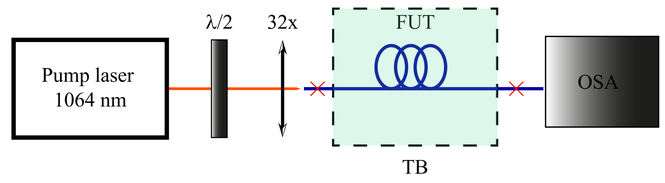
The PCFs employed during the experiments has the following fabrication parameters: $d/\Lambda=0.75$ and $\Lambda=3.9$ µm.
PCFs present anomalous dispersion at the pump wavelength when holes are with air. After ethanol infiltration, the dispersion shift to normal and ZDW is near to the pump wavrlength.



Fiber output spectrum shows typical modulation instability trace when the fiber holes are with air, after ethanol infiltration, two PMI bands appears centered at 940 nm for anti-Stokes band and 1226 for Stokes band when the fiber is pumped in the slow axis. Raman scattering (RS) is also generated.

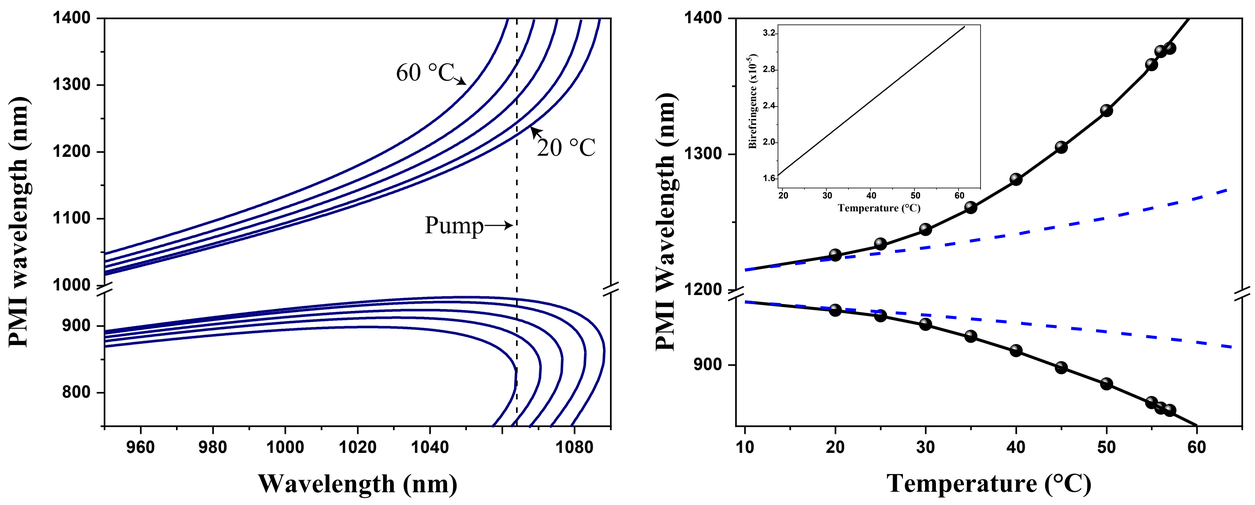
Spectral tuning of PMI bands





By increasing ethanol temperature, fiber dispersion also increase, leading the Stokes band to displace to larger wavelengths while anti-Stokes band shift to shorter wavelengths.
For temperatures above 60 °C, the amplitude of PMI bands decrease into noise level and no more PMI was observed.

Discussion



Evolution on PMI phase matching curves with temperature shows how PMI wavelengths shifts away from the pump wavelength. Furthermore, it is shown that the phase matching condition is no longer fulfillment for temperatures above 60 °C

In the experiments, we found out that small birefringence variations (~$1.3X10^{-5}$) due increasing temperature, enhance considerable the tuning range on PMI bands when the ZDW is near to the pump.

Conclusions

-Broad spectral tuning of widely-spaced PMI bands generated in ethanol-filled PCFs is demonstrated

-It is shown that slight changes on fiber properties induced by temperature, can lead to large PMI wavelengths shift when the fibers are pumped near the ZDW.

-The results presented in this communication can be of interest for development of dual-wavelength light sources with tunable frequency spacing

Further information here