

# Mirror-like display creates rich color pixels by harnessing ambient light

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Using a simple structure comprising a mirror and an absorbing layer to take advantage of the wave properties of light, researchers at Qualcomm MEMS Technologies, Inc., a subsidiary of Qualcomm Incorporated, have developed a display technology that harnesses natural ambient light to produce an unprecedented range of colors and superior viewing experience. An article describing their innovative approach appears today in The Optical Society's new high-impact journal *Optica*.

This [display](#) technology, which could greatly reduce the amount of power used in multiple consumer electronics products, is the latest version of an established commercial product known as Qualcomm Mirasol. Based on a new color rendering format that the researchers call Continuous Color, the new design helps solve many key problems affecting mobile displays such as how to provide an always-on display function without requiring more frequent battery charging and a high quality viewing experience anywhere, especially in bright outdoor environments.

The innovation was made possible by using a combination of a mirror with a thin absorbing layer separated by a precise and controllable gap. While the mirror by itself would simply reflect all of the incident light energy, the absorbing layer selectively filters out a narrow slice of the spectrum, thus coloring the reflected light. The gap is controlled to produce nearly every conceivable color, not just the red, green, and blue (RGB) of earlier display technologies.

"We have developed an entirely new way of creating a color display," said John Hong, a researcher with Qualcomm MEMS Technologies, Inc. and lead author on the *Optica* paper. "The incredibly efficient display is able to create a rich palette of colors using only ambient light for viewing, much like the way we would read and view printed material."

## Harnessing Ambient Light

Typical color displays are essential yet power-hungry components of virtually every digital product with a human-machine interface, from cell phones and computers to home televisions and massive displays at sporting events. Since even the most energy-efficient models require some form of backlighting, they can quickly draw-down a power supply.

To save on power and extend the life of these devices, engineers have been exploring ways to replace emissive technologies with displays that can reflect [ambient light](#).

Earlier attempts to create reflective light color displays, however, presented a number of vexing problems. The designs required using three separate pixels to produce the red, green and blue of a traditional display. Though adequate for certain applications, the fact that only one-third of the incoming light can be reflected back toward the viewer in a typical reflective RGB format limits the gamut of colors and brightness of the display.

The new display reported in *Optica* is able to overcome these hurdles by reflecting more of the incoming light and enabling the full spectrum of visible light to be displayed, including bright white and deep black.

Hong and his colleagues were able achieve these results by using a property of light they call interferometric absorption to create a broad spectrum of colors. To produce this effect, the researchers designed, in

essence, a two-layer device. The first layer consists of a thin absorbing material that lets most of the light pass through to the second mirror layer where it is reflected back upon itself.

With this design, the incoming light and the reflected light interfere with one another, producing a variety of standing waves with each component periodicity producing a unique color in the spectrum.

By adjusting the distance between the reflective and absorbing layers with tiny actuators known as Micro-Electro-Mechanical Systems (MEMS), the absorbing layer is moved to match a node in the standing wave that corresponds to a desired color. The spectral components not associated with that node are efficiently absorbed, allowing only the desired color to leak through the structure and back toward the viewer. Each pixel therefore behaves as a colored mirror, with the color tunable across the entire visible spectrum.

## **Extending Power and Saving Energy**

Depending on how the display is used, the power savings can exceed current backlit technologies tenfold. The greatest benefit is when a particular image is retained on the display, which then operates like a form of analog memory in a virtually power-free display mode.

The design presented in the paper consists of a panel that is about 1.5 inches across and contains approximately 149,000 pixels. Both the resolution and area of the display, however, can be scaled to match those of various mobile devices such as Internet-of-Things (IoT) enabled wearables and smartphones.

Fabrication can be achieved in one piece, with the MEMS, upper layer, and lower layer created using the same deposition, lithography and etching processes that are used to create liquid crystal displays.

"Our goal is to improve the technology and design so it can be easily integrated into manufacturing processes at existing factories." said Hong. The researchers believe that this technology has the potential to change the smartphone experience and that of other personal devices.

"No more squinting at a hard to read display outdoors where we spend much of our time," noted Hong. "We ultimately hope to create a paper-like viewing experience, which is probably the best display experience that one can expect, with only the [light](#) behind you shining on the page."

**More information:** J. Hon, E. Chan, T. Chang, T. Fung, B. Hong, C. Kim, J. Ma, Y. Pan, R. Van Lier, S. Wang, B. Wen, L. Zhou, "Continuous Color Reflective Displays Using Interferometric Absorption," *Optica*, 2, 7, 589 (2015). [DOI: 10.1364/OPTICA.2.000589](https://doi.org/10.1364/OPTICA.2.000589)

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