

A 20 μm -core PM endlessly single-mode photonic crystal fiber for delivery of high-power single frequency lasers

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Since the appearance of the so-called endlessly single-mode fiber in the late 1990s, photonic crystal fibers (PCFs) and the exploration of their wide range of possible applications have garnered significant interest [1, 2].

We report on the development of a 20 μm -core diameter Polarization Maintaining (PM) endlessly single mode PCF for the use in delivery of high-power single-frequency lasers, required in the quantum field. Based on an in-depth numerical study, three versions of this fiber with different pitch (Λ) and hole size (d) ratios were drawn. We have fully characterized these fibers at 1064 nm by measuring transmission, phase birefringence, polarization extinction ratio (PER) and modal quality (see Fig. 1). We also measured the threshold of appearance of the Brillouin effect at 1064 nm which is the first nonlinear effect limiting the delivery power in single frequency regime. Our results shown that the developed fiber exhibits a significantly higher threshold than commercially available fibers (see Fig. 2) and we successfully demonstrated the transmission of over 40 W at 1064 nm through a 5 m-long fiber without distortion. Thanks to our study, we proved that the theory existing for all-silica fibers could describe the behavior of large-core PCF and that we could therefore extrapolate our results to other wavelengths.

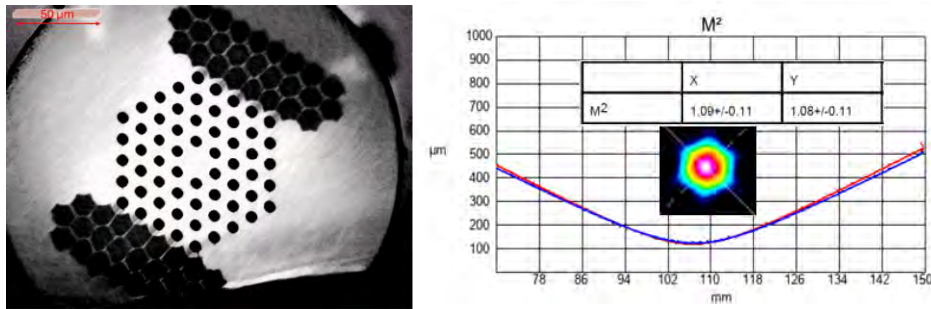


Fig. 1 Microscope image of the 20 μm -core and 260 μm -clad PM-PCF fabricated (left). M^2 measurement at 1064 nm for a 30 m-long PM-PCF and spatial profile shown in the inset (right).

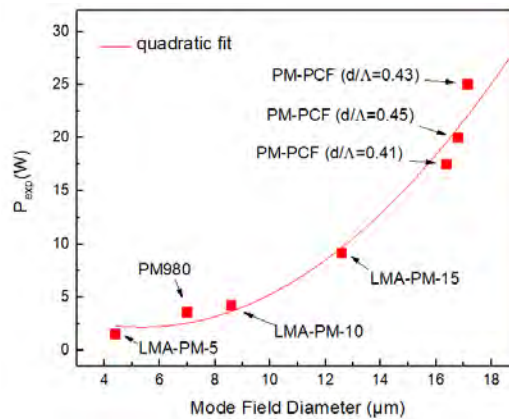


Fig. 2 Experimental Brillouin threshold power, P_{exp} , at 1064 nm for the 10 m-long tested fiber

Additional measurements at 780 nm and 1550 nm confirmed endlessly single-mode behavior and the preservation of the PER. The wavelength of 780 nm is widely used for cooling Rubidium atoms while 1550 nm is particularly useful in quantum physics for creating dipole traps and in optical communications. Consequently, having an endlessly single-mode fiber capable of delivering high optical power across these spectral ranges represents a significant advantage.

[1] T.A. Birks, J.C. Knight, and P.S.J. Russell, "Endlessly single-mode photonic crystal fiber," *Opt. Lett.* 22, 961-963 (1997).

[2] J.C. Knight, "Photonic crystal fibres," *Nature* 424, 847-851 (2003).