New kind of optical fiber developed

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Credit: Gonzalo Pineda Zuniga

(PhysOrg.com) -- A team of scientists led by John Badding, a professor of chemistry at Penn State University, has developed the very first optical fiber made with a core of zinc selenide -- a light-yellow compound that can be used as a semiconductor. The new class of optical fiber, which allows for a more effective and liberal manipulation of light, promises to open the door to more versatile laser-radar technology. Such technology could be applied to the development of improved surgical and medical lasers, better countermeasure lasers used by the military, and superior environment-sensing lasers such as those used to measure pollutants and to detect the dissemination of bioterrorist chemical agents. The team's research will be published in the journal *Advanced Materials*.

"It has become almost a cliché to say that optical fibers are the cornerstone of the modern information age," said Badding. "These long, thin fibers, which are three times as thick as a human hair, can transmit over a terabyte -- the equivalent of 250 DVDs -- of information per second. Still, there always are ways to improve on existing technology." Badding explained that optical-fiber technology always has been limited by the use of a glass core. "Glass has a haphazard arrangement of atoms," Badding said. "In contrast, a crystalline substance like zinc selenide is highly ordered. That order allows light to be transported over longer wavelengths, specifically those in the mid-infrared."

Unlike silica glass, which traditionally is used in optical fibers, zinc selenide is a compound semiconductor. "We've known for a long time that zinc selenide is a useful compound, capable of manipulating light in ways that silica can't," Badding said. "The trick was to get this compound into a fiber structure, something that had never been done before." Using an innovative high-pressure chemical-deposition technique developed by Justin Sparks, a graduate student in the Department of Chemistry, Badding and his team deposited zinc selenide waveguiding cores inside of silica glass capillaries to form the new class of optical fibers. "The high-pressure deposition is unique in allowing formation of such long, thin, zinc selenide fiber cores in a very confined space," Badding said.

The scientists found that the optical fibers made of zinc selenide could be useful in two ways. First, they observed that the new fibers were more efficient at converting light from one color to another. "When traditional optical fibers are used for signs, displays, and art, it's not always possible to get the colors you want," Badding explained. "Zinc selenide, using a process called nonlinear frequency conversion, is more capable of changing colors."

Second, as Badding and his team expected, they found that the new class of fiber provided more versatility not just in the visible spectrum, but also in the infrared -- electromagnetic radiation with wavelengths longer than those of visible light. Existing optical-fiber technology is inefficient at transmitting infrared light. However, the zinc selenide optical fibers that Badding's team developed are able to transmit the longer wavelengths of infrared light. "Exploiting these wavelengths is exciting because it represents a step toward making fibers that can serve as infrared lasers," Badding explained. "For example, the military currently uses laser-radar technology that can handle the near-infrared, or 2 to 2.5-micron range. A device capable of handling the mid-infrared, or over 5-micron range would be more accurate. The fibers we created can transmit wavelengths of up to 15 microns."

Badding also explained that the detection of pollutants and environmental toxins could be yet another application of better laser-radar technology capable of interacting with light of longer wavelengths. "Different molecules absorb light of different wavelengths; for example, water absorbs, or stops, light at the wavelengths of 2.6 microns," Badding said. "But the molecules of certain pollutants or other toxic substances may absorb light of much longer wavelengths. If we can transport light over longer wavelengths through the atmosphere, we can see what substances are out there much more clearly." In addition, Badding mentioned that zinc selenide optical fibers also may open new avenues of research that could improve laser-assisted surgical techniques, such as corrective eye surgery.

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