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A New TEM / Ion Accelerator Facility at the University of Salford, UK

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A facility permitting in-situ situ ion irradiation of thin foils within a transmission electron microscope (TEM) has been constructed at the University of Salford, UK with funding from the UK Engineering and Physical Sciences Research Council (EPSRC). A primary focus of the facility is to study the combined effect of the presence of gases such as H and He, high temperature and displacing irradiation on the properties of a variety of potential nuclear reactor materials including steels, refractory metals and ceramics. In order to implant light elements such as H and He into foils of a suitable thickness for TEM (typically 50–100 nm), implantation energies of order a few keV must be employed and this requirement has led to the design of an ion accelerator consisting of a low energy ion-beam system capable of producing mass-analysed ion beams (of most ion species up to the mass of Xe) at energies from 1 to 10 keV. Post-acceleration by means of a uniformly graded acceleration stage then allows the ion beam energy to be increased to 100 keV (200 keV for doubly charged species) enabling, for instance, the use of self-ion irradiation to simulate neutron damage effects. The ion-beam system has been interfaced with a JEOL JEM-2000FX TEM through a high-angle port originally designed to accommodate an energy dispersive X-ray spectrometer. A custom-designed electrostatic deflector system is mounted inside the column of the TEM within a totally shielded enclosure, allowing the ion beam to irradiate the specimen at an angle of 25° from the optical axis of the microscope. The ion-pump on the microscope has been replaced with a magnetically levitated turbomolecular pump to ensure efficient pumping of any additional gas load introduced by the ion-beam system.

In general, this type of in situ TEM / ion accelerator facility offers unique opportunities for investigation into the effects of ion beams on materials as it allows the observation and recording of dynamic processes occurring under ion irradiation rather than just the recording of end states. In addition, it permits full control of the temperature of specimens under observation and renders straightforward, for instance, the carrying out of experiments at cryogenic temperatures which would otherwise require a means of transferring specimens between ion implanter and microscope at a constant low temperature. There are a number of in-situ facilities around the world [1] but the Salford system is unique in permitting irradiation, at fluences of approximately 2×10^{12} ions/cm^2/s of both light ions at energies in the range 1–10 keV and and heavier ions (e.g. self ions) at energies in the range 100 – 200 keV. A particular focus of the facility will be the behaviour of materials subjected to irradiation with both He and heavier ions in order to model the behaviours of nuclear materials containing He from transmutation reactions and/or direct implantation sunbjected to displacing irradiation by neutrons. To this end, it is envisaged that most investigations will invlove close collaboration with computer modellers.

The presentation will describe in detail the design and specifications of the new facility and will present preliminary results on the nucleation and growth of helium bubbles at high temperature in SiC and W.

References

[1] C W Allen and E A Ryan, Microscopy Research and Technique, 42 (1998) 255

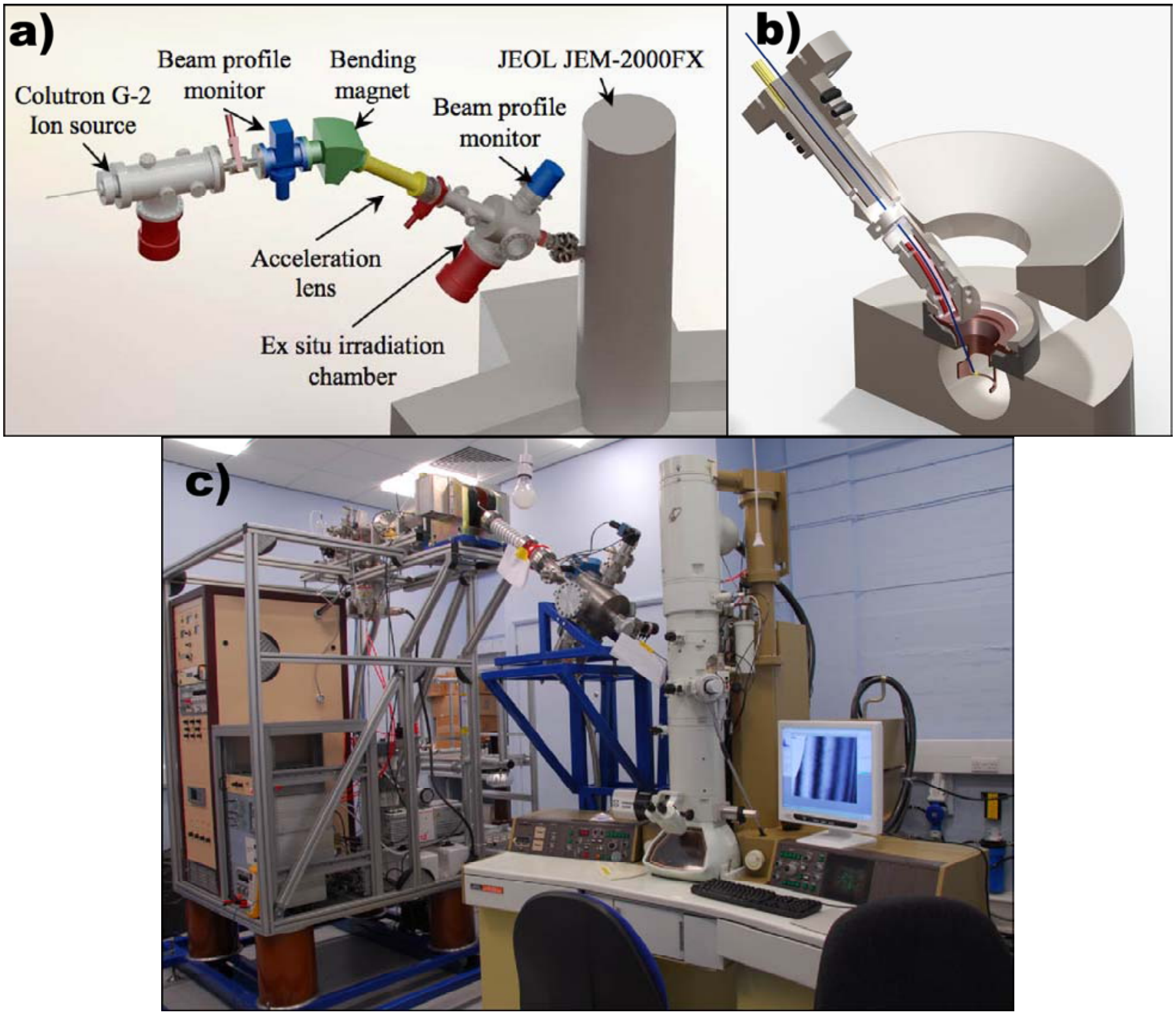

Figure 1: The in-situ TEM / Ion Accelerator Facility at the University of Salford.
a) Schematic of ion-beam system; b) Detail of in-column deflector;
b) The full facility in the final stages of construction.

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