Scientists engineer a surface to trap a rainbow

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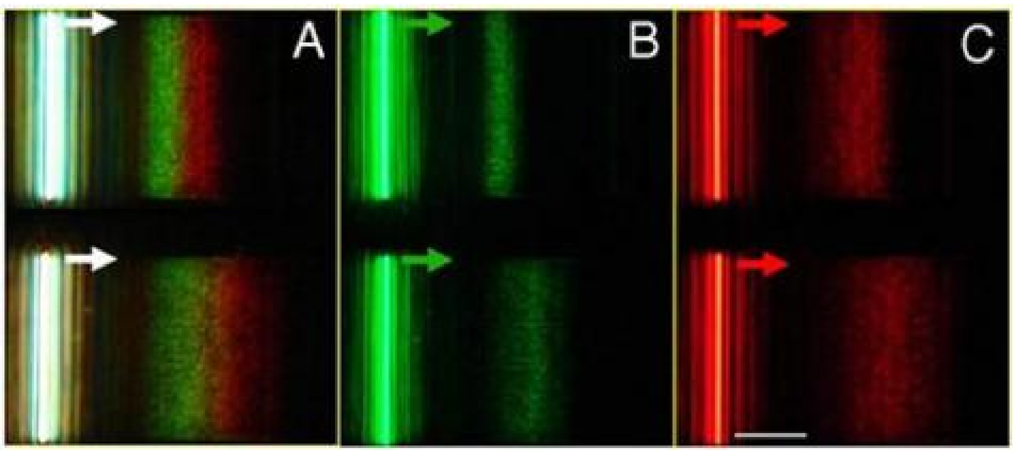


Microscope images of graded gratings with different gradients employing different filters for a, b and c.

(PhysOrg.com) -- The development promises significant improvements in optical data processing and transmission and other technologies.

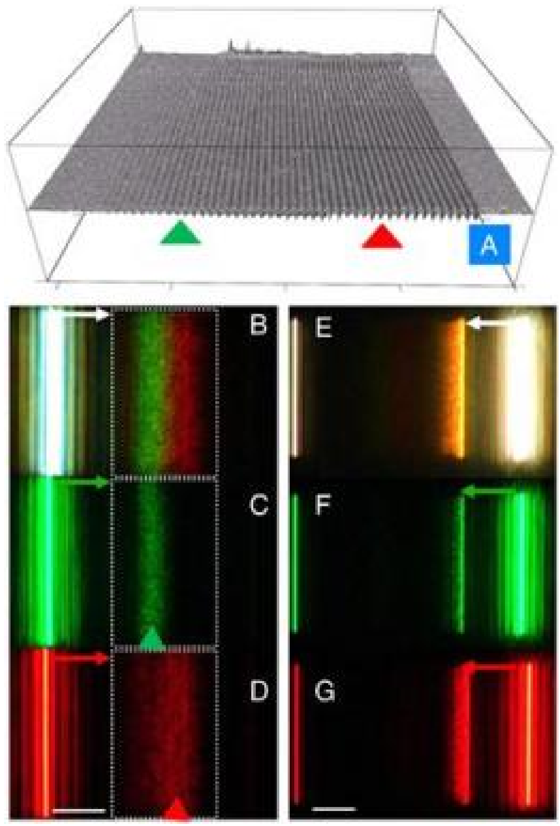
A group of electrical engineers and chemists at Lehigh has experimentally verified the “rainbow” trapping effect, demonstrating that plasmonic structures can slow down light waves over a broad range of wavelengths.

The results of the study, says Qiaoqiang Gan, hold promise for significant improvements in the processing and transmission capacity of optical data, and also in data storage, solar cells, biosensors and other technologies. Gan earned a Ph.D. in electrical engineering from Lehigh in 2010 and is now an assistant professor of electrical engineering at the State University of New York in Buffalo.

The Lehigh researchers described their work in an article titled "Experimental verification of the rainbow trapping effect in adiabatic plasmonic gratings," which was published in March by the *Proceedings of the National Academy of Sciences* (*PNAS*), one of the world's most frequently cited multidisciplinary science journals.

Filbert J. Bartoli, department chair and professor of electrical and computer engineering, was principal investigator on the project, which was funded by the National Science Foundation. Gan was lead author on the PNAS article.

The idea that a rainbow of broadband light could be slowed down or stopped using plasmonic structures has only recently been predicted in theoretical studies.



An image of a graded grating obtained with atomic force microscopy. The groove depth (a) increases from approximately 6nm to 100nm. Images b, c and d show emission from the structure with different filters. Images e, f and g are emission images with the SPP modes coupled and propagating in a direction opposite to that for images b, c and d.

Controlling photons, interpreting light signals

While the notion of trapping a rainbow sounds like ad speak, finding ways to control photons—the particles that makes up light—could greatly improve the capacity of data storage systems and speed the processing of optical data.

“At the moment, processing data with optical signals is limited by how quickly the signal can be interpreted,” Gan said. “If the signal can be slowed, more information could be processed without overloading the system."

The Lehigh group used focused ion beams to mill a series of increasingly deeper, nanosized grooves into a thin sheet of silver. This technique, called Surface Dispersion Engineering, alters the optical properties of a metallic surface.

By focusing light along this plasmonic structure, the series of grooves, or nano-gratings, slowed each wavelength of optical light. The individual colors of the visible spectrum were captured at different groove depths along the grating, resulting in a trapped rainbow of light.

Through direct optical measurements, the team showed that wavelengths of light in the 500-700nm region were "trapped" at different positions along the grating, consistent with computer simulations.

"Metamaterials, which are man-made materials with feature sizes smaller than the wavelength of light, offer novel applications in nanophotonics, photovoltaic devices, and biosensors on a chip," says Bartoli.

"Creating such nanoscale patterns on a metal film allows us to control and manipulate light propogation. The findings of this paper present an unambiguous experimental demonstration of rainbow trapping in plasmonic nanostructures."

"This technology for slowing light at room temperature can be integrated with other materials and components, which could lead to novel platforms for optical circuits," says Gan. "The ability of surface plasmons to concentrate light within nanoscale dimensions makes them very promising for the development of biosensors on chip and the study of nonlinear optical interactions."

The *PNAS* article was coauthored by other members of the Lehigh group: Yujie J. Ding, professor of electrical and computer engineering; Dmitri Vezenov, associate professor of chemistry; and graduate students Yongkang Gao and Kyle Wagner.

More information: Experimental verification of the rainbow trapping effect in adiabatic plasmonic gratings, doi: 10.1073/pnas.1014963108

Provided by Lehigh University