Photonic Crystal Fiber Nanosensors

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Stevens Institute of Technology's Dr. Henry Du and his research team have pioneered work on the **integration of photonic crystal fibers (PCFs) with nanoscale** technologies that will potentially lead to robust chemical and biological sensing devices. The National Science Foundation recently granted Du's team $1.3 million to pursue a multidisciplinary project in the area.

Using molecular and nanoscale surface modification, state-of-the-art laser techniques, and computer simulation, their research seeks to enhance the prospects of PCF sensors, sensor arrays, and sensor networks for diverse applications such as remote and dynamic environmental monitoring, manufacturing process safety, medical diagnosis, early warning of biological and chemical warfare, and homeland defense.

"Through basic and applied research," said Du, "the optically robust PCFs with surface-functionalized, axially-aligned air holes are expected to achieve a quantum leap in chemical and biological detection capability over conventional fiber-optic sensor technology."

PCF sensors enabled by nanotechnology also have the potential to be a powerful research platform for in-situ fundamental studies of surface chemistry and chemical/biological interactions in microchemical and microbiological systems.

Specifically, PCFs will be fabricated via a modified sol-gel method for optical fibers with the aid of simulation-based design for optimum light-

analyte interactions. Nanoscale surface functionalization will be conducted following two strategies:

1. Surface attachment of Ag nanoparticles mediated by 3-mercaptopropyltrimethoxysilane self-assembled monolayer (SAM) for chemical sensing of NOx, CO, and SO2, where surface-enhanced Raman scattering (SERS) can be exploited for high sensitivity and molecular specificity; and
2. Surface binding of biospecific recognition entities for biological sensing using the following recognition pairs: biotin/avidin, cholera toxin/anticholera toxin and organophosphorous hydrolase (OPH)/paraoxon, where SERS may also be exploited.

The functionalized hollow core or cladding air holes will be filled with analytes for evaluation of sensing capabilities of PCFs. Surface functionalization studies will employ various surface-sensitive analytical techniques. Sensing measurements will make use of a range of state-of-the-art laser techniques. Experimental studies will be augmented by computer simulation, taking into account of the effects of surface functionalization, analyte medium, and biospecific interactions on the optical characteristics of PCFs.

An interdisciplinary team of academic and industrial researchers cutting across a broad spectrum of disciplines has been assembled to carry out this project. The project also involves postdoctoral fellows, graduate students, and several undergraduate/high-school summer research scholars, thus affording them the training and exposure in chemical and biological sensing and monitoring, a priority area of federal R&D, in view of the challenges faced by the nation.

Broad dissemination of research findings will be achieved via conference presentations, publications, and yearly on-site workshops.

A program-specific website will also be developed for timely release of significant research outcomes. The project is being conducted in collaboration with OFS Laboratories (formerly the Optical Fiber Division, Bell Laboratories), a world leader in fiber optic research, via NSF's GOALI mechanism.

The research team consists of Professor Du (PI), Stevens' Department of Chemical, Biomedical, and Materials Engineering; Professor Svetlana Sukhishvili (Co-PI); Stevens' Department of Chemistry and Chemical Biology; Professors Hong-Liang Cui (Co-PI), Rainer Martini (Faculty Fellow), and Kurt Becker (Faculty Fellow), Stevens' Department of Physics and Engineering Physics; Professor Christos Christodoulatos (Co-PI), Stevens' Center for Environmental Systems; and Dr. Ryan Bise (Co-PI), OFS Laboratories (formerly Fiber Optic Research Department of Bell Laboratories).

Source: Stevens Institute of Technology