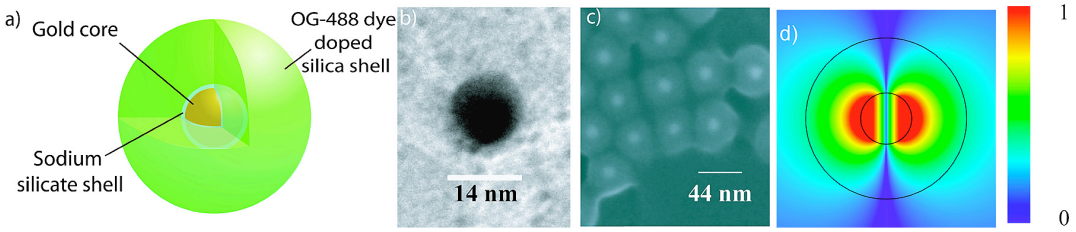
Nanoscale 'Spaser' Brings Promise of Optical Computing

Editor's Note: Tiny lasers are very cool, and harnessing surface plasmons for something other than sensors is even cooler. Besides, beyond optical computers, how else would microbots be able to shoot at stuff?



WEST LAFAYETTE, Ind. (Purdue [1]) - Researchers have created the tiniest laser since its invention nearly 50 years ago, paving the way for a host of innovations, including superfast computers that use light instead of electrons to process information, advanced sensors and imaging.

Because the new device, called a "spaser," is the first of its kind to emit visible light, it represents a critical component for possible future technologies based on "nanophotonic" circuitry, said Vladimir Shalaev, the Robert and Anne Burnett Professor of Electrical and Computer Engineering at Purdue University.

Such circuits will require a laser-light source, but current lasers can't be made small enough to integrate them into electronic chips. Now researchers have overcome this obstacle, harnessing clouds of electrons called "surface plasmons," instead of the photons that make up light, to create the tiny spasers.

Findings are detailed in a paper appearing online in the journal Nature that reports on work conducted by researchers at Purdue, Norfolk State University and Cornell University.

Nanophotonics may usher in a host of radical advances, including powerful "hyperlenses" resulting in sensors and microscopes 10 times more powerful than today's and able to see objects as small as DNA; computers and consumer electronics that use light instead of electronic signals to process information; and more efficient solar collectors.

"Here, we have demonstrated the feasibility of the most critical component - the nanolaser - essential for nanophotonics to become a practical technology," Shalaev said.

The "spaser-based nanolasers" created in the research were spheres 44 nanometers, or billionths of a meter, in diameter - more than 1 million could fit inside a red blood cell. The spheres were fabricated at Cornell, with Norfolk State and Purdue performing the optical characterization needed to determine whether the devices behave as lasers.

The findings confirm work by physicists David Bergman at Tel Aviv University and Mark Stockman at Georgia State University, who first proposed the spaser concept in 2003.

"This work represents an important milestone that may prove to be the start of a revolution in nanophotonics, with applications in imaging and sensing at a scale that is much smaller than the wavelength of visible light," said Timothy D. Sands, the Mary Jo and Robert L. Kirk Director of the Birck Nanotechnology Center in Purdue's Discovery Park.

The spasers contain a gold core surrounded by a glasslike shell filled with green dye. When a light was shined on the spheres, plasmons generated by the gold core were amplified by the dye. The plasmons were then converted to photons of visible light, which was emitted as a laser.

Spaser stands for surface plasmon amplification by stimulated emission of radiation. To act like lasers, they require a "feedback system" that causes the surface plasmons to oscillate back and forth so that they gain power and can be emitted as light. Conventional lasers are limited in how small they can be made because this feedback component for photons, called an optical resonator, must be at least half the size of the wavelength of laser light.

The researchers, however, have overcome this hurdle by using not photons but surface plasmons, which enabled them to create a resonator 44 nanometers in diameter, or less than one-tenth the size of the 530-nanometer wavelength emitted by the spaser.

"It's fitting that we have realized a breakthrough in laser technology as we are getting ready to celebrate the 50th anniversary of the invention of the laser," Shalaev said.

The first working laser was demonstrated in 1960.

The research was conducted by Norfolk State researchers Mikhail A. Noginov, Guohua Zhu and Akeisha M. Belgrave; Purdue researchers Reuben M. Bakker, Shalaev and Evgenii E. Narimanov; and Cornell researchers Samantha Stout, Erik Herz, Teeraporn Suteewong and Ulrich B. Wiesner.

Future work may involve creating a spaser-based nanolaser that uses an electrical source instead of a light source, which would make them more practical for computer and electronics applications.

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