Electrochemically Actuated Optical Modulator

VANDERBILT UNIVERSITY
CTTC Center for Technology Transfer & Commercialization

Summary

Vanderbilt University researchers have developed a novel approach for creating dynamic, tunable reflective color displays using an electrochemical modulator. The technology can be implemented into devices requiring low power reflective color displays, such as smart watches and e-readers, and is adaptable for spectral control across a broad spectrum of frequencies from the visible to the far infrared. This technology provides a low power, tunable approach for modulating the optical properties of a material.

Addressed Need

This technology addresses: (1) the high power consumption of traditional display technologies, particularly as it relates to portable devices, and (2) the poor spectral performance achieved by converting low-power e-ink black/white displays to color displays. In addition to color displays, this technology can be scaled to produce low-power, reconfigurable optical filters over a broad range of frequencies—a feature that is not currently possible with other technologies.

Technology Description

The modulator is based on metallic or dielectric optical resonators that are incorporated with a material, graphene, into which ions can be stored. The graphene is placed between the optical resonators and a metallic backplane. The film's color is dictated by an absorption band generated by the optical resonator. Upon electrical biasing, ions are shuttled into the graphene, generating a significant volume increase which increases the spacing between the resonator and metallic backplane. Importantly, modulation of the spacing results in a shift in the absorption band resulting in color tuning. This process results in a bi-stable response which means the color will persist without further energy consumption until the circuit is shorted or current is applied. Furthermore, moving ions into graphene occurs in stages such that the color can be smoothly tuned across the spectrum. The technology can be employed for reflective color modulation from the visible to the far infrared frequency regimes. Lastly, using a mechanism of co-intercalation, the graphene material shows negligible loss of modulation performance over 8000 cycles.

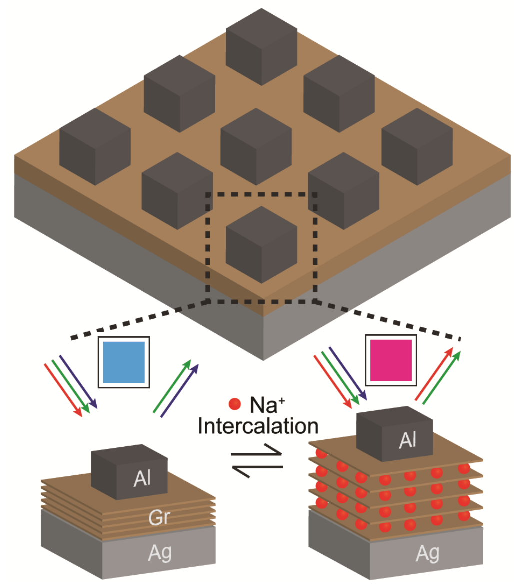

Figure 1: The operational concept of the dynamic reflective color display is shown. Intercalation of Na ions into the multilayer graphene (Gr) sheets results in expansion of the sheets and modulation of the reflected spectrum of the device. The color is changed by varying the separation between the aluminum (Al) resonators and the silver (Ag) backreflector, as shown.

Unique Properties and Applications

- Low power reflective color displays for portable devices with power consumption lower than current black and white e-ink displays and with video refresh rates.
- Tunable optical filters for imaging and sensing with a bandwidth that covers the entire spectrum. The technology can be designed for the visible to long wave infrared bands.
- Coatings with complex and reconfigurable reflective properties.

Technology Development Status

A prototype has been developed and proof of concept has been shown. Additional experiments are under way to demonstrate color purity, spectral tuning range, speed and power consumption.

Intellectual Property Status

A patent application has been filed.

CTTC CONTACT:
Ashok Choudhury, PhD
(615) 322-2503
Ashok.choudhury@vanderbilt.edu

INVENTORS:
Jason Valentine, PhD
Cary Pint, PhD
Zachary Coppens, PhD
Adam Cohn, PhD
Valentine Research Lab
Nanomaterials and Energy Devices Laboratory

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