SHeM: "Scanning Helium atom Microscopy" A novel atom probe technique

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Microscopy is an indispensable tool for the investigation of materials and surfaces. It has often been said that the whole field of Nanotechnology and Nanoscience began with the invention of scanning tunneling microscopy (STM) and scanning force microscopy (SFM) [1]. Recent years have also seen a rapid development in particle probe microscopies; enabling, for example, atomic resolution in Transmission Electron Microscopy (HRTEM).

While these state-of-the-art microscopy and imaging techniques are very powerful, particularly with respect to their high resolution, they suffer some inherent challenging issues. Charged particle probe techniques like electron or ion microscopes as well as STM traditionally require the sample to be electrically conducting, whilst scanning probe techniques in general are rather slow and can only be used on quite flat samples and for small areas.

Recent years have shown significant advancements in the field of scanning helium atom microscopy (SHeM); enabling the development of a new type of matter wave microscope which utilizes neutral atoms as a probe beam [2-6]. The major advantage of the SHeM technique is that the neutral helium probe has a much lower beam-energy than other particle probe microscopes: less than 100meV for a de Broglie wavelength of less than 0.1nm. This energy is simply too low to cause any surface damage or penetration into solid material. At the same time, the helium atoms are uncharged (neutral) and chemically inert. Thus, SHeM offers a completely non-destructive imaging technique that is equally suited to imaging insulators, semiconductors, metals and delicate samples such as organic materials.

Presently, the few current existing SHeM microscopes are either based on a pinhole camera approach [3, 4], or use a focused helium beam concept [2,5,6]. Here we present the concept and advantages of the SHeM technique based on the work conducted on two of these microscopes: (1) a focused beam NEutral helium MIcroscope (NEMI), developed in Bergen and (2) the pinhole SHeM system developed in Newcastle. This technology offers a unique way of imaging with a neutral helium beam and presents a complementary tool to other already existing imaging technologies.

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