turned off. The researchers noted several possible improvements to the system, including optimization of the zeolite chemistry and the use of more sophisticated optical reflection measurement techniques.

COLIN MCCORMICK

Highly Ordered Isoporous Membranes Fabricated from Nanocomposites

Isoporous films, which have application in photonics, biotechnology, and biomedical devices, have previously been formed by the incorporation of inorganic nanoparticles into an organic polymer matrix. However, the properties of this class of nanocomposite materials are adversely affected by nanoparticle aggregation. In general, attachment of polymer chains to nanoparticles increases their dispersion and results in improved mechanical properties and thermal stability. Recently, D. Nystrom and colleagues from KTH, together with M. Whittaker from the University of Queensland, grafted polymers onto silica nanoparticles and used them to fabricate isoporous membranes.

As reported in *Macromolecular Rapid Communications* **26** (p. 524; DOI: 10.1002/marc.200400617), KTH researcher A. Hult and colleagues used atom-transfer radical polymerization to graft polystyrene (PS) onto functionalized silica nanoparticles. Infrared spectroscopy confirmed the PS grafts, which had a molecular weight of 23,400 g/mol. The researchers cast films on a glass substrate from a mixture of hybrid nanoparticles, CS_2, and linear PS under humid conditions. A temperature decrease resulting from solvent evaporation caused water to condense onto the film surface. Stabilized water droplets were then formed when hybrid nanoparticles precipitated at the water–solvent interface. An opaque film formed when all solvent evaporated, with the final membrane containing 10 wt% silica. The researchers, using an optical microscope and atomic force microscopy to analyze the membrane structure, observed a hexagonal array of pores, that is, a honeycomb structure, with an average pore diameter of 2.5 µm, a nearly monodisperse pore size distribution, and a pore depth varying from 0.8–1.5 µm. By changing the humidity and the rate of air flow, the researchers were able to vary the pore size from 2 µm to 8 µm.

Hult and co-researchers said that their method is applicable to a broad range of materials and that the large surface areas, open pore structure, and isoporous nature of the films make them very attractive for membrane applications.

Hult said, "We can also make nanocomposites in which copolymers are grafted to the silicon microstructure."

STEVEN TROHALAKI

Ice Used As Resist for Patterning Nanostructures

G.M. King and researchers at Harvard University have recently demonstrated the use of frozen water as a resist for electron-beam lithography. They patterned chromium lines as narrow as 17 nm and lines of local surface chemical transformations as narrow as 5 nm, as reported in the June 8 issue of *NanoLetters* (p. 1157; DOI: 10.1021/nl050405n).

The researchers cooled a silicon substrate in a scanning electron microscope chamber to 128 K before leaking in water vapor to grow a stable ice film. They patterned the ice film using the electron beam (1–30 keV, 30–150 pA, ~5 nm diameter) and performed a lift-off process by sput-

CNT Arrays Encapsulated into Freely Suspended Flexible Films

Carbon nanotubes (CNTs), with their mechanical strength and electrical properties, are excellent candidates for multifunctional membrane sensors requiring high electrical conductivity and extreme robustness. However, it is hard to obtain long-living, freestanding, organized micro- and nanostructured membranes composed of nanowires and nanotubes due to their extreme fragility. Recently, H. Ko and a group of researchers at Iowa State University introduced a method to fabricate freestanding microarrays of CNTs by encapsulating them into robust, albeit compliant, polymeric nanofilms.

As reported in the May 17 issue of *Chemistry of Materials* (p. 2490; DOI: 10.1021/cm050495x), the researchers encapsulated CNT microarrays into freely suspended layer-by-layer (LbL) membranes by using spin-assisted LbL (SA-LbL) assembly and microcontact printing by sacrificial polymer patterning. The experimental procedure for patterned arrays of CNTs is outlined schematically in Figure 1. The CNT layer was ~5 nm thick with a density of ~18 bundles/μm^2. Raman spectra at the CNT area confirmed that neither the oxidation process nor deposition routine significantly affected the microstructure of the CNTs encapsulated into the LbL membranes. High optical contrast caused by the alternating layers into the LbL membrane creates an efficient Raman grating with a variation of G-band intensity of 1:1000 and higher.

By using interferometry, the researchers also studied how the encapsulation of the CNT arrays affects elastic properties of the freely suspended films. The result confirms that the filler-toughening mechanism effectively enhances the elastic properties of the patterned nanomembranes similarly to that demonstrated for thick homogeneous LbL films.

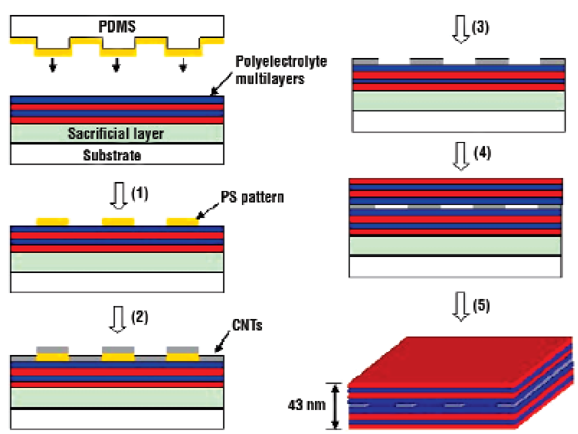

Figure 1. Schematic illustration of the procedure for fabricating freely suspended carbon nanotube arrays: (1) microcontact printing of polystyrene (PS) onto polyelectrolyte multilayers; (2) deposition of carbon nanotubes on the patterned substrates; (3) removal of PS layers; (4) formation of topmost polyelectrolyte multilayers by layer-by-layer assembly; and (5) release of carbon nanotube arrays by rinsing away the supporting sacrificial film. PDMS is poly(dimethylsiloxane). Reprinted in part with permission from Chem. Mater. ***17*** *(May 17, 2005) p. 2490. ©2005 American Chemical Society.*

The researchers said that the excellent mechanical properties of CNTs can be retained and finely tuned by embedding freely suspended carbon nanotube arrays in nanoscale polymer films. New anisotropic properties such as optical (Raman) gratings and potentially directional conductivity can be introduced. These new anisotropic properties have prospective applications for directional sensing and anisotropic electrical conduction.

TAO XU

https://doi.org/10.1557/mrs2005.153 Published online by Cambridge University Press