Multicolor meta-hologram produces light across entire visible spectrum

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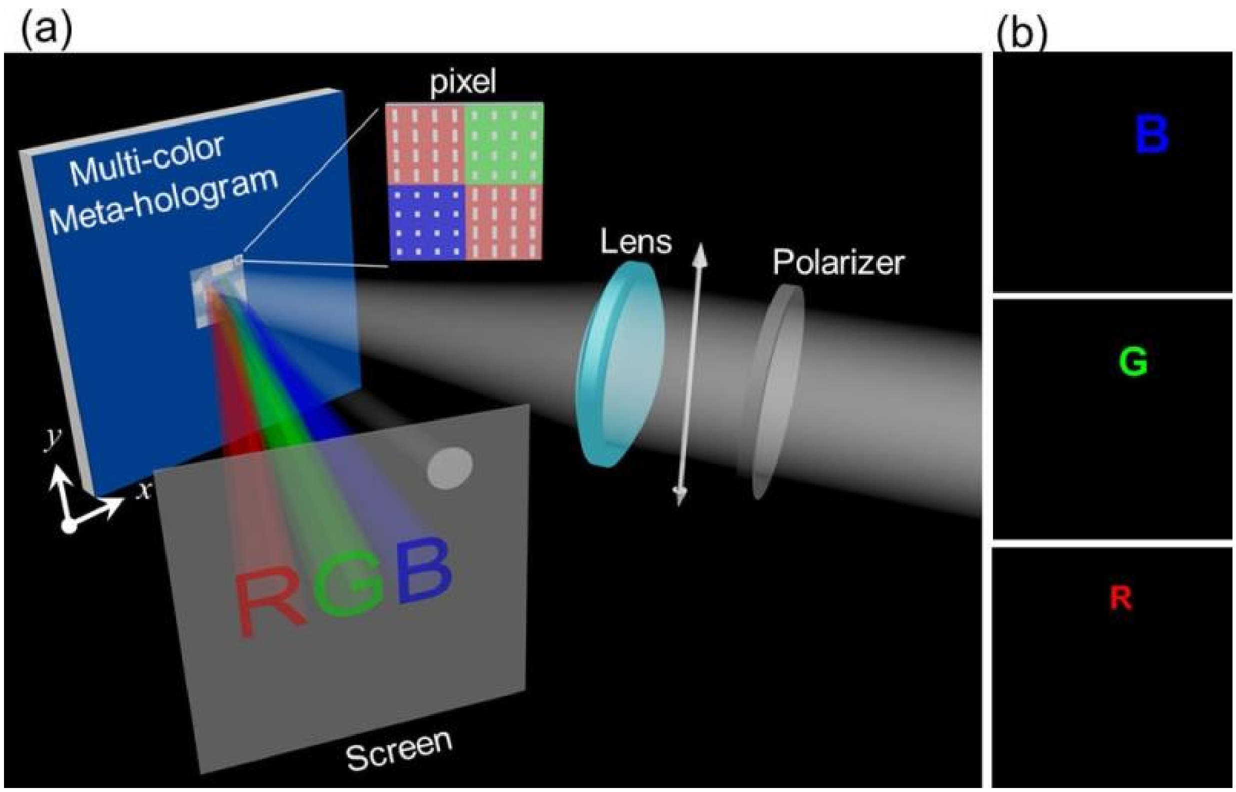

The multicolor meta-hologram is made of a pixel array consisting of aluminum nanorods of different lengths that produce different colors of light. Credit: Huang, et al. ©2015 American Chemical Society

(Phys.org)—There are many different ways to generate a hologram, each with its own advantages and disadvantages. Trying to maximize the advantages, researchers in a new study have designed a hologram made of a metamaterial consisting of aluminum nanorods that can produce light across the entire visible spectrum, and do so in a way that yields brighter images than other methods.

The researchers, led by Din Ping Tsai at National Taiwan University and Academia Sinica, both in Taipei, Taiwan, have published a paper on the new hologram in a recent issue of *Nano Letters*.

As the researchers explain, multicolor holograms have existed for many years and are often used on credit cards and for other security purposes. These "rainbow holograms" mix red, blue, and green light under white light illumination to produce a variety of colors. The main drawback, however, is that a viewer sees different colors depending on the viewing angle, which has limited the applications of these holograms.

More recently, researchers have demonstrated that an alternative way to generate multicolor holograms involves metamaterials—man-made materials composed of repeating patterns of small structures, allowing their optical properties to be tuned. Holograms made of metamaterials are called "meta-holograms."

In general, holograms use either amplitude modulation or phase modulation of light waves to achieve the holographic effect. In the new study, the researchers explain that phase modulation is more desirable because it produces a brighter image. However, so far phase-modulation-based multicolor meta-holograms haven't been successfully achieved. This is because phase modulation with the gold and silver materials that are typically used in meta-holograms simply cannot extend across the entire visible spectrum due to the properties of the gold and silver materials.

In the new paper, the researchers built the metamaterial from nanorods made of aluminum, which does not suffer from the same limitations as gold and silver, and so can produce light across the entire visible spectrum. The new method is the first demonstration of a phase-modulated, full-color meta-hologram made of aluminum nanorods.

The nanorods have different lengths (50 to 150 nm), with longer rods resonating at longer wavelengths of light to produce the full spectrum of colors. The technique can also project different images to different locations on the display surface.

"Compared to the meta-holograms in the literature, our proposed meta-hologram consisting of low-cost and mass-producible aluminum has polarization-switchable and color-multiplexing images that cannot be demonstrated by the widely used metals, such as gold and silver," Tsai told *Phys.org*.

The researchers expect that the technique can be adapted to generate 3D images by using cross nanorods that consist of two sets of perpendicular aluminum rods, each of which produces a single image but with a different polarization. The dual images could have applications in glasses-free 3D imaging and data storage.

"Our future plans aim to enhance the efficiency of the reported meta-hologram and demonstrate a multi-dimensional meta-hologram which is capable of reconstructing polarization-dependent color images on different focal planes," Tsai said.

More information: Yao-Wei Huang, et al. "Aluminum Plasmonic Multicolor Meta-Hologram." *Nano Letters*. DOI: 10.1021/acs.nanolett.5b00184