The Size, Shape and Distribution of Intragranular Fission Product Bubbles in Spent Nuclear Fuel

M.J.D. Rushton[1], C.O. Galvin[2], M.W.D. Cooper[3], P.A. Burr[2], S.C. Middleburgh[1], R.W. Grimes[4] and W.E. Lee[1,4]

[1]Nuclear Futures, Bangor University, Bangor, Gwynedd, UK
[2]University of New South Wales, Sydney, NSW, Australia
[3]Los Alamos National Laboratory, Los Alamos, NM, USA
[4]Imperial College, London, UK

During its life in a reactor fission products build up in nuclear fuel. Some of these such as Xe, Kr and He form bubbles in the fuel. Whilst in a reactor, these have a detrimental effect on fuel performance as fission product bubbles may lead to swelling and a degradation of mechanical properties, and when released from the fuel, where the gas degrades the thermal conductance of the fuel-clad gap and leads to an increase in fuel temperature and cladding pressure. Having been removed from the reactor, the effects of these bubbles still need to be understood, in particular it is useful to know how much of a spent fuel's fission product inventory is contained inside intergranular bubbles. This is an important consideration for both the long-term storage of spent fuel and for fuel reprocessing. Additionally the way in which the bubble size distribution may develop due to the effects of decay and time in a repository environment have important implications for the direct disposal of spent fuel.

In this work, molecular dynamics simulations have been used to study fission product bubbles in UO_2. The results of these will be presented and aim to show the behaviour of small fission product bubbles in the range of diameters below <100nm. In particular bubble morphology is considered with both spherical and faceted Wulff shapes being compared. The effect of bubble internal pressure on morphology and its dependence on bubble size will be presented. The simulation results will be described in terms of the bubble size and pressure distribution expected in spent fuel. The implications of these for fuel performance codes and for licensing repositories for long term storage will also be discussed.