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Researchers develop scalable methods for manufacturing metamaterials

April 18 2014, by Alan Flurry

(Phys.org) —Metamaterials, or materials that have had their matter rearranged so they interact with light in specific ways, could be key to making everything from super lenses for satellite surveillance to biosensors that can detect Alzheimer's disease—if they weren't so expensive to fabricate. A one-millimeter-square sample can take up to two weeks to produce.

University of Georgia researchers led by Yiping Zhao recently published three papers documenting a simple method to fabricate metamaterials that could lead to industrial-scale production. The first two studies appeared in the journal *Nano Letters* and the third in the March issue of *Advanced Optical Materials*.

Zhao is a professor in the Franklin College of Arts and Sciences department of physics and astronomy and director of the Nanoscale Science and Engineering Center. His co-authors on the studies were research assistants George Larsen, Yizhuo He and Whitney Ingram.

"What we do in the lab is try to think about simple, scalable methods," said Larsen, who along with He is supported by the National Science Foundation. Ingram is an Alfred P. Sloan Foundation Minority Ph.D. Scholar and a Southern Regional Educational Board State Doctoral Scholar. "Metamaterials depend on good optical properties and precise arrangements, so our work interfaces with nanotechnology and microtechnology because we design these structures smaller than the wavelength of light."

Most materials in nature take their properties from the atoms of which they are made-we can see through glass because it is made from silicon dioxide, which has an atomic structure that does not impede visible light. Scientists can arrange matter to interact differently with light, or to interact in specific ways. The resulting metamaterials take their properties both from their structure and the materials from which they are made.

A specific class of metamaterials, known as chiral metamaterials, represents an opportunity to design structures that interact with polarized light, holding all manner of possibility for new methods for sensing and detection on the molecular level. Chirality, or the lack of mirror image symmetry, is a hallmark of living systems and represents one of the unsolved mysteries in science.

"Conventional techniques for the detection of biomolecules are only sensitive to their presence, not their handedness," Larsen explained. "This is a major limitation because biomolecules that are identical but have opposite handedness can have vastly different effects on the body. For example, naproxen occurs in both right- and left-hand forms—one form reduces arthritic inflammation, while the other is a liver poison."

The team has combined a technique called SERS (Surface-enhanced Raman spectroscopy) with chiral metamaterials to develop a sensor for biomolecular structure previously not available.

"All biological systems function on this idea of structure, whether they're left-handed or right-handed," Zhao said. "So, to be able to determine not just what they're made of but their structure could be very beneficial for rapidly detecting diseases and pathogens, with major implications for biomedicine."

The team's goal all along was to develop cheap, more easily available methods for fabrication.

"The idea is to fabricate metamaterials using the methods that we have, which should be easily translated out of the lab into industry," Zhao said, "and to become more potentially useful in conventional manufacturing."

More information: Yizhuo He, George K. Larsen, Whitney Ingram, and Yiping Zhao. "Tunable Three-Dimensional Helically Stacked Plasmonic Layers on Nanosphere Monolayers." *Nano Letters* 2014 14 (4), 1976-1981. DOI: 10.1021/nl404823z

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Provided by University of Georgia