Electrically switchable structural color using electrowetting on superhydrophobic surface

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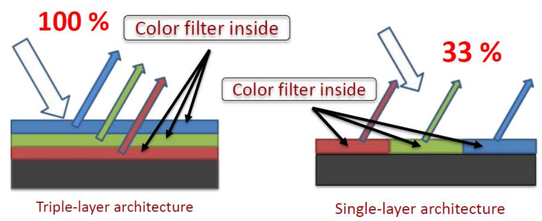
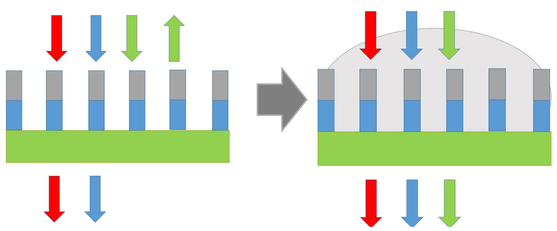
Triple-layer stacked display



Triple-layer Architecture
Ideal efficiency: 100 %
Operations: Colored or Transparent

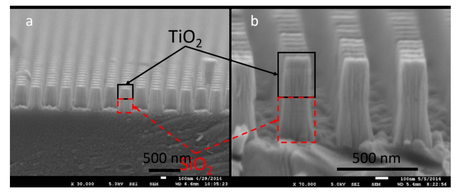


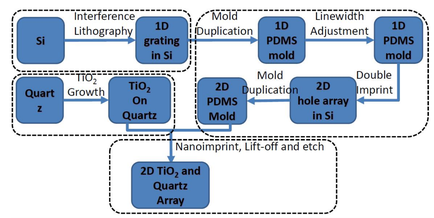
Fabrication process

2-D high contrast gratings:
Top layer: Titanium dioxide
Bottom layer: Silicon dioxide

For electrically switchable needed, a Teflon layer will be spin coated on the top.

Fabricated by interference lithography and nanoimprint lithography.

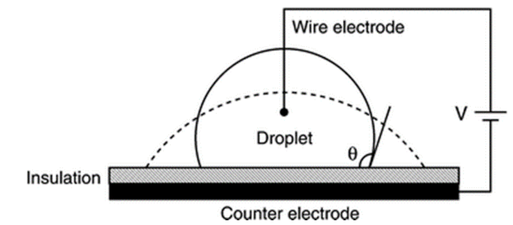




Electrowetting on flat/ patterned surface

Electrowetting: When potential was applied between the droplet and counter electrode, the contact angle will decrease.
A thin dielectric layer is used between droplet and counter electrode to prevent electrolysis.

$$\cos\vartheta = \cos\vartheta_Y + \frac{\varepsilon_0\varepsilon_d}{2d\sigma_{lv}}U^2$$



Due to the 2-D grating structures, the surface become superhydrophobic.

a: Wenzel's model

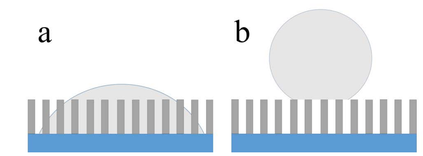
$$\cos\vartheta = r\cdot\cos\vartheta_Y + \frac{C}{2\sigma_{lv}}U^2$$

r: roughness ration

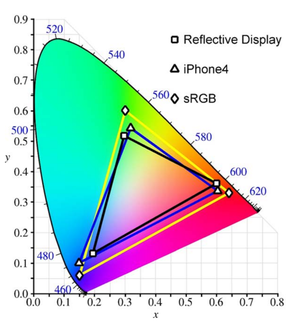
b: Cassie-Baxter's model

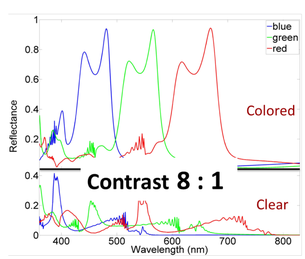
$$\cos\vartheta = f\cdot\cos\vartheta_Y + f - 1 + \frac{C}{2\sigma_{lv}}U^2$$

f: fraction of solid surface

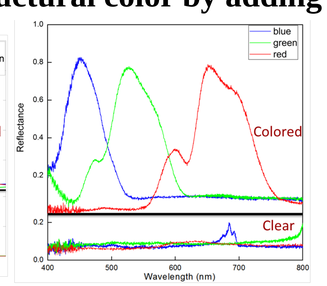


Gamut and Switchable structural color by adding liquid

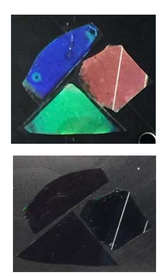




Calculated reflection spectrums



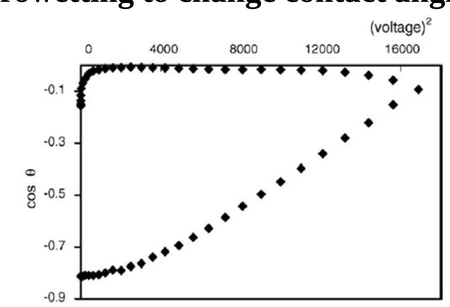
Measured reflection spectrums

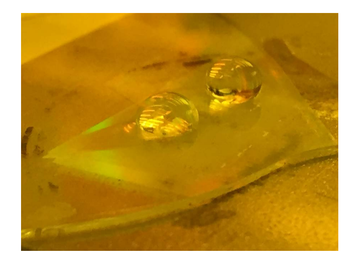


Electrowetting to change contact angle (not enough)

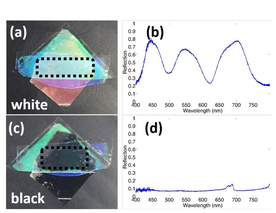
Irreversible for electrowetting on superhydrophobic surface.

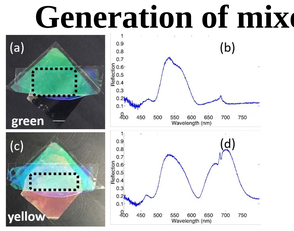
Both Wenzel State and Cassie-Baxter State are stable.

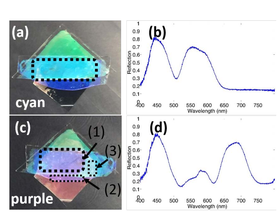




Generation of mixed color







Electrowetting to move liquid (our solution)

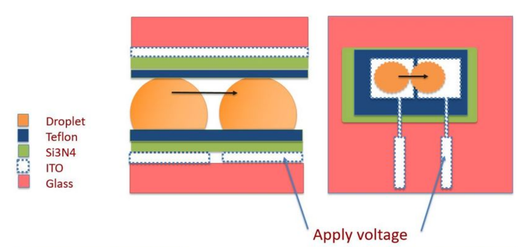
Drive the liquid by a pair of electrodes instead of relying on wetting and dewetting of the superhydrophobic surface.

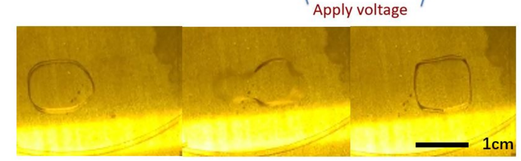
The whole process was achieved within 0.1s.

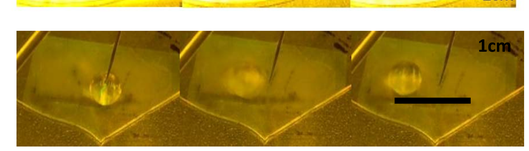
Not only move the droplet back and forth on flat surface, but also realize it moving on superhydrophobic surface.

Successfully achieved droplet moving in centimeter scale, which is much beyond the need for high reflective display in nanoscale.

That proved the feasibility of electrically switchable full color reflective display using electrowetting.







References:

[1] He Liu, Yuanrui Li, Yuhan Yao, Yifei Wang, and Wei Wu. Full color reflective display based on high contrast gratings. EIPBN 2016.
[2] He Liu, Hao Yang, Yuanrui Li, Yifei Wang, Haneol Lim†, Jongseung Yoon†, Wei Wu. Switchable and Stackable Color Filters for a Transparent Full-color Reflective Display.
[3] He Liu, Yuhan Yao, Yifei Wang, and Wei Wu. Full-color reflective display system based on high contrast gratings. Journal of Vacuum Science & Technology B, Nanotechnology and Microelectronics: Materials, Processing, Measurement, and Phenomena,2014.

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