Hardness Evolution of Zr2.5Nb and Zirconium Hydride Due to Proton-Irradiation.

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There remains a lack of knowledge as to the detailed mechanical properties of zirconium hydrides, which at present are determined indirectly; such properties are needed in assessing the potential for crack propagation in Zirconium based alloys, for example by DHC. Thus, having a mechanistic understanding of hydride behavior is of extreme importance to the long-term operation of the Canadian Deuterium Uranium (CANDU) reactor designs particularly as H concentrations increase towards end-of-life, as well as for future applications where zirconium-based alloys may be used. In addition, hydride properties are of relevance to high burnup cladding for LWR and PWR applications.

The objective of this work is to understand the mechanical behavior of both ZrH and the zirconium matrix, as a function of irradiation. To study these effects, a Zr2.5Nb pressure-tube alloy was hydrided using an electrolytic method, increasing its hydrogen content to 100ppm. Proton irradiation was then used to study the effect of irradiation damage on the properties of both the pressure-tube metal and the hydride. The alloy and the hydrides irradiated to different doses and non-irradiated, were then characterized using nanoindentation. Tests on irradiated material showed clear hardness increase in both the ZrH and the matrix at 0.5dpa. Results showed a clear difference between the increase in hardness of the matrix and the hydride, proving the eligibility of using this methodology to characterize the ZrH. In addition tests are carried out as a function of temperature, to explore the development of hydride properties, and in particular the brittle-ductile transition.