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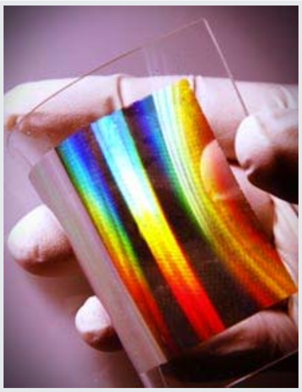

Light warp: This is the largest sheet ever made of a metamaterial that can bend near-infrared light backwards.
Credit: John Rogers

COMPUTING

A Practical Way to Make Invisibility Cloaks

With a new printing technique, researchers can now make enough metamaterials to begin fabricating invisibility cloaks and superlenses.

FRIDAY, JUNE 10, 2011 | BY KATHERINE BOURZAC

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A new printing method makes it possible to produce large sheets of metamaterials, a new class of materials designed to interact with light in ways no natural materials can. For several years, researchers working on these materials have promised invisibility cloaks, ultrahigh-resolution "superlenses," and other exotic optical devices straight from the pages of science fiction. But the materials were confined to small lab demonstrations because there was no way to make them in large enough quantities to demonstrate a practical device.

"Everyone has, perhaps conveniently, been in the position of not being able to make enough [metamaterial] to do anything with it," says John Rogers, a professor of materials science and engineering at the University of Illinois at Urbana-Champaign, who developed the new printing method. Metamaterials that interact with visible light have previously not been made in pieces larger than hundreds of micrometers.

Metamaterials are made up of intricately patterned layers, often of metals. The patterns must be on the same scale as the wavelength of the light they're designed to interact with. In the case of visible and near-infrared light, this means features on the nanoscale. Researchers have been making these materials with such time-consuming methods as electron-beam lithography.

Rogers has developed a stamp-based printing method for generating large pieces of one of the most promising types of metamaterial, which can make near-infrared light bend the "wrong" way when it passes through. Materials with this so-called negative index of refraction are particularly promising for making superlenses, night-vision invisibility cloaks, and sophisticated waveguides for telecommunications.

The Illinois group starts by molding a hard plastic stamp that's covered with a raised fishnet pattern. The stamp is then placed in an evaporation chamber and coated with a sacrificial layer, followed by alternating layers of the metamaterial ingredients—silver and magnesium fluoride—to form a layered mesh on the stamp. The stamp is then placed on a sheet of glass or flexible plastic and the sacrificial layer is etched away, transferring the patterned metal to the surface. So far Rogers says he's made metamaterial sheets a few inches per side, but by using more than one stamp he expects to increase that to square feet. And,

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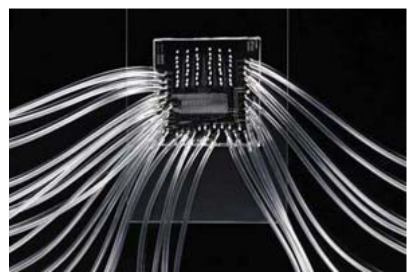

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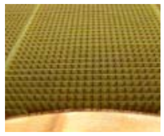

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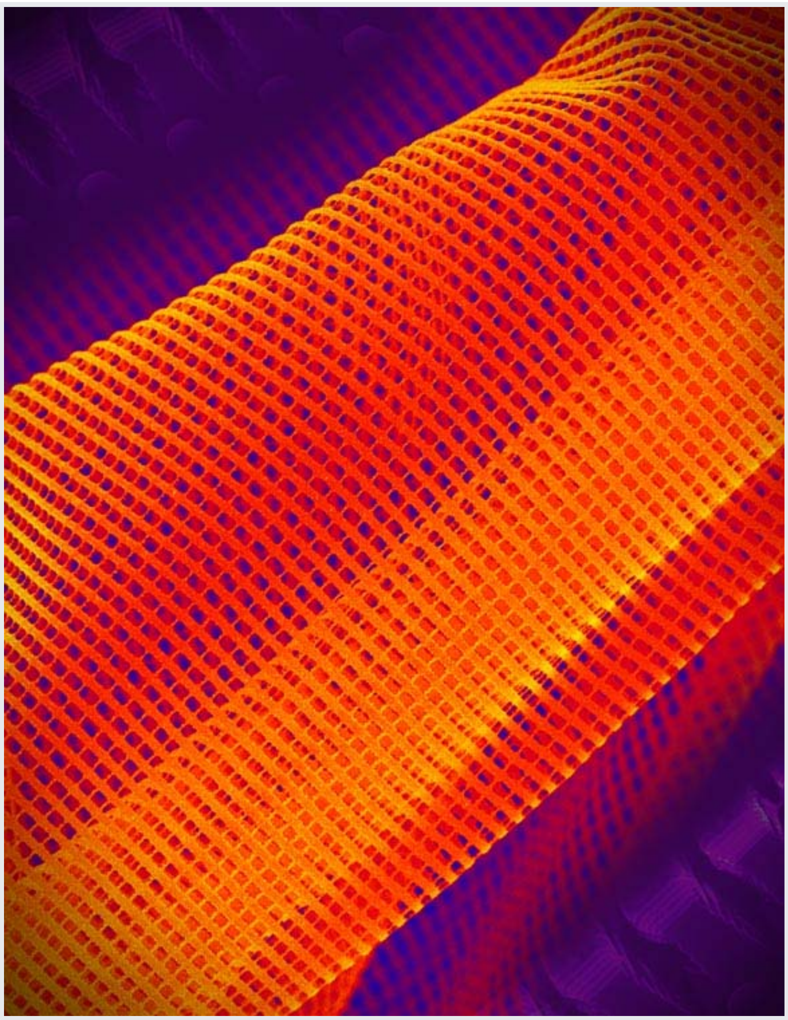

Light mesh: The large-area metamaterial is made up of a layered mesh of metals patterned on the nanoscale.
Credit: John Rogers

"We can now bang out gigantic sheets of this stuff," Rogers says. Making the mold for the stamp takes care, but once that mold has been created, it doesn't take long to make many reusable stamps.

Xiang Zhang, chair of mechanical engineering at the University of California, Berkeley, says this work represents an important step toward applications for optical metamaterials. "Various metamaterials could be made bigger by this method," says Zhang, who in 2008 created the design that Rogers used for this first demonstration. "For example, macroscale 2-D lenses and cloaks may be possible, and possibly solar concentrators, too." One potential application is in lenses that integrate multiple functions in single devices, for telecommunications and imaging.

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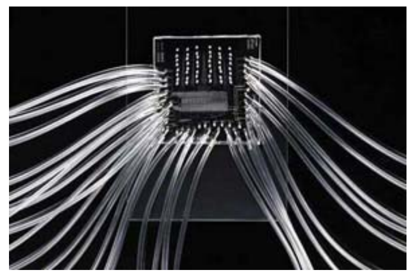

Separating Chromosomes

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"This printing technique is quite powerful and has the potential to scale to very large areas," says Nicholas Fang, an associate professor of mechanical engineering at MIT. Fang says this type of metamaterial would be particularly interesting for infrared imaging devices.

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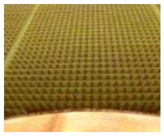

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