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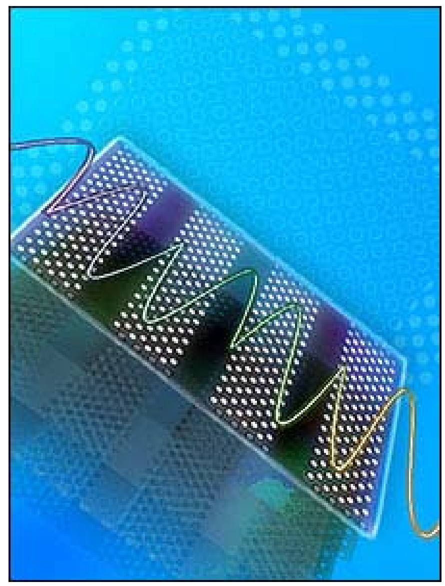
Light Propagation Controlled in Photonic Chips

New York, N.Y., July 11, 2011 — In what is being touted as a major breakthrough in the field of telecommunications, scientists built optical nanostructures that can slow down photons and fully control light dispersion. They showed that it is possible for light to propagate from point A to point B without accumulating any phase, spreading through the artificial medium as if the medium is completely missing in space. This is the first time simultaneous phase and zero-index observations have been made on the chip-scale and at the infrared wavelength.



The nanofabricated superlattices consist of alternating stacks of negative index photonic crystals and positive index homogeneous dielectric media have zero phase delay despite the varying physical path. (Image: Nicoletta Barolini)

“We’re very excited about this. We’ve engineered and observed a metamaterial with zero refractive index,” said Serdar Kocaman who led the study with Chee Wei Wong, both at Columbia University's Fu Foundation School of Engineering and Applied Science. “What we’ve seen is that the light disperses through the material as if the entire space is missing. The oscillatory phase of the electromagnetic wave doesn’t even advance such as in a vacuum — this is what we term a zero-phase delay.”

This exact control of optical phase is based on a unique combination of negative and positive refractive indices. All natural known materials have a positive refractive index. By sculpturing these artificial subwavelength nanostructures, the researchers were able to control the light dispersion so that a negative refractive index appeared in the medium. They then cascaded the negative index medium with a positive refractive index medium so that the complete nanostructure behaved as one with an index of refraction of zero.

“Phase control of photons is really important,” said Wong. “This is a big step forward in figuring out how to carry information on photonic chips without losing control of the phase of the light.”

“We can now control the flow of light, the fastest thing known to us,” Wong said. “This can enable self-focusing light beams, highly directive antennas, and even potentially an approach to cloak or hide objects, at least in the small-scale or a narrow band of frequencies currently.”

This research was supported by grants from the National Science Foundation and the Defense Advanced Research Projects Agency and was conducted in collaboration with scientists at the University College of London, Brookhaven National Laboratory and the Institute of Microelectronics of Singapore.

For more information, visit: www.engineering.columbia.edu

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