

3D micro/nano-polymerised black silicon and Image of the Year

Researchers at MCN have pioneered an approach that produces intricate structures with micro/nano-polymerisation using the highly refractive long thin nanoscale needles of black silicon. The woodpile structure illustrated here was produced by the research group of Saulius Juodkasis (MCN Technology Fellow) and described in the article to be published in *Optics Express* entitled 'Black silicon: substrate for laser 3D micro/nano-polymerization'.

The reflectivity of other materials that are commonly used in 3D laser structuring can cause interference during direct laser writing and consequent changes in structural morphology. Of the materials studied, black silicon showed the least amount of breakdown during direct laser writing and this combined with its electrical conductivity and liquid permeability indicate great promise for the material in applications ranging from cell bioimaging microfluidics to photoelectrodes.

The winner of the inaugural MCN Image of the Year for 2012 is Gediminas Seniutinas, also part of the research group at MCN with Saulius Juodkasis. The black silicon landscape in 'Nanowinter' was produced with assistance from Sasi Kandasamy at MCN. Congratulations to Gediminas and thank you to everyone who participated.

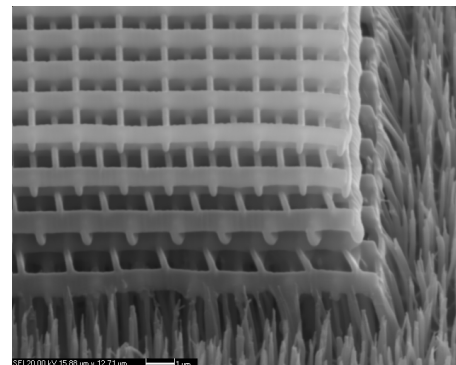
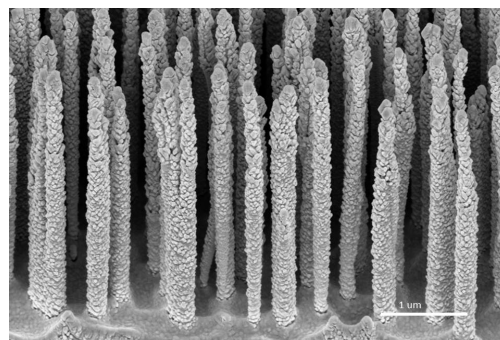


Image of the edge of a black silicon woodpile structure obtained by SEM. The width of a line is approximately 300 nm.



MCN 2012 Image of the Year: 'Nanowinter'

Ellipsometer



MCN has just received delivery of its new spectroscopic ellipsometer (pictured above). The system is a M2000DI + from JA Woollam. This system will be at the heart of thin film development at MCN allowing the non-destructive characterisation of films from a range of processes including ALD, PECVD, evaporation, sputtering and oxidation. The spectral range of the

system is 193 nm to 1700 nm and can be used in single point mode or for wafer mapping up to 150 mm substrates. Please contact Lachlan Hyde at lachlan.hyde@monash.edu for details of training sessions to be held in late March.

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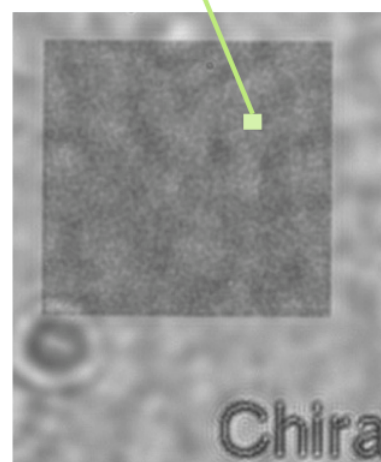
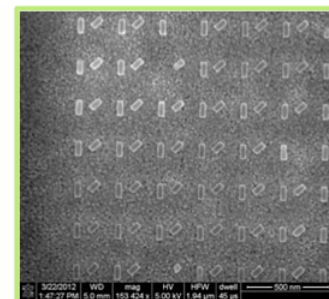
Creating a new optical material

Fatima Eftekhari and Tim Davis from CSIRO have created an artificial material with a strong chiral optical response using an array of gold nanorods. The rods resonate when exposed to light, a phenomenon called surface plasmon resonance. Creating a material with a strong chiral optical response is a first step towards improving our ability to detect the chirality of biological molecules.

Many biological molecules such as the building blocks of proteins and DNA are chiral, meaning that they come in left-handed and right-handed forms even though they are chemically identical. Detecting these forms is important since their handedness affects how they interact. For instance with biological enzymes, which are sensitive to the difference between left-handed and right-handed forms and their overall 3D structure.

The rods created in this study (Eftekhari and Davis, *Phys Rev B* 2012;86: 075428), each about 100 nm long and 40 nm wide, were arrayed in pairs on a glass substrate. The researchers spaced and oriented the rods in such a way that the array appeared as a uniform, thin film material, known as a metamaterial and produced an optimum chiral optical response.

The metamaterial was fabricated using electron beam lithography on a 30 nm-thick gold film on glass followed by an etching process and showed a difference in scattering of left and right circularly polarized light of 16%, some 3000 times stronger than obtained with equivalent solutions of standard chiral materials.



SEM image of planar metamaterial composed of arrays of gold nanorods.

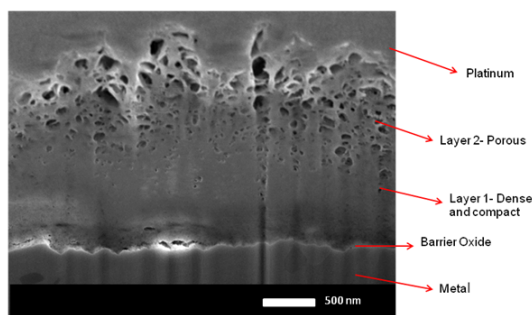
Understanding corrosion

The aim of an ongoing project led by Sebastian Thomas (CSIRO) at MCN is to characterise oxide layers that form on metals during corrosion. Once formed, these oxide layers are responsible for long-term protection of the metal surface by serving as a barrier, constraining the contact of the metal with the external corrosive environment. For example, the oxides that form on zinc are responsible for making different types of zinc-coated steel (used in civil and automobile engineering) and last for many decades.

In the past, using conventional SEM or other analytical techniques like FTIR and Raman spectroscopy, one could only study the surface properties of these oxides, consequently excluding the cross-sectional interface. Using the focused ion beam (FIB)-SEM, the researchers were able to clearly see that the oxides that develop on metals were composed of a multi-layered structure, with the inner layers being the ones that were most likely to protect the metal surface.

The breakthrough of finding, imaging and characterising the cross-section of oxides formed on metals after corrosion (currently in press) went against the existing theories on 'corrosion through oxides' based on surface properties of the oxide. This will potentially encourage researchers to focus more on the oxide layers present beneath the surface to understand the mechanisms underlying corrosion processes.

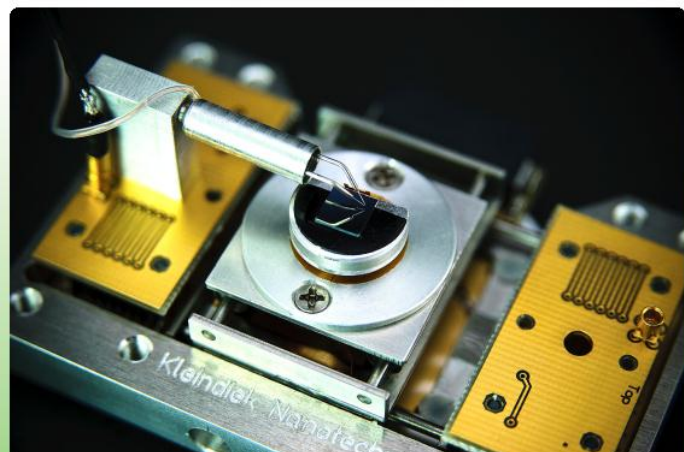
Based on these results, new models for metal corrosion accounting for the presence of the different oxide layers could be developed, and innovative, corrosion-resistant materials may be developed by strategically enhancing the barrier properties of these oxide layers.



Cross-sectional view (right) of the zinc patina formed under a 1 µl sea-water droplet after a 6 h exposure (platinum is layered over substrate prior to analysis).

This work is currently being prepared for publication.

Kleindiek micromanipulator



The Kleindiek Lift-out Shuttle for the FIB-SEM

A state-of-the-art Kleindiek Nanotechnik Lift-out Shuttle accessory to the dual-beam FIB-SEM has recently been added at MCN. The Lift-out Shuttle is the first to be installed on a Helios FIB system in Australia. It consists of a three-axis sub-stage and a microgripper, and provides a very intuitive way of manipulating objects in 3D space within the FIB-SEM chamber under high vacuum.

In recent years, the need for high throughput, in-situ TEM sample preparation has grown steadily as researchers are able to fabricate thin film heterostructures of increasingly smaller dimensions. The Kleindiek Lift-out Shuttle, when combined with the high resolution FEI Helios Nanolab 600 FIB-SEM will allow for reduced cost, higher throughput TEM sample preparation with higher yield in a shorter timeframe than currently possible.

For further information on the Kleindiek Lift-out Shuttle, please contact Matteo Altissimo at matteo.altissimo@monash.edu.

New faces at MCN

Hemayet Uddin, BSc, MSc, PhD

Hemayet holds a BSc (Hons) and MSc in Chemistry, and PhD in Chemical Engineering and Materials Science from Yokohama National University. He undertook three postdoctoral terms from 2003 to 2008 at the Ajinomoto Co. Inc., Yokohama National University and Tohoku University, Japan. He also worked as a Research Fellow and Instrument Manager at the Particulate Fluid Processing Centre (PFPC), University of Melbourne. Hemayet brings his considerable AFM and materials/surface characterisation expertise to MCN.

Ricky Tjeung, BEng, MEng, PhD

Ricky has had a variety of work experience with NTU, Singapore Institute of Manufacturing Technology (SIMTech - A*STAR) and Avago Technologies. His past responsibilities ranged from development and performance characterisation of novel micro-devices, to maintenance and optimisation of a production line in manufacturing. Ricky is responsible for user training and process support for the UV mask aligners, hot embossing, chemical vapor deposition and reactive ion etching tools.

Yang Lim, BEng, PhD

Yang joined Intel Microelectronics Malaysia as a test equipment development engineer for a year and a half before pursuing her postgraduate studies. She graduated with a PhD in Engineering from Deakin University in 2012 in the field of BioMEMS. Yang's thesis research area is on the development, characterisation and gas plasma functionalisation of SU-8 microcantilever aptasensor for disease detection. At MCN, Yang will support thin film deposition via e-beam evaporation, direct-write photolithography, 3D printing, laser doppler vibrometry, dicing saw and the PDMS laboratory.

Lachlan Hyde, BSc, PhD

Lachlan holds a BSc (Hons) in Nanotechnology from Flinders University and a PhD in Applied Science (Minerals and Materials) at the University of South Australia. He has research proficiencies using the techniques of X-ray photoelectron spectroscopy (XPS), variable angle spectroscopic ellipsometry (VASE), atomic force microscopy (AFM), Fourier transform infrared spectroscopy (FTIR) and scanning electron microscopy (SEM). At MCN, Lachlan is available to assist with ALD, ellipsometry, PECVD (thin films) and wire bonding.

Refresher induction program

MCN has been fully operational for more than two years with regular updates to the induction procedure over this period. In order to harmonise the training for all users and keep everyone up to date with current OHS information, MCN is now holding annual refreshers for everyone currently issued with a FOB.

Attendance at these annual induction refreshers will be a **prerequisite condition for continued access** of the MCN facility.

The refresher will take approximately 1 to 1.5 hours and will be offered every day at 10 am for the week of the 25th to 28th, March, in the MCN Boardroom.

Bookings are not necessary, however all attendees will need to bring their fobs.

If you are unable to attend a refresher session on these dates, you can attend the regular induction which is offered weekly at 10 am on Mondays.

Stay informed by checking the MCN training page of the website at <http://www.nanomelbourne.com/training>. All enquiries should be directed to the MCN Facility Manager: Paul.spizzirri@monash.edu.

Featured publications of 2012

MCN staff and the user community regularly feature their research in academic and industry-based journals. Some highlights from 2012 were:

Rezk AR, Manor O, Friend JR, Yeo LY. **Unique fingering instabilities and soliton-like wave propagation in thin acoustowetting films.** Nat Commun 2012;3:1167.

Tan S-Y, Tabor RF, Ong L, Stevens GW, Dagastine RR. **Nano-mechanical properties of clay-armoured emulsion droplets.** Soft Matter 2012;8:3112-3121.

Eftekhari F, Davis TJ. **Strong chiral optical response from planar arrays of subwavelength metallic structures supporting surface plasmon resonances.** Phys Rev B 2012;86:075428.

Save the date

The International Society for Optics and Photonics (SPIE) 2013 Micro+Nano Materials, Devices, and Applications Conference will be held at RMIT on the 8th to 11th of December 2013.

Papers will be accepted in the following areas:

- Biomaterials and biological microdevices
- Micro/nanofluidics
- Photonics
- Fabrication
- Metrology: microscopy and measurement
- Solar cell technologies
- Plasmonics
- MEMS/NEMS
- Nanomaterials

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