0.04 cm^2, consisted of a tin phthalocyanine (SnPc)-based bulk heterostructure layer as a near-IR (NIR) sensitizer and an iridium-doped biphenyl OLED layer as a phosphorescent emitter—one of the most efficient OLED materials in use today. In photovoltaic mode, the EQE of the NIR sensitizer layer can be higher than 20%, while the EQE for the OLED emitter layer is close to 20% (compared to typical EQE values of less than 5% for most conventional fluorescent OLEDs).

In the absence of IR radiation, the poor-hole-transport NIR sensitizer keeps the OLED layer in the off state. But upon photoexcitation, photogenerated holes are injected into the OLED layer and recombine with electrons injected from a cathode layer to emit visible light. The 100 nm thick NIR sensitizer layer or film has strong NIR absorption up to 1000 nm, with a peak at 740 nm. Using an 830 nm, 14.1 mW/cm^2 NIR source, green light emission began at 2.7 V and reached a luminance of 853 cd/m^2 at 15 V. At 12.7 V, the on/off ratio of luminescence intensity was about 1400 (see figure).

Even though maximum photon-to-photon conversion efficiency was only 2.7% for this device, the researchers say that this value represents an order-of-magnitude increase compared to conventional (and more expensive and complicated) hybrid organic/inorganic devices. "Since OLEDs are being used for flat-panel displays, the costs of making these organic devices are expected to be low because they can use the existing OLED manufacturing infrastructure," says Franky So, associate professor of materials science and engineering at the University of Florida.—*Gail Overton*

REFERENCE

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MICROSTRUCTURED FIBER

Fiber-sensor technology is thin-skinned but robust

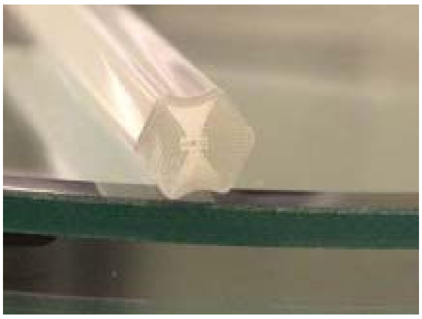
Progress continues apace for a European project aiming to create a fully integrated photonic sensing "skin" that can be used anywhere that requires close monitoring of mechanical properties. The three-year European Commission-funded project, known as "photonic skins for optical sensing" (PHOSFOS), has now perfected its fiber-production methods and has its sights set largely on medical applications.

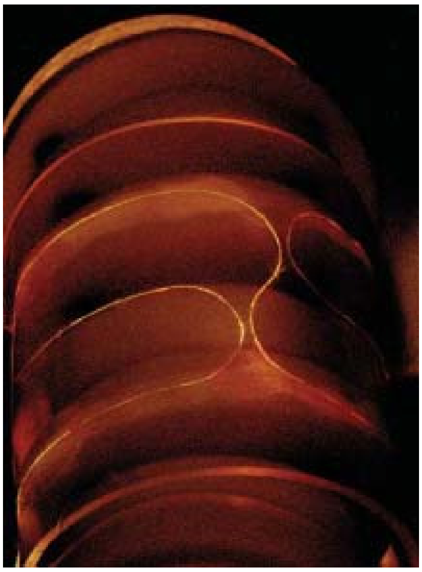
The 2.5-million-Euro PHOSFOS project is being led by Francis Berghmans of the Free University Brussels in Belgium, in collaboration with a number of European universities and the nanotechnology firm IMEC (Leuven, Belgium). At the project's heart is the use of fiber Bragg gratings created in silica fibers, microstructured fibers, or exotic plastic optical fibers. Those in turn are to be embedded in a thin foil or skin which the team envisions could be put to uses ranging from dentistry to civil engineering.

Key to the whole enterprise, Berghmans says, is the integration of the elements—the ability to integrate the optical sensing functionality with on-board signal processing, a power source, and even wireless communication inside the flexible polymer skin. The skin can then be tacked to, wrapped around, or built into any shape the application requires.

"There are other ways to do it but not in such an integrated manner," he says. "You're getting your complete system inside a flexible material that can be attached to anything you would like. It's applicable in many different cases, whether you're thinking of medical applications or of structural health monitoring—since everything is embedded and comes in a single system, you're not limited."

The idea for PHOSFOS came from a longstanding collaboration. "We were working with microstructured fibers and had collaborations with the University of Ghent and IMEC," Berghmans says. "They had the microsystems technology, thinning diodes down until they were flexible. We said it would be great if we could combine everything to achieve these fully fledged integrated sensor systems."





A PHOSFOS photonic-crystal fiber (shown here as a preform) will be patterned with Bragg gratings and be embedded in a flexible polymer skin for sensing (top). An experimental polymer skin, illuminated with a supercontinuum source, is wrapped around a surface to be monitored (bottom). (*Courtesy of Vrije Universiteit Brussel*)

Insensitive to temperature

But making fiber Bragg gratings in a number of types of fibers while maintaining optical performance wasn't—and still isn't—a straightforward business. One principal problem was limiting the temperature sensitivity of the photonic skins; they should measure the same mechanical properties regardless of the ambient temperature. Berghmans is somewhat guarded about the secret but says that the team now has fibers with a temperature sensitivity so low as to be unmeasurable.

"You have to take advantage of the thermal properties of the polymer fiber; normally these things are quite sensitive to temperature, but if you thermally treat them in a proper way, you can achieve writing multiplex gratings."

Most recently, the team pulled off a landmark result: fiber Bragg gratings with features smaller than ever before, made point by point with an ultrafast near-IR laser.[1] Each period of the grating is made with a single pulse, and the grating is built up by translating the fiber through the focused spot. The team's method is simple—their optical setup doesn't even attempt to account for the curvature of the fiber, for instance—so it bodes well for large-scale manufacturing in the future.

For now, the team is working to make the production of the fibers reliable and repeatable. The European-funded part of the project finishes early next year and potential uses for the skins are already mounting up.

"The killer applications are definitely in the medical field," Berghmans notes. "We're now working toward a demonstrator for respiratory monitoring, and there's another project in artificial limbs or 'smart prosthetics.'"—*Jason Palmer*

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1. T. Geernaert et al., *Opt. Lett. 35*, p. 1647 (2010).