Give Me Some (Photonic) Skin

BRUSSELS, Belgium – A unique sensor system that combines optoelectronics and fiber optics in a flexible, stretchable, skin-like polymer film for applications including health care and structural engineering is being developed under the three-year, €1.9-million project PHOSFOS (Photonic Skins for Optical Sensing) that launched in April.

The project is funded by the European Commission as a Specifically Targeted Research Project of the Seventh Framework Programme and is coordinated by Vrije Universiteit Brussel (Free University of Brussels).

A consortium of European researchers intends to develop a technology that overcomes issues that have prevented fiber sensors from penetrating the market, such as true system integration, optical coupling and interfacing, and dependable strain transfer and reliability. Depending on the application, the sensing sheets could include optical and electrical power supplies as well as onboard signal processing and wireless communications capabilities.

The skin will be flexible and stretchable so that it can be wrapped around, embedded in, attached and anchored to irregularly shaped and moving objects or bodies.

Because they would be sensitive to touch, pressure or deformation, the skins could be used to help health care workers keep patients from developing bedsores, or as a way to monitor respiration and cardiac activity over the long term for enhanced rehabilitation following accidents or surgery.

The photonic skins also could serve as an easy-to-use, affordable early warning system to alert engineers to stress or strain problems with dams, bridges, aircraft wings, or helicopter or windmill blades. Other potential applications include the automotive industry, aeronautics and aerospace, and robotics.

"The optical sensors rely on Bragg gratings written in silica and plastic microstructured optical fibers (photonic crystal fibers)," all integrated within the polymer films, said project leader Francis Berghmans of Vrije Universiteit Brussel.

The silica fibers will be designed to exhibit almost zero temperature sensitivity, while the polymer optical fibers can stretch up to 300 percent before breaking.

Superluminescent LEDs (SLEDS) are targeted as the light source. "We are also looking at supercontinuum generation to power the sensor array in the silica fiber," Berghmans said.

It would be nice to combine the supercontinuum generating capabilities with sensing, but that is outside PHOSFOS' stated goals, he said.

Shown is a 1 × 4 array of vertical-cavity surface-emitting lasers (VCSELs) thinned from 150 to 30 µm and embedded in a polymer sheet. The sheet contains optical waveguides that have been lithographically defined. This thinning and embedding technique is applied in the PHOSFOS project. Image copyright Centre for Microsystems Technology (IMEC-associated lab at Ghent University)

Concepts prove out

"Since the project officially began, we have been focusing on the design of the microstructured fibers for enhancing their sensitivity to transverse load and pressure, and we have already demonstrated fiber Bragg gratings in these fibers. We have also demonstrated that the fibers with Bragg gratings can be embedded in the polymer sheets," Berghmans said.

"Once integrated, the polymer sensing sheets will be a couple of millimeters thick. For demonstration purposes, we target a sheet size somewhere in between an A4 and A3 format paper sheet," he said, or roughly that of letter- and legal-size pieces of paper. The output of the sheets will have a simple electrical connection.

Berghmans said that the biggest challenge for the project is "making everything work together" as it is integrated, while also reaching targeted measurement accuracy and speed specifications.

Other institutions helping to design, fabricate and test the system are micro- and nanoelectronics research center IMEC in Leuven, Ghent University, Aston University in the UK, Wroclaw University of Technology and Marie Curie-Sklodowska University in Poland, and Cyprus University of Technology in Cyprus.

The project has an end date of March 31, 2011. PHOSFOS will conclude with two proof-of-concept demonstrators. The first will consist of a multiplexed array of Bragg gratings in silica microstructured fibers for a structural-integrity monitoring application, which is the focus of Fibre Optic Sensors and Sensing Systems BV (FOS&S), one of two businesses partnering in the project.

Decisions about sensor density and whether the Bragg grating array will be multiplexed on one or several fibers will largely depend on input from the Industrial User Club. "The powering and detection will most likely be separated on a hard board from the actual sensing skin, not to hinder the characterization of the latter," Berghmans said.

The second proof-of-concept, using the polymer microstructured fibers, targets a health care application, the focus of the second company partner, UK-based Astasense Ltd. The system will take advantage of the flexibility and safety of the polymer optical fiber. "A prime candidate application would be for a flexible garment enabling monitoring of respiration, cardiac activity or pressure on a patient in bed," Berghmans said.

Businesses interested in possibly gaining access to the technologies PHOSFOS develops are being asked to join its Industrial Users Club via the www.phosfos.org Web site.

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