

NEUTRON DIFFRACTION STUDY OF INTERGRANULAR STRESS DEVELOPMENT IN ZR-2.5%NB

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The harsh environment in the core of a nuclear reactor imposes high constraints for the choice of materials for structural components: materials need high corrosion resistance, good mechanical properties at high temperatures and must sustain their properties under high irradiation. Zr-2.5%Nb is a zirconium-based alloy which fulfils these criteria and has a low neutron cross section. Therefore it is used for the manufacture of pressure tubes in CANDU reactors, for example.

It is now well understood that Zr crystals, because of their hexagonal close packed structure at room temperature, present a strong plastic anisotropy [1]. In polycrystals, this anisotropy is responsible for the heterogeneity of grain-to-grain behaviour and the generation of high intergranular misfits after deformation. Moreover, the strong texture usually found in processed materials brings the anisotropy to a macroscopic level. It is therefore important to understand the mechanisms of deformation. The use of neutron diffraction during in-situ mechanical deformation has proven to be a real asset for such studies and much work has been performed on various alloy systems [2]. However some gaps remain in our understanding of how to link, model and predict the behaviours at the macro and micro scales. The influence of some parameters such as initial texture, grain size/shape and the initial intergranular stress state is also not very well identified.

This paper presents the results of a set of in-situ thermo-mechanical processes on coupons cut from a Zr2.5%Nb pressure tube. The experiment was performed in-situ at ENGIN-X, the engineering neutron diffractometer at ISIS, UK. A first set of samples were compressed at room temperature along the three processing directions and up to 10% deformation. Another two samples were briefly annealed in-situ up to 560°C and 620°C respectively and then compressed at room temperature.

During compression in the as received state, the macroscopic as well as the microscopic anisotropy were evidenced. As expected from the texture, the hoop direction was stronger than the other directions. The neutron diffraction results show that the 0002 reflections generally bear most of the load in the alpha hcp phase. In the rolling direction no such reflections are present and during compression along this direction the second phase undergoes very high strains. In the Poisson's directions the intergranular strains are particularly high (up to 5000 microstrain). During annealing substantial changes in the diffraction spectra are evidence of the Beta phase decomposition. By comparing the initial and the post heat treatment d-spacings, it was found that some strain relief occurred.

[1] E. Tenckhoff, *Deformation Mechanisms, Texture and Anisotropy in Zirconium and Zircaloy*, ASTM, Philadelphia, 1988, p. 77.

[2] J. W. L. Pang, T. M. Holden, P. A. Turner, T. E. Mason, *Intergranular stresses in Zircaloy-2 with rod texture*, Acta Materialia 47 (1999), pp.373-383.