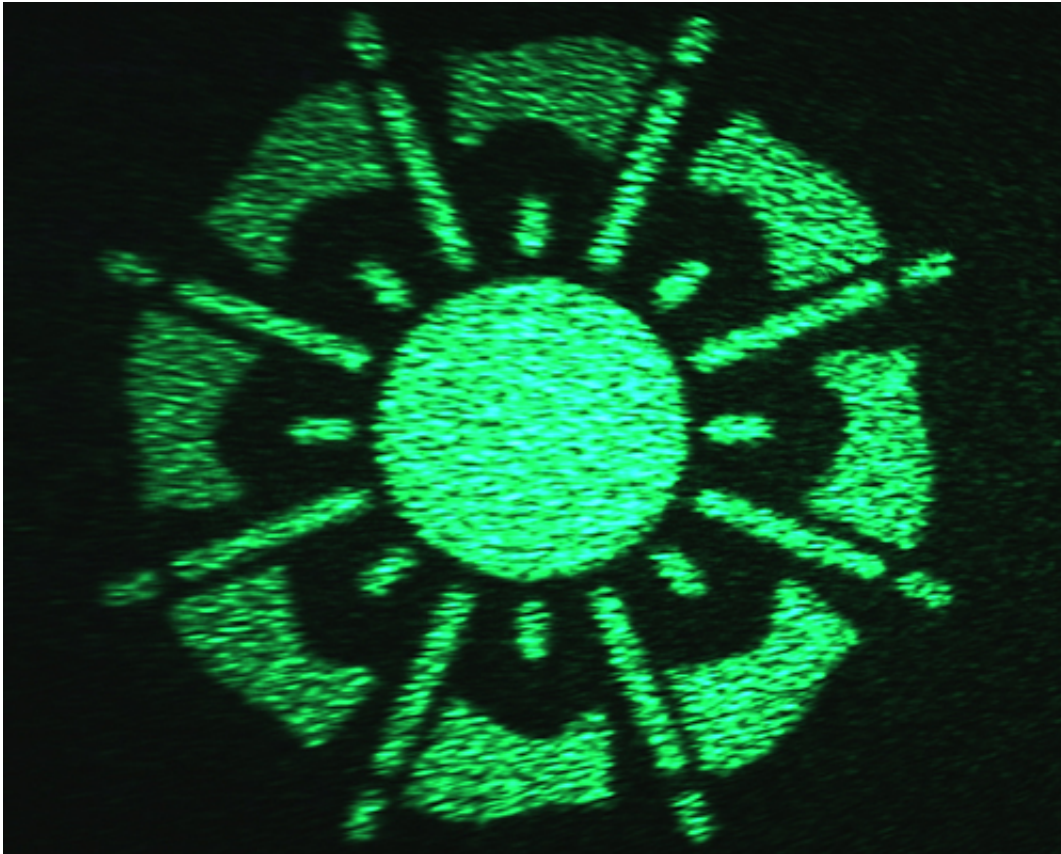


Nanotechnology improves holographic capabilities by encoding light polarization

May 13 2016



New hologram produces 3-D images across different spectrums of light. Credit: Capasso Lab

Holograms are a ubiquitous part of our lives. They are in our wallets—protecting credit cards, cash and driver's licenses from fraud—in grocery store scanners and biomedical devices.

Even though holographic technology has been around for decades, researchers still struggle to make compact holograms more efficient, complex and secure.

Researchers at the Harvard John A. Paulson School of Engineering and Applied Sciences have programmed [polarization](#) into compact holograms. These holograms use nanostructures that are sensitive to polarization (the direction in which light vibrates) to produce different images depending on the polarization of [incident light](#). This advancement, which works across the spectrum of light, may improve anti-fraud holograms as well as those used in entertainment displays.

The research is described in *Science Advances*.

"The novelty in this research is that by using nanotechnology, we've made holograms that are highly efficient, meaning that very little light is lost to create the image," said Federico Capasso, the Robert L. Wallace Professor of Applied Physics and Vinton Hayes Senior Research Fellow in Electrical Engineering and senior author of the paper. "By using incident polarized light, you can see far a crisper image and can store and retrieve more images. Polarization adds another dimension to holograms that can be used to protect against counterfeiting and in applications like displays."



Holograms projected on a white screen while changing the wavelength of light from blue to red. Credit: Capasso Lab

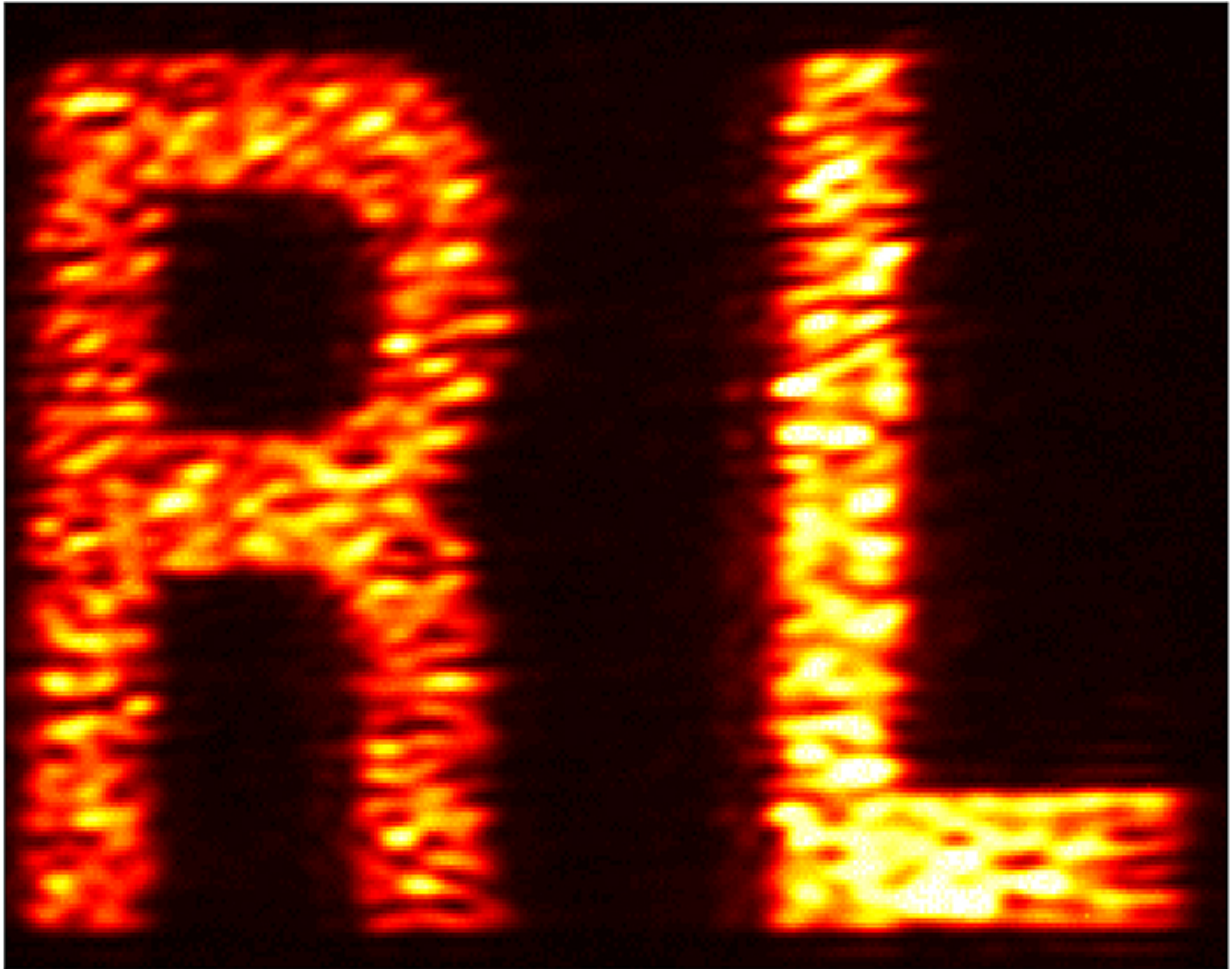
Harvard's Office of Technology Development has filed patents on this and related technologies and is actively pursuing commercial opportunities.

Holograms, like digital photographs, capture a field of light around an object and encode it on a chip. However, photographs only record the intensity of light while holograms also capture the phase of light, which is why holograms appear three-dimensional.

"Our holograms work like any other but the image produced depends on the polarization state of the illuminating light, providing an extra degree of freedom in design for versatile applications," said Mohammadreza Khorasaninejad, postdoctoral fellow in the Capasso Lab and first author of the paper.

There are several states of polarization. In linearly [polarized light](#) the direction of vibration remains constant while in [circularly polarized light](#) it rotates clockwise or counterclockwise. The direction of rotation is the chirality.

The team built silicon nanostructured patterns on a glass substrate, which act as superpixels. Each superpixel responds to a certain polarization state of the incident light. Even more information can be encoded in the hologram by designing and arranging the nanofins to respond differently to the chirality of the polarized incident light.



The same hologram illuminated with different polarizations displays two vastly

different images. Credit: Capasso Lab

"Being able to encode chirality can have important applications in information security such as anti-counterfeiting," said Antonio Ambrosio, a research scientist in the Capasso Lab and co-first author. "For example, chiral holograms can be made to display a sequence of certain images only when illuminated with light of specific polarization not known to the forger."

"By using different nanofin designs in the future, one could store and retrieve far more images by employing [light](#) with many states of polarization," said Capasso.

Because this system is compact, it has application in portable projectors, 3D movies and wearable optics.

"Modern polarization imaging systems require cascading several optical components such as beam splitters, polarizers and wave plates," said Ambrosio. "Our metasurface can distinguish between incident polarization using a single layer dielectric surface."

"We have also incorporated in some of the [holograms](#) a lens function that has allowed us to produce images at large angles," said Khorasaninejad. "This functionality combined with the small footprint and lightweight, has significant potential for wearable optics applications."

More information: "Broadband and chiral binary dielectric meta-holograms," *Science Advances*,
advances.sciencemag.org/content/2/5/e1501258

Provided by Harvard University

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