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Microstructural Characterization of Irradiated and Hydrurate Zr-2.5%Nb and Zr – 1%Nb

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Zirconium-based alloys are the main structural materials in nuclear power plants. During operation the working environment of these components is a combination of temperature and reactive conditions such as irradiation, oxidation and hydrogen pick-up. The Zr cladding is expected to absorb hydrogen and form hydrides when the solubility limit is exceeded. Morphology, orientation, distribution and crystallographic aspects of hydrides and second phase particles play important roles.

The aim of this work is to compare how the interaction between hydrides and crystal defects affects mechanical properties such as hardness and ductility in Zr-2.5%Nb and Zr-1%Nb. All specimens were hydrided and irradiated at room temperature in the CNEA-RA3 nuclear reactor. They were placed in a capsule located in one of the reactor irradiation channels. In this case, neutron fluence was $3.5x10^{23}nm^{-2}$ after an irradiation of 30 days. The structures of both alloys hydrided and irradiated were analyzed by transmission electron microscopy.

In both alloys TEM micrographs show hydrides in the α-Zr matrix. These hydrides have been characterized as needle-shaped type ɛ (zeta), with HCP structure, lattice parameters a= 0.33 nm and c=1.029 nm, corresponding to a trigonal crystal with space group P3m1 [1]. The same hydrides were observed in the irradiated specimen on the basal and pyramidal planes of the αZr phase. As well, small spherical precipitates were founded. Their crystal structure was characterized as hexagonal close-packet Laves phase (C14), knowing as $Zr(Cr,Fe)_2$ Laves phase [2]. The presence of them is due the β-Zr phase decomposition during irradiation and the corresponding Fe depletion inside of the matrix [3]. In Zr-1%Nb samples ω phase was also found.

The tensile test of the irradiated material with ξ hydrides showed a high hardening and a significant decrease of the ductility, therefore, it can be inferred that the irradiation damage influence more in the mechanical properties. If irradiation loops or point defects clusters were present, their size is below the size detection limits for the TEM and could not be resolved. It is necessary to perform recoveries to grow them [4].

References:

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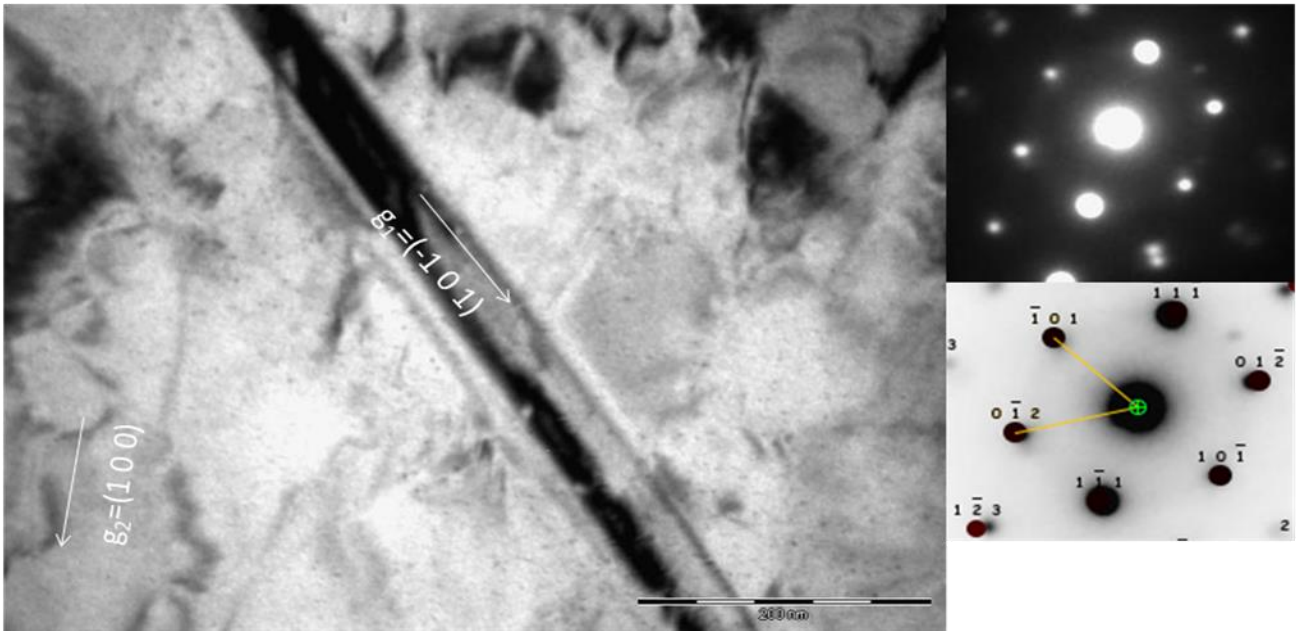

Figure 1. Enlarged TEM bright field image of *ξ* hydride and the electron diffraction pattern of the hydride $[0\ 1\ {-1}\ 1]_{H}$ / $[0\ 0\ 01]_{\alpha Zr}$, in Zr-1%Nb.

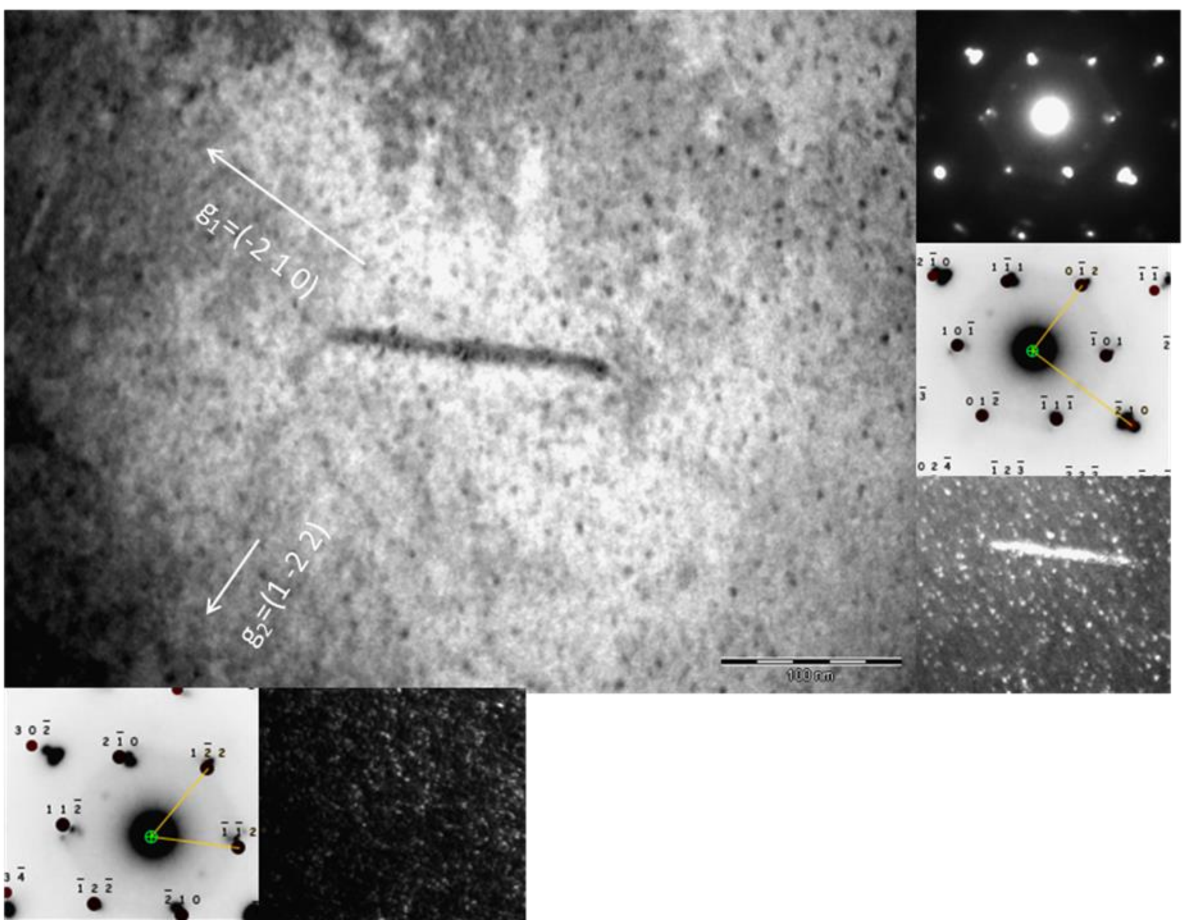

Figure 2. TEM bright field image of ξ hydrides and Fe precipitates in the α-Zr matrix, SAD pattern and dark fields in Zr-2.5%Nb.

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