In-Situ Measurement of Deformation-Induced Phase Transformation in Zr-Excel Alloy

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Samples of zirconium Excel alloy were heat treated to develop a high proportion of meta-stable b phase, and subsequently deformed in tension at room temperature. Prior work at Chalk River has provided evidence for a mechanically-induced phase transformation in Excel alloy. This study aimed to expand upon the ex situ work done previously at Chalk River Labs to provide further evidence for TRIP (transformation induced plasticity) behaviour.

Blanks were heat treated at 840C for 2 hours, followed by a water quench to room temperature. Samples were cut from the blanks and deformed at the L3 beamline with in situ neutron diffraction. Samples were prepared in two orientations, with deformation along either the plate rolling direction (RD) or the plate transverse direction (TD). Mechanical loading was performed in steps. Samples were deformed first in load control, in 75 MPa steps, up to 450 MPa. At each step, the sample was allowed to relax under load for 90 seconds, and diffraction measurements were subsequently taken for 20 minutes. The diffraction measurements involved the measurement of the lattice spacing, diffraction intensity, and peak width for the (10-10)α, (0002)α, (10-11)β, (110)β, and (0002)ω lattice planes. Above 450 MPa, samples were deformed in strain control, with diffraction measurement at 0.2% strain increments.

The evolution of diffraction peak integrated intensity along the loading direction with applied plastic strain is shown for a sample deformed along TD in Figure 1 and a sample deformed along TD in Figure 2. There is a clear decrease in the integrated intensity of the (110)β peak along the loading direction with increasing plastic strain in both samples. For the sample deformed along RD, there is a minor increase in the integrated intensity of the peaks measured in the α phase. Due to the texture of the sample, the (0002)α peak could not be measured in the sample deformed along RD. Similar behaviour is observed in the sample deformed along TD, although there is much greater activity observed in the peaks associated with the α phase.

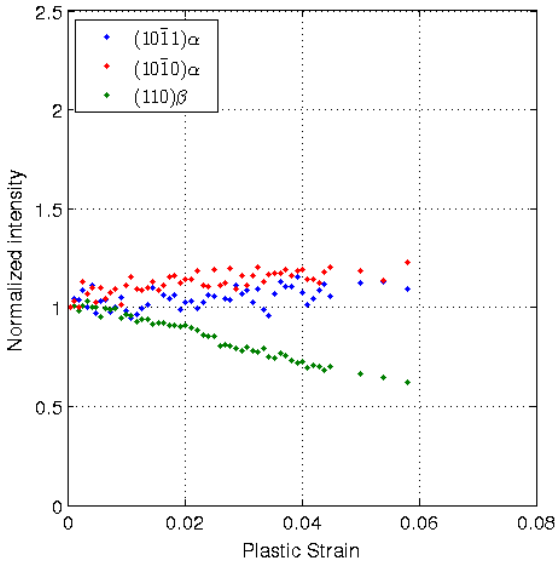

Figure 1 Evolution of peak integrated intensity with applied strain for a sample deformed along the rolling direction. Integrated intensity is shown, normalized against the initial integrated intensity in the unloaded state.

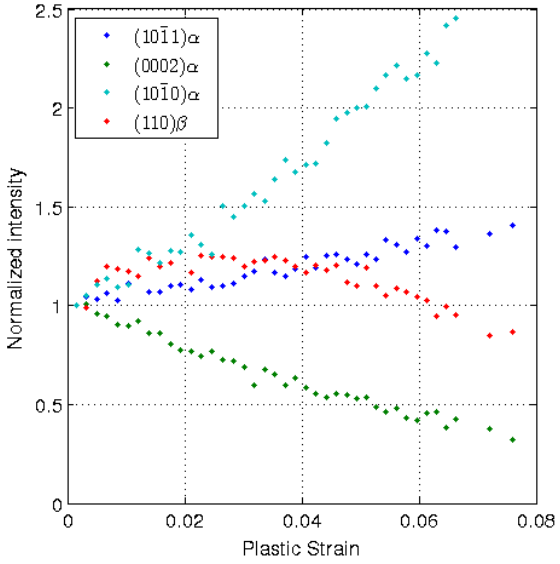

Figure 2 Evolution of peak integrated intensity with applied strain for a sample deformed along the transverse direction. Integrated intensity is shown, normalized against the initial integrated intensity in the unloaded state.