Physicist developing, improving designer optical materials

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Costas Soukoulis of Iowa State University and the Ames Laboratory is studying and developing metamaterials. The exotic, artificially created materials provide optical properties not found in natural materials. Credit: Photo by Ames Laboratory.

Advancements in fabrication technologies may lead to superlenses and other designer optical materials, according to an Iowa State University and Ames Laboratory physicist.

In an article titled "Improving Metamaterials" published in the Perspectives section of the Dec. 17 issue of the journal *Science*, Costas Soukoulis and Martin Wegener write about the man-made materials designed to deliver certain properties not found in nature.

Soukoulis is an Iowa State University Distinguished Professor and

Frances M. Craig Professor of Physics and Astronomy and a senior scientist for the U.S. Department of Energy's Ames Laboratory who collaborates with the University of Crete in Greece and with the Institute of Electronic Structure and Laser at the Foundation for Research and Technology – Hellas, Greece. Wegener is the group leader for the Institute of Applied Physics at the Karlsruhe Institute of Technology in Karlsruhe, Germany.

Metamaterials, sometimes called left-handed materials, are exotic, artificially created materials that provide optical properties not found in natural materials. Metamaterials are able to refract light to the left, or at a negative angle. Natural materials can't do this.

"This backward-bending characteristic provides scientists the ability to control light similar to the way they use semiconductors to control electricity, which opens a wide range of potential applications," Soukoulis said.

One possibility is using metamaterials to develop a flat superlens that operates in the visible light spectrum.

"Such a lens would offer superior resolution over conventional technology, capturing details much smaller than one wavelength of light to vastly improve imaging for materials or biomedical applications," Soukoulis said. "A metamaterial superlens could give researchers the power to see inside a human cell or observe DNA."

The *Science* article by Soukoulis and Wegener describes the development of optical metamaterials from thin films to 3-D nanostructures. They also describe the challenges of further, practical development of the new materials.

"First, the structures must be tiny and are therefore difficult and expensive to produce," Soukoulis said. "Optical metamaterials also absorb light, making it difficult to create a metamaterial superlens."

But Soukoulis and Wegener offer some hope in their paper. They say experiments have demonstrated optical metamaterials can operate within the visible light spectrum, 3-D optical metamaterials can be produced and light loss in metamaterials can be reduced.

They wrote the ideal optical metamaterial requires all three properties. Wrapping them all into one new metamaterial will take more research and development. And then, researchers will need to find ways to reduce the cost of production.

But, wrote Soukoulis and Wegener, the introduction of advanced fabrication techniques to metamaterials research "may lead to realization of such designer materials."

Provided by Iowa State University