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V. Garric[1], P. Donnadieu[2], F. Lepretre[3], M. Loyer-Prost[3], B. Kapusta[1], K.Colas[1]

[1]*DEN-Service d'Etudes des Matériaux Irradiés, CEA Université Paris-Saclay, F-91191, Gif-sur-Yvette*

[2]*Univ. Grenoble Alpes, CNRS, Grenoble INP, SIMaP F-38000 Grenoble*

[3]*DEN-SRMP-JANNuS, CEA Université Paris-Saclay, F-91191, Gif-sur-Yvette*

Presenter's e-mail address: victor.garric@cea.fr

Abstract

Aluminum alloys have been widely used in nuclear research reactors since 1960. Even though many data on their mechanical behavior are available, few studies focus on the understanding of void swelling. Indeed, the density measurements of aluminum samples before and after irradiation allow to assess the total swelling but don't discriminate the contributions of thermal and fast neutrons. In the material testing reactors, the higher fast neutron flux (E>1MeV) is expected to impact the relative contributions to total swelling. Therefore, this study aims to reproduce reactor irradiation conditions using a simultaneous triple beam irradiation to simulate the materials damage observed in aluminum components. Aluminum specimens were irradiated with different ions: helium ions, simulating the production of alpha particles inside the reactor, silicon ions to reproduce the aluminum transmutation and tungsten ions to enhance the DPA rate. Using the proper energy and flux conditions, a 200 nm wide area of interest was obtained (figure 1a) and TEM specimens were prepared in this specific zone. TEM examinations show multiple defects and a unique microstructure. A wide area with helium bubbles (figure 1b) is present, thus modifying the initial microstructure (precipitates and dispersoïds). Comparing the current results with previous single beam studies using gold ions, we strive to explain and understand the peculiar role of helium and silicon in the void swelling process.

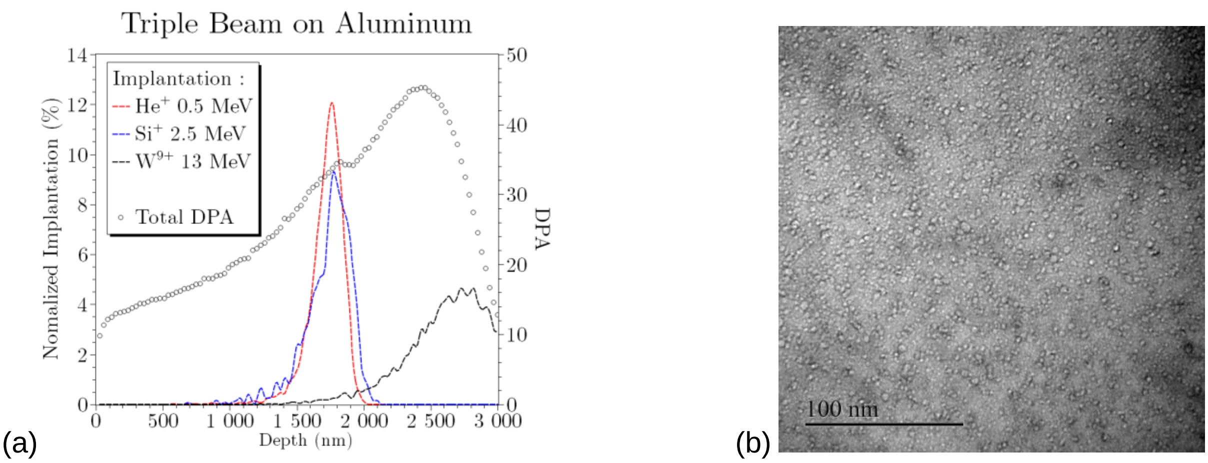

Figure 1: (a): ion beam profile, (b): helium bubble at the implantation peak seen in TEM

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