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The effect of proton irradiation on the microstructural evolution and mechanical properties of Zirconium alloys

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Neutron irradiation of structural materials used in the nuclear industry produces dislocation loops which cause undesired embrittlement by hardening and loss of ductility. Neutron irradiated Zr alloys become highly radioactive and are not easy to investigate. Proton irradiation proved to be an excellent surrogate for neutron irradiation due to the similar damage structure formed, substantially smaller radioactivity with shorter decaying time, shorter irradiation times, and lower costs [1]. However, protons produce a depth dependent damage profile starting at a relatively low dpa level which after a plateau region increases into a Bragg peak at about 30 µm for 2 MeV protons in Zr [2]. In the present work we show that depth dependent damage can be exploited for obtaining abundant information about irradiation induced damage by using the depth profiling capability of the P21.2 high energy beamline at the PETRA-III synchrotron in Germany, as shown in Fig. 1a. The XRD dislocation density data are supported by hardness measurements along the depth of the sample shown in Fig. 1b. The correlation between dislocation densities and the mechanical properties in terms of hardness will be discussed at the conference.

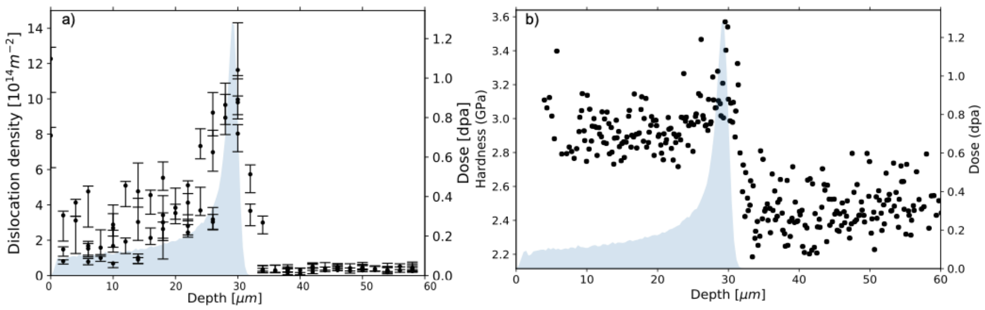

Figure 1: a) Dislocation density of loops and b) hardness vs. depth in a Zircaloy-2 sample proton irradiated to 0.15dpa (related to 60% Bragg peak) by 2 MeV protons.

Keywords: Nuclear materials, zirconium, proton irradiation, hardness, EBSD

References:

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