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Better, bolder printing with silicon nanostructures

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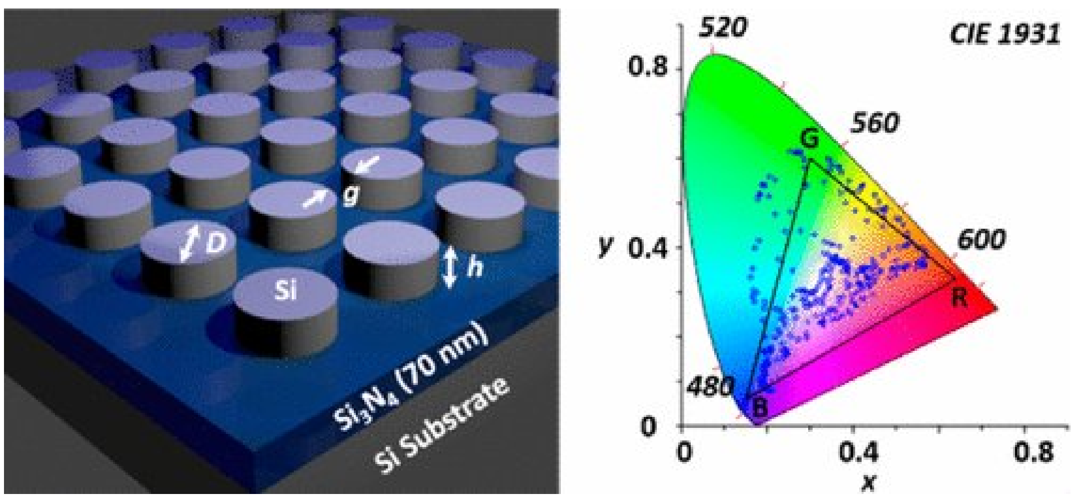

Credit: American Chemical Society

From textbooks to artwork to newspapers, printed items are a part of our everyday life. But the ink used in today's printers are limited in colors and resolution. Now in a new study in ACS' journal *Nano Letters*, scientists have found a way to expand the printable color spectrum with a novel nanostructure system.

The current color range for computers and printers is based on the sRGB (standard Red Green Blue) color space, which was developed in 1996 by Microsoft and Hewlett-Packard. But the hues in the sRGB system only encompass a subset of colors that the human eye can see. Researchers have been trying to develop a better system to surpass sRGB that would broaden the printable color spectrum while maintaining high resolution.

For example, they have used metallic nanostructures for color printing, but this has resulted in either high-resolution images with less-rich colors, or images with vivid colors but lower resolution. Also, the use of metals like silver and gold would likely be too expensive for wide adoption. So researchers have turned to silicon because it has unique properties that might be optimal for expanding computer and printing colors at a lower price. But so far, silicon color systems have shown poor color saturation and range. So Joel Yang and colleagues wanted to design a novel silicon nanostructure that could potentially overcome these limitations and compete with the sRGB system.

The researchers tested differently sized silicon nanodisks, controlling how close the structures were to each other. Once they figured out the optimal disk sizes and distances between them, the team used the nanodisks to print an art piece on silicon coated with an anti-reflective layer consisting of silicon nitride. This anti-reflective coated substrate was important to more closely mimick the color range visible to the human eye. The researchers concluded that the silicon nanostructures expanded the range of printable colors by 121 percent, while maintaining both high color saturation and resolution. The scientists note that although their design still has some limitations that need to be addressed, it has achieved the largest color gamut for printing while maintaining a print resolution better than 40,000 dpi.

More information: Printing Beyond sRGB Color Gamut by Mimicking Silicon Nanostructures in Free-Space, *Nano Lett.*, Article ASAP, DOI: 10.1021/acs.nanolett.7b03613

Abstract
Localized optical resonances in metallic nanostructures have been increasingly used in color printing, demonstrating unprecedented

resolution but limited in color gamut. Here, we introduce a new nanostructure design, which broadens the gamut while retaining print resolution. Instead of metals, silicon nanostructures that exhibit localized magnetic and electric dipole resonances were fabricated on a silicon substrate coated with a Si_3N_4 index matching layer. Index matching allows a suppression of substrate effects, thus enabling Kerker's conditions to be met, that is, sharpened transitions in the reflectance spectra leading to saturated colors. This nanostructure design achieves a color gamut superior to sRGB, and is compatible with CMOS processes. The presented design could enable compact high-resolution color displays and filters, and the use of a Si_3N_4 antireflection coating can be readily extended to designs with nanostructures fabricated using other high-index materials.

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