Hiden Analytical Ltd.
420 Europa Boulevard
Warrington WA5 7UN
England

T +44 [0] 1925 445 225
F +44 [0] 1925 416 518
E info@hiden.co.uk
W www.HidenAnalytical.com

Unlocking new contrast in a scanning helium microscope

Ubiquitous across all branches of science, scanned probe microscopies have facilitated discovery and innovation by allowing a glimpse into the microscopic realm. The ability to reliably image a sample is perhaps more important than ever with the rise of modern fabrication methods capable of controlling structures to sub-optical length scales. However, there remain many materials which suffer degradation, or even wholesale destruction, under the energetic photons, electrons or ions used as the probe in conventional microscopies. Compounding the issue is the ever-broadening catalogue of new materials used in manufacturing; samples of particular interest at risk of damage include biological samples, thin film coatings and polymer electronics.

Figure 1. The Mk II scanning helium microscope (SHeM)

The scanning helium microscope or SHeM (see Figure 1) alleviates any potential for sample degradation by exploiting the properties of neutral helium atoms to form the ideal surface probe. In contrast to the high-energy probes utilised in traditional microscopies, neutral helium atoms possess no spin or charge, and offer a de Broglie wavelength of the order of Angstroms whilst remaining at meV kinetic energies [1]. This low kinetic energy ensures that the helium atoms are completely non-damaging and are unambiguously surface sensitive (scattering from the outermost electron corrugation of the sample). Furthermore, the nature of the probe-sample interaction does away with the requirement for any form of sample preparation, such as the coatings required to prevent charging in insulating samples in scanning electron microscopy.

Harnessing neutral helium for microscopy presents a challenge; the very properties which make it an ideal surface probe also render it difficult to both focus and detect. With regards to the latter, the Hiden HAL/3F PIC quadrupole mass spectrometer offers the high sensitivity required to allow SHeM to generate images of delicate surfaces. Figure 2 shows a comparison of an optical and SHeM micrograph of a section of a wing from the honey bee species *Apis mellifera*. The primary contrast mechanism is topological in nature: the changing mean plane of the wing surface leads to differences in the helium signal directed towards the detector, making the ripples through the membrane quite obvious. Both shadowing and masking of areas of the sample are evident, in particular by the raised veins throughout the wing and the hairs protruding from its surface. Moreover, the SHeM image displays excellent depth of field; despite the height of the bee wing varying over almost 1.5 mm all the features are in focus, yielding an intuitive image.

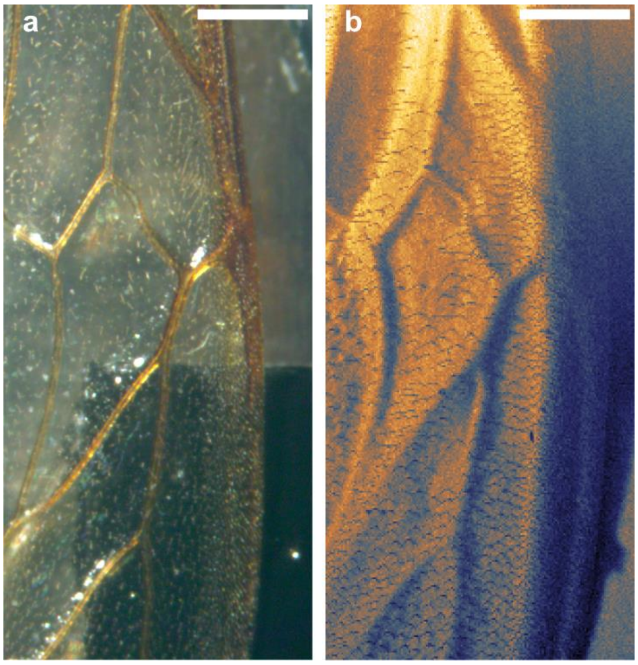

Figure 2. Topological contrast in SHeM*.* *Comparison of reflection optical (Leica M205 C) (****a****) and SHeM (****b****) micrographs of a honey bee wing (Apis mellifera) as an example of topological contrast. Scale bars are 500 um.*

In addition to topological contrast, SHeM has recently demonstrated the capability to observe contrast arising from surface chemistry (*Nature Communications* **7**, "Unlocking new contrast in a scanning helium microscope", doi:10.1038/ncomms10189). A number of patterned metal-semiconductor interfaces, created using electron-beam lithography, were investigated using the new instrument. The SHeM micrographs shown in Figure 3 exhibit distinct contrast, not only between the metals and the silicon substrate, but also between each of the different metal layers. Further investigation of the nature of the chemical contrast revealed it to arise from inelastic interactions between the helium atoms and the surface. The unique opportunities afforded by this chemical contrast, in tandem with topological contrast, open the door to the use of SHeM as a complementary microscopy technique in the surface analyst's toolbox.

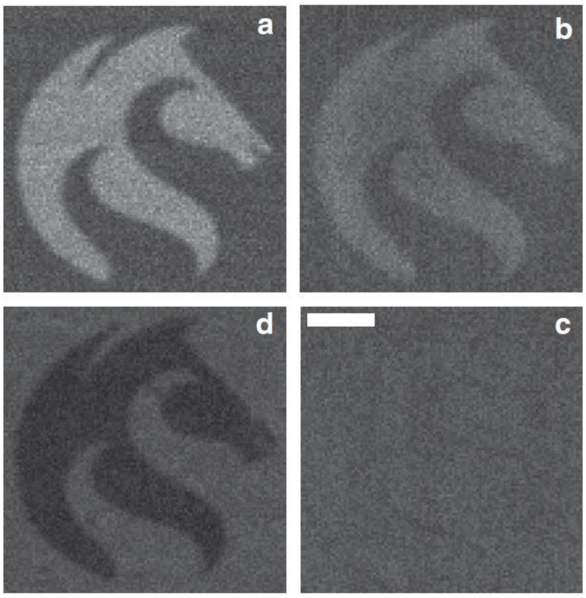

Figure 3. Metal–semiconductor interfaces as imaged using neutral helium*. SHeM micrographs show the University of Newcastle logo in different metals on a silicon substrate. Clockwise from top left: (****a****) gold (****b****) nickel (****c****) platinum and (****d****) chromium. Scale bar, 50 um.*

[1] D. A. MacLaren, B. Holst, D. J. Riley, and W. Allison, Surf. Rev. Lett. 10, 249–255 (2003)

Project Summary By:
Matthew Barr
Research Associate
Materials Node, Australian National Fabrication Facility
Priority Research Centre for Organic Electronics
University of Newcastle
Callaghan, NSW 2308
Australia
Email: matthew.g.barr@gmail.com

Paper Reference:

Barr, M. *et al.* Unlocking new contrast in a scanning helium microscope. *Nat. Commun*. 7:10189 doi: 10.1038/ncomms10189 (2016).

Hiden Product:

3F PIC specialist gas analysis system for fast event UHV studies

Follow the link to the product catalogue on our website for further information
http://www.hidenanalytical.com/en/products/for-residual-gas-analysis/rga-3f-pic-for-fast-event-uhv-studies