



### Hyper-reflective cholesteric liquid crystal fabricated using surface-initiated photopolymerization

Cholesteric liquid crystals (CLCs) are promising candidates for a variety of photonic applications because they selectively reflect incident radiation. The central wavelength of the Bragg reflection is a function of the helical pitch, which can typically be controlled by a chiral dopant. A key limitation of a single CLC film is a maximum reflectivity of 50% due to the circular polarization of the reflection, which matches the handedness of the CLC's helical structure. Increased reflectivity can be achieved with designs employing multiple CLC cells but such devices suffer drawbacks related to the increased number of interfaces. Fabrication approaches of so-called hyper-reflective CLC devices, which simultaneously reflect both right- and left-handed (RH and LH) circularly polarized light from a single film, have heretofore relied on local differences in handedness in the film's  $x$ - $y$  plane (where the pitch axis is in the  $z$ -direction). Resulting devices exhibit >50% reflectivity at a fixed wavelength. Now, T.J. Bunning, T.J. White, and co-researchers at Wright-Patterson Air Force Base have fabricated hyper-reflective CLC films where spatial segregation of LH and RH domains is in the  $z$ -direction—through the cell thickness. In addition, the researchers incorporated photosensitive liquid crystals to create dynamically induced hyper-reflective cells.

As reported recently in *Chemical Communications* (DOI: 10.1039/c0cc02215b; p. 505), Bunning, White, and co-researchers fabricated a CLC cell—a central CLC layer (containing an achiral nematic LC, a RH chiral dopant, an achiral diacrylate monomer, and a RH chiral monomer that reflects at about 720 nm) sandwiched by two polyimide layers, all sandwiched by two glass layers (see Figure 1)—all fairly typical except that one of the polyimide layers contained a photoinitiator. Polymerization therefore proceeded from only one side of the cell,

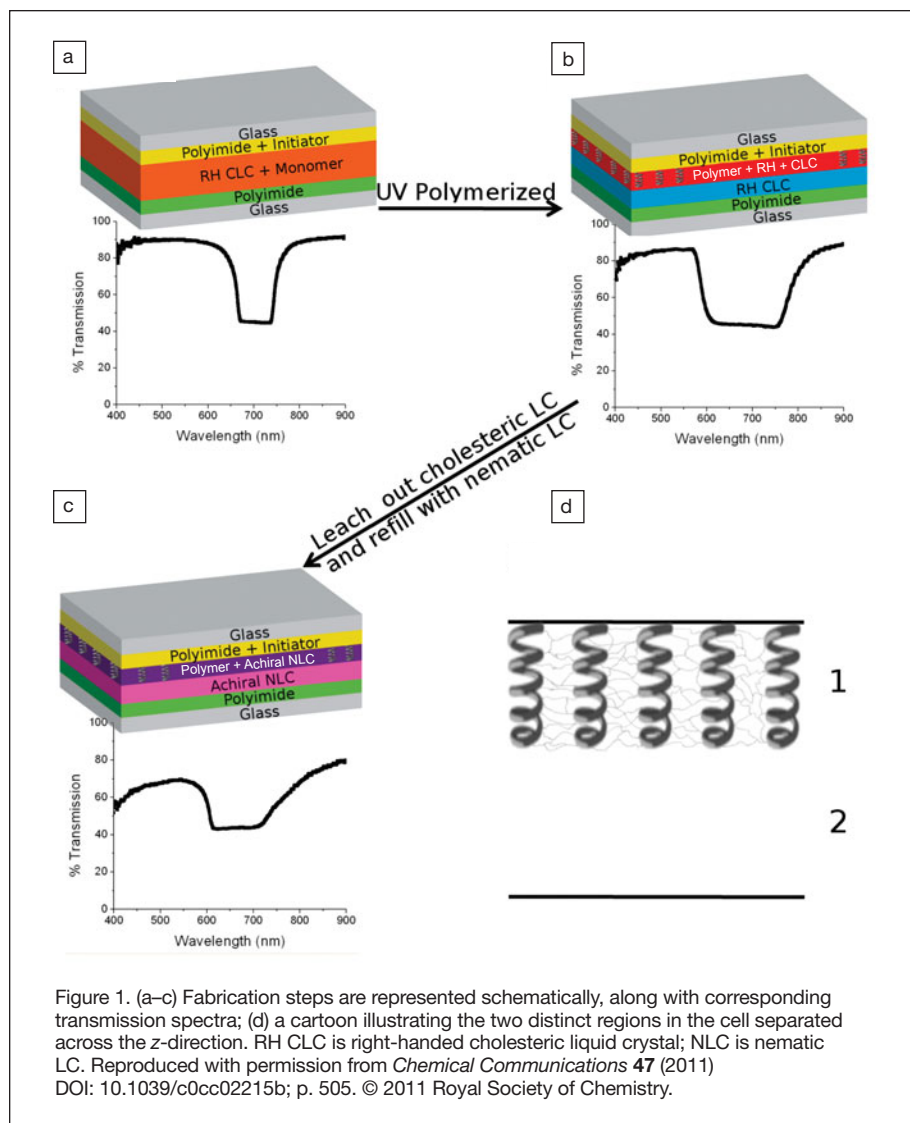


Figure 1. (a–c) Fabrication steps are represented schematically, along with corresponding transmission spectra; (d) a cartoon illustrating the two distinct regions in the cell separated across the  $z$ -direction. RH CLC is right-handed cholesteric liquid crystal; NLC is nematic LC. Reproduced with permission from *Chemical Communications* 47 (2011) DOI: 10.1039/c0cc02215b; p. 505. © 2011 Royal Society of Chemistry.

creating a RH helical polymer scaffold that extends about two-thirds into the cell, about 19  $\mu\text{m}$  (see Figure 1d). The LC mixture and unreacted monomer were subsequently leached from the cell.

A Bragg reflection of 670 nm was observed after the cell was refilled with the same nematic LC (see Figure 1c), confirming that the polymer scaffold is RH helical, and maintains the original pitch after the leaching/refilling process.

The researchers said that structural chirality, imposed by the chiral polymer scaffold, induces the reflection, as opposed to induction by chiral dopants, whereas the third of the cell without the polymer scaffold maintains the reflection characteristics of the filling agent.

After re-filling the cell with a LH CLC

mixture, the researchers observed reflections centered at 690 nm and 900 nm, which correspond to the RH polymer scaffold and the LH CLC mixture, respectively. Refilling the cell with a LH CLC mixture whose reflection matches the RH polymer scaffold results in a static hyper-reflective CLC cell (>99% reflectivity) from a single cell geometry.

The researchers were able to dynamically induce hyper-reflectivity by incorporating a chiral, azo-based, photosensitive dopant into the mixture used to refill the cell. As UV exposure increased (for a total of 293 seconds), the reflectivity varied from 50% to greater than 98% and then back to 50% as a red shift of the LH reflection progressed from 450 nm to past 1000 nm. Subsequent exposure of

the cell to green light blue-shifted the LH reflection back to where it overlapped the RH reflection.

The researchers said, “Inducing hyper-reflectivity was the first step; now we are working toward making the polymer

scaffold dynamic to enable fully tunable hyper-reflectivity.”

**Steven Trohalaki**

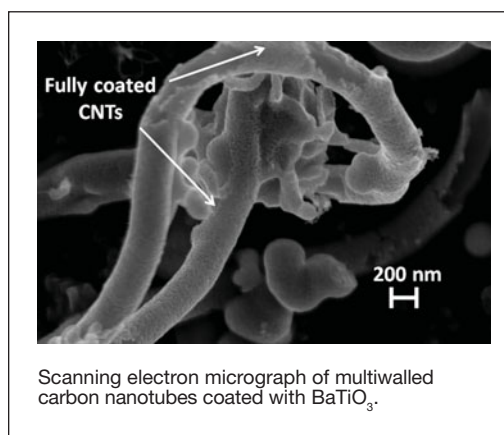
**Nano Focus**

**High-yield, low-cost approach developed to functionalize MWCNT surface**

**M**ultiwalled carbon nanotubes (MWCNTs) are finding increasing use in a variety of applications such as scanning probe microscope tips, hydrogen storage devices, catalyst support, and energy storage devices. Carbon nanotubes (CNTs) are often modified to prepare templates for advanced sensing technologies. A number of studies have reported attempts to functionalize the surface of CNTs for improved templating. A recent study by researchers from Virginia Tech has yielded CNTs functionalized with a uniform layer of metal oxide on the nanotube surface that afford high yield with low costs.

Previous studies have mostly resulted in CNTs functionalized with metal nanoparticles. There has been limited success

with coating CNTs with oxides. In the November 2010 issue of the *Journal of the American Ceramic Society* (DOI: 10.1111/j.1551-2916.2010.04154.x; p. 3618), V. Bedekar, S. Priya, and their colleagues from Virginia Tech introduce a technique to prepare MWCNTs uniformly coated with BaTiO<sub>3</sub>.



Scanning electron micrograph of multiwalled carbon nanotubes coated with BaTiO<sub>3</sub>.

In this two-step process, CNTs were first immersed in nitric acid to incorporate surface –OH functional groups that act as sites for BaTiO<sub>3</sub> attachment. The acid-functionalized CNTs were immersed in a solution of barium titanium ethylhexanoisopropoxide and isopropanol. Transmission electron micrographs revealed that the MWCNTs were uniformly coated by BaTiO<sub>3</sub> with thickness in the range of 5–20 nm. Changes in chemical composition resulting from surface functionalization were characterized using a combination of infrared and x-ray energy-dispersive spectroscopy.

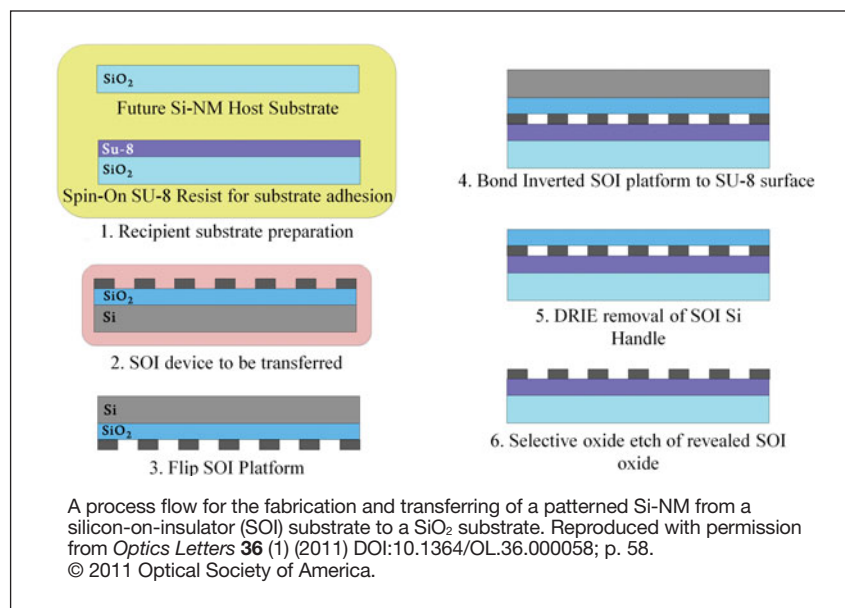
The research team said that these surface-functionalized CNTs will find use in diodes, sensors, and smart textiles.

**Kaushik Chatterjee**

**Nano Focus**

**High-fidelity transfer of intricate photonic devices via nanomembranes demonstrated**

**S**ilicon nanomembranes (Si-NM) are typically fabricated by harvesting the top Si layer of the silicon-on-insulator (SOI) wafers. Selective etching of the middle buried oxide layer releases the top Si device layer from the bulk as a nanomembrane. The fragile nanomembrane is susceptible to cracks and wrinkles during transfer to other substrates often resulting in a partial transfer. Furthermore, the scalability of the transfer process is limited. Now M.J. Zablocki and D.W. Prather from the University of Delaware and A. Sharkawy and O. Ebil from EM Photonics, Newark have overcome these challenges by developing a high-fidelity direct transfer process that can be used



to transfer electronic and photonic devices without compromising structural integrity and functionality.

The researchers describe their fabrication protocols in the January 1st issue of *Optics Letters* (DOI:10.1364/