**Ion interactions with fusion relevant materials**

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As the world's population continues to increase, and billions of people throughout the developing world emerge from poverty, humanity's demand for energy is expected to surge to ever greater heights. ITER is a significant international programme of research with the aim to develop magnetically confined fusion technologies capable of providing base-load electrical power.

In the next-step fusion experiment ITER, temperatures exceeding 100 million K will be generated within the reactor core to generate 500 MW of fusion power. The potential of this and future fusion devices is ultimately limited by the performance of plasma facing armour materials. In the "divertor" region of ITER, where the heat and particle load will be greatest, steady state heat fluxes of up to 20 MW/m2 are expected, with further transient heat loading also occurring due to plasma instabilities. This demanding environment requires well-characterised high-performance materials. However, a lack of data on the performance of many potential materials under conditions relevant to fusion presents a serious obstacle to the future development of fusion energy. The fusion environment is in many respects unique – materials are exposed not only to high heat loads, but also high H/He particle fluxes, neutron irradiation, and strong magnetic fields. In this project, Grazing-incidence small angle scattering has been applied for the study of nanostructure damage of tungsten in these extreme environments. Tungsten has been selected as the armour material for ITER's divertor, on account of its excellent thermal properties and low SIEF John Stocker Postgraduate Scholarship – Final Report sputtering rate. However, its performance is sensitive to many factors. Under hydrogen and helium particle fluxes, temperature sensitive micro-structure formation has been observed. After helium plasma exposure with material surface temperatures below 1000 K, 1-2 nm diameter helium-filled bubbles form within 30 nm or so of the sample surface. Measuring the formation of sub-surface features such as nano-bubbles is challenging. To date, most work on this has been conducted via TEM. However, due to the difficulties associated with this technique it is only practical to perform it on a small selection of key samples. This is a serious obstacle to systematic studies on the synergistic effects that may be present. To overcome this limitation, the project has focussed on applying grazing incidence small angle xray scattering (GISAXS) to measure helium nano-bubble formation. The studies have demonstrated the power of this technique, and it has already been successfully applied to the study of a number of plasma systems. This work has attracted significant interest from the international fusion materials research community, and the PhD stduent has given invited talks about this technique at research institutions in France, Germany, and Japan.