Full 3-D invisibility cloak in visible light

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Watching things disappear "is an amazing experience," admits Joachim Fischer of the Karlsruhe Institute of Technology in Germany. But making items vanish is not the reason he creates invisibility cloaks. Rather, the magic-like tricks are attractive demonstrations of the fantastic capabilities that new optical theories and nanotechnology construction methods now enable.

This new area, called “transformation optics” has turned modern optical design on its ear by showing how to manipulate light in ways long thought to be impossible. They promise to improve dramatically such light-based technologies as microscopes, lenses, chip manufacturing and data communications.

In his talk at this year's Conference on Lasers and Electro Optics (CLEO: 2011, May 1 - 6 in Baltimore), Fischer will describe the first-ever demonstration of a three-dimensional invisibility cloak that works for visible light—red light at a wavelength of 700 nm—independent of its polarization (orientation). Previous cloaks required longer wavelength light, such as microwaves or infrared, or required the light to have a single, specific polarization.

Fischer makes the tiny cloak—less than half the cross-section of a human-hair—by direct laser writing (i.e. lithography) into a polymer material to create an intricate structure that resembles a miniature woodpile. The precisely varying thickness of the “logs” enables the cloak to bend light in new ways. The key to this achievement was incorporating several aspects of a diffraction-unlimited microscopy technique into the team's 3-D direct writing process for building the cloak. The dramatically increased resolution of the improved process enabled the team to create log spacings narrow enough to work in red light.

"If, in the future, we can halve again the log spacing of this red cloak, we could make one that would cover the entire visible spectrum," Fischer added.

Practical applications of combining transformation optics with advanced 3-D lithography (a customized version of the fabrication steps used to make microcircuits) include flat, aberration-free lenses that can be easily miniaturized for use in integrated optical chips, and optical "black holes" for concentrating and absorbing light. If the latter can also be made to work for visible light, they will be useful in solar cells, since 90 percent of the Sun's energy reaches Earth as visible and near-infrared light.

More information: Presentation QTuG5 "Three-dimensional invisibility carpet cloak at 700 nm wavelength," by Joachim Fischer et al. is at 11 a.m. Tuesday, May 3. Fischer et al. will also present CML1, "Three-Dimensional Laser Lithography with Conceptually Diffraction-Unlimited Lateral and Axial Resolution," at 10:15 a.m. Monday, May 2.

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