MICRONOVA
CENTRE FOR MICRO- AND NANOTECHNOLOGY
TKK – HELSINKI UNIVERSITY OF TECHNOLOGY

FIBER-OPTICS GROUP

OPTICS AND MOLECULAR MATERIALS LABORATORY

The Fiber-Optics group is involved in various activities ranging from the development of novel coherent light sources to research on gas sensing technology. These activities are strongly related to the latest advance in optical fiber technology, the so-called photonic crystal fibers. Photonic crystal fibers contain a periodic array of air-holes in the cladding running along the entire length of the fiber. The great flexibility in the design of the microstructure cladding offers a wide variety of possible applications. Examples of advances introduced by photonic crystal fibers include enhanced/reduced nonlinearity, special dispersion properties or single-mode guidance from visible to infrared wavelengths. This new type of fiber has shown great promise in the development of fiber-based optical sources, nonlinear devices and sensing applications. Our effort is mainly devoted to the study of photonic crystal fibers' properties and applications of these.

RECENT RESULTS

We have been very active in supercontinuum research and provided detailed description of the various nonlinear phenomena involved in their generation. Recently, we have developed a compact supercontinuum source that makes use of a large mode-area microstructured fiber (MF). Using a nanosecond Q-switched Nd:YAG laser operating at the fundamental wavelength of 1064 nm, we have generated a continuum that spans more than an optical octave and covers the different telecom windows [3]. Exploiting the geometrical and physical properties of microstructured fibers, we have also demonstrated the realization of a broadband light source and a reference gas cell in a single narrow-core MF [2]. Supercontinuum sources find numerous applications, e.g. in the fields of telecommunication, optical metrology, spectroscopy and medical imaging.

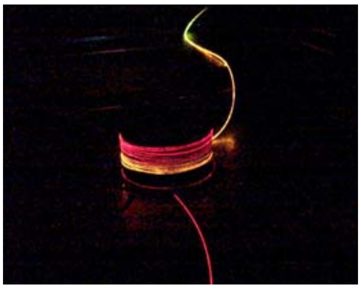

Figure 1. Generation of supercontinuum along a MF.

Figure 2. Output beam of a MF-based supercontinuum source.

Photonic bandgap fibers (PBFs) offer interesting possibilities for compact gas sensor devices as they can provide a long light-gas interaction path resulting in enhanced sensitivity. Our group has recently demonstrated that these novel air-guiding PBFs can indeed be conveniently employed for gas sensing/detection [7]. We have also demonstrated that gas-filled PBFs can be used as optical wavelength references in monitoring and calibrating channels in optical communications [4].

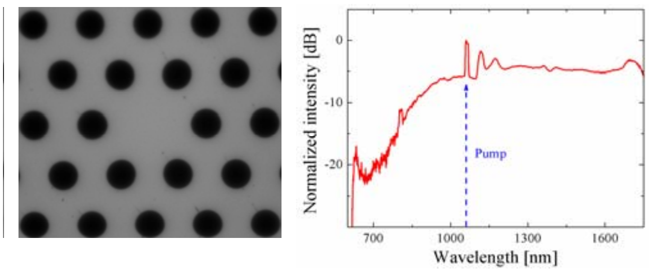

Figure 3. Left: Microscope image of a large-mode area microstructured fiber. Right: Supercontinuum spectrum generated from a Q-switched Nd:YAG laser.

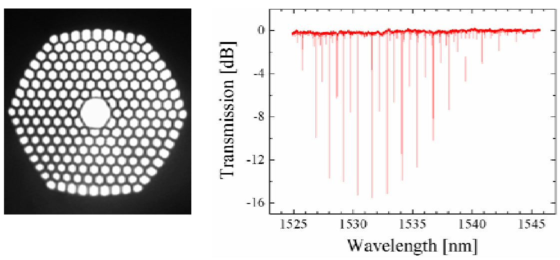

Figure 4. Left: Microscope image of photonic bandgap fiber guiding around 1550 nm. Right: Absorption spectrum of acetylene at 1 mbar measured with a 5 m long photonic bandgap fiber.

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Recent Publications:

1. M. Lehtonen, *Applications of microstructured fibers: Supercontinua and novel components*, Doctoral dissertation, Helsinki University of Technology, Espoo 2005.
2. T. Ritari, G. Genty, and H. Ludvigsen, *Supercontinuum and gas cell in a single microstructured fiber*, Opt. Lett. (2005).
3. G. Genty, T. Ritari and H. Ludvigsen, *Supercontinuum generation in large mode-area microstructured fibers*, Opt. Express **13**, 8625-8633 (2005).
4. J. Tuominen, T. Ritari, J.C. Petersen, and H. Ludvigsen, *Gas filled photonic bandgap fibers as wavelength references*, Opt. Commun. **255**, 272-277 (2005).
5. M. Lehtonen, G. Genty, and H. Ludvigsen, *Absorption and transmission spectral measurements of fiber-optic components using supercontinuum radiation*, Appl. Phys. B **81**, 231–234 (2005).
6. M. Lehtonen, G. Genty, and H. Ludvigsen, *Tapered microstructured fibers for efficient coupling to optical waveguides: a numerical study*, Appl. Phys. B **81**, 295–300 (2005).
7. T. Ritari, H. Ludvigsen, and J.C. Petersen, *Photonic bandgap fibers in gas detection*, Spectroscopy **20** (4), pp. 30-33, April 2005.
8. G. Genty, M. Lehtonen, and H. Ludvigsen, *Optical bistability and signal processing in a microstructured fiber ring resonator*, Appl. Phys. B **81**, 357–362 (2005).
9. A. Lamminpää, T. Niemi, E. Ikonen, P. Marttila, and H. Ludvigsen, *Effects of dispersion on nonlinearity measurement of optical fibers*, Opt. Fiber Technol. **11**, 209-214 (2005).
10. G. Genty, M. Lehtonen, and H. Ludvigsen, *Route to broadband blue light generation in microstructured fibers*, Opt. Lett. **30**, 756-758 (2005).

Patents

S. C. Buchter, H. Ludvigsen, and M. Kaivola, *Method of generating supercontinuum optical radiation, supercontinuum optical radiation source, and use thereof*, International patent application WO2005071483.