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Scanning helium microscopy (SHeM), contrast mechanisms, resolution and sensitivity in a new imaging technique

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Microscopy has been a major enabling technique for the development and understanding of materials from the bottom up. Some of the major insights in the development of modern materials have come from scanning probe, electron and ion microscopies, with advances in resolution and sensitivity enabling new material science. Unfortunately charged beam techniques tend to cause surface damage and scanning probe techniques are limited to relatively flat surfaces and suffer from limited scan speeds.
In the current work we present recent advances in the development of neutral beam microscopy. In collaboration with colleagues at the University of Newcastle, NSW, we have recently published some of the first reflective mode images measured with a neutral helium beam [1,2]. Using a neutral beam of helium atoms at very low energy (<100meV) and with a de Broglie wavelength of around 1Å[1,2] the aim of the project is to deliver uniquely surface sensitive images with atomic resolution and no surface damage. Helium microscopy is suitable for measuring a variety of samples including insulator, semiconductor, explosive, biological and 3D self-assembled materials and being a real space technique will not involve complicated post processing techniques.
Helium atom microscopy has been in development for some years internationally. Many of the technological barriers, for example helium focusing, sample preparation and nanoscale manipulation have now been addressed to enable preliminary instruments to be developed[1,2,3], however detection of neutral beams remains a challenge, particularly for helium given its high ionisation energy[3]. Applications that require time sensitive measurements require a small ionisation volume; however, when high temporal resolution is not required, ionisers having a much larger volume are possible. We describe a detector developed on the basis of recent successful results[8] applied to surface spin-echo experiments[5,6,7] and having a sensitivity of 0.83A/mbar, the highest yet reported for helium atoms.
Finally we discuss contrast mechanisms other than topographical in origin and discuss various alternatives, and applications of the technique.

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Primary author: WARD, David (University of Cambridge)

Co-authors: Dr JARDINE, Andrew (University of Cambridge); Dr ALLISON, Bill (University of Cambridge); Dr ELLIS, John (University of Cambridge); Mr BERGIN, Matthew; Mr LAMBRICK, Sam (University of Cambridge); Dr SCHULZE, Susanne (University of Cambridge)

Presenter: WARD, David (University of Cambridge)

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