In-situ electron irradiation within a TEM: a way to study the stability and evolution of cavities in pure aluminium

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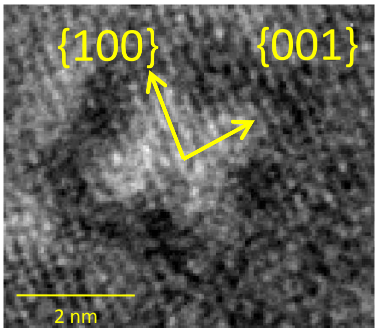

Cross shape of a facetted cavity, z=[100], Cs-corrected FEI Titan, ECP

Al-based alloys are foreseen for the cladding of the future material testing reactor Jules Horowitz. Under irradiation, a large amount of point defects (interstitials and vacancies) are created. They are mobile and may cluster to form extended defects such as dislocation loops in 2 D or cavities in 3D. This work is focused on cavities, which may induce swelling and embrittlement. Because of its low Z number, it is possible to create defects in this metal with the typical low-electron energy available within a Transmission Electron Microscope (TEM), as recently obtained at the atomic scale in a Mg metal[1].

Facetted cavities are indeed observed within in-situ experiments performed with 200 and 300 keV electrons and stabilities of cavity surfaces can be determined. In fact, the surface free energy ratio of low-index planes {100} to {111} in pure Al (99.999%) are estimated by means of the Wulff construction and measurement of the relative proportion of the corresponding facets. This ratio is then compared to recently published *ab initio* values.

On the other hand, to determine the kinetics of cavity evolution under irradiation in pure aluminium, other experiments are performed in a zone axis [100]. In situ observations show that cavities appear after the formation of interstitial loops. Surprisingly, cavities adopt a cross shape along <100> directions during growth (figure) before taking a cubic shape. A model based on a pentavacancy cluster[2] is proposed to explain those results. To improve statistics, electron irradiation under lower electron intensity and lower electron energy within the TEM are on-going so that more data per unit time will be collected. The effect of irradiation flux on the cavity formation will be studied.

1. Xu W *et al.*, *In-situ atomic-scale observation of irradiation-induced void formation*, Nat. Commun. 4, 2288, 2013
2. Wang H *et al.*, *Defect kinetics on experimental timescales using atomistic simulations*, Phil. Mag., 93:1-3, 186-202, 2013