

A HORIZON OF COMPACT NONLINEAR OPTICAL MICROSCOPY: DOUBLE-CLAD PHOTONIC CRYSTAL FIBERS

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Recently, the emergency of photonic crystal fibers (PCF) has been a renaissance of fundamental research and development on optical fibers and devices [1]. Nonlinear optical microscopy such as two-photon absorption and second harmonic generation (SHG) exhibits advantages of intrinsic sectioning ability, direct imaging of highly polarisable structures, and deep optical penetration. To achieve a compact and miniature microscope, flexible fiber-optic components such as optical fibers, optical fiber couplers and micro-lenses are usually integrated into the imaging system to replace complicated bulk optics [2-6]. Although single-mode fibers can deliver superior quality of the laser beam and provide an enhanced sectioning ability compared with multimode fibers or fiber bundles, the lower numerical aperture (N.A.) of the single-mode fiber and nonlinearities as a result of the small fiber core size limit the sensitivity of the system. However, the attractive properties of double-clad PCF [1], including a large mode area in the core for single-mode delivery and high N.A. in the inner cladding for signal collection, may add a new horizon for nonlinear microscopy. We report on a two-photon fluorescence and SHG microscope based on double-clad PCF [7]. The output pattern of the fiber at various coupling wavelengths is shown in Fig.1. It reveals that the core of the fiber can support single-mode operation in the near infrared region while the inner cladding can propagate light efficiently at a visible wavelength. This feature demonstrates that a length of double-clad PCF can play a dual role of efficient delivery of the infrared illumination beam and efficient collection of visible signal in nonlinear optical microscopy. Double-clad PCF could hold a promising future for the application in nonlinear optical endoscopy.

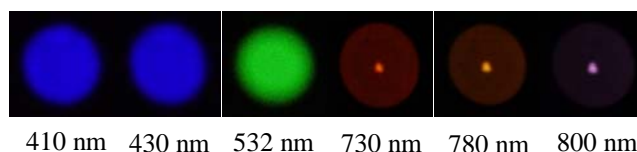


Figure 1. Output pattern of a double-clad PCF in the wavelength range of 410-800 nm.

Reference

- [1] J. C. Knight. *Nature*, 424 (2003), 847-851
- [2] D. Bird, Min Gu, *Opt. Lett.*, 27 (2002), 1031-1033.
- [3] D. Bird, Min Gu, *J. Microscopy*, 208 (2002), 35-48.
- [4] Damian Bird, Min Gu, *Opt. Lett.*, 28 (2003), 1552-1554.
- [5] Min Gu, D. Bird, *J. Opt. Soc. Am. A*, 20 (2003), 941-947.
- [6] L. Fu, X. Gan and M. Gu, *Opt. Lett.* (2005) in press.
- [7] L. Fu, X. Gan and Min Gu, to be submitted to *Opt. Lett.*