NANO HIGHLIGHT
Photonic Crystal Fibers with Nanoscale Functionalized Air Holes as Robust Chemical and Biological Sensors

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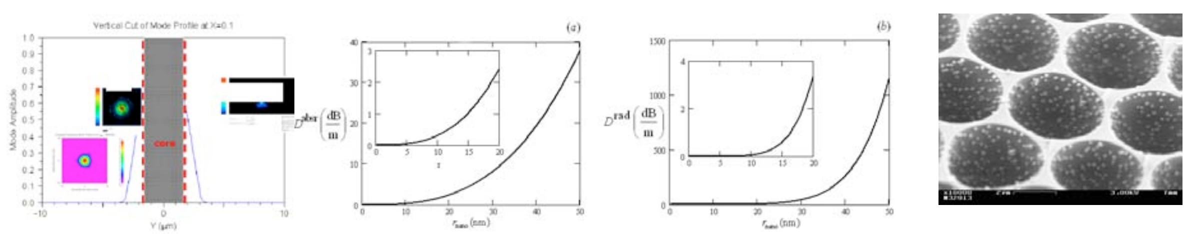
This project aims to integrate surface-enhanced Raman scattering (SERS) with the emerging photonic crystal fiber (PCF) technology to develop a powerful SERS/PCF platform for ultra-trace chemical and biological sensing and molecular fingerprinting. The premise of such platform rests on the strong mode-field overlap with the analyte over the entire PCF length as well as on the advantage that SERS offers. Key to realizing SERS/PCF is controlled immobilization of SERS-active Ag or Au nanoparticles inside the axially-aligned air channels in silica PCF with air cladding microstructure optimized for sensing applications. Major progress to date by this interdisciplinary team of investigators is highlighted below.

(1) We have completed the design of a novel solid-core PCF with steering-wheel cladding air channel structure. Fabrication of the new PCF is near completion. Our simulation has indicated low confinement loss and strong evanescent field of such structure, ideal for evanescent-field SERS-based sensing. (2) We have modeled for the first time evanescent field interaction with metallic nanoparticles randomly immobilized on the surface of a waveguide structure in general and solid-core of PCF in specific. The unique self-consistent system of equations takes into account all possible light scattering and coupling mechanisms, leading to a set of selection guidelines for nanoparticle size and coverage as well as excitation wavelength suitable for SERS/PCF platform. (3) We have established a new synthesis route to *in-situ* solution reduction of Ag nitrate and subsequent immobilization of the resultant SERS-active Ag nanoparticles in the air channels of PCF. A high degree of control of particle size and coverage can be achieved with mediation by self-assembled polyelectrolyte monolayer on air-channel surface.



(A) (B) (C) (D)

(A) Simulated intensity distribution of guided mode in PCF with steering-wheel structure (insets: far field pattern of PCF (top-left) and 3-D power profile of fundamental mode in PCF); The power-damping coefficients as a function of Ag nanoparticle radius due to (B) electromagnetic energy absorption in the nanoparticles and (C) radiative scattering by the nanoparticles; (D) Scanning electron micrograph of a cleaved PCF after in-situ immobilization of Ag nanoparticles via reduction of Ag nitrate using (N-(2-hydroxyethyl) piperazine-N'-2-ethanesulfonic acid.

References

[1] For further information about this project email hdu@stevens.edu
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[3] A. Raspopin, H.-L. Cui, and H. Du, "Calculation of Evanescent Field Interaction with Metallic Nanoparticles Immobilized on the Air Holes of Solid-Core Photonic Crystal Fiber," *Proceedings of the Conf on Photonic Crystals and Photonic Crystal Fibers for Sensor Applications*, Optics East 05, Oct. 23-26, 2005, Boston, MA (in press).