LSI SUPPORT FOR PhD-STUDENTS IN APPLIED AREAS

In-situ diffraction for determining deformation twinning behaviour in Ni based alloys

THE PURPOSE OF THE PHD PROJECT

Metals with a combination of high strength and high elongation are most desired for applications requiring high toughness. Twinning induced plasticity (TWIP), which occurs mainly in alloys with low stacking fault energy, is recognized as an important mechanism that can increase both the strength and elongation. High Ni alloys (Ni > 25 wt%) and Ni based superalloys have outstanding corrosion resistance, mechanical properties and high temperature resistance and have been extensively used in the most demanding industries such as aerospace, energy, power, chemical and petrochemical industries. These alloys usually have high stacking fault energy. The aims of the Ph D project were to investigate the TWIP behaviour and TWIP mechanisms in these alloys, especially the influence of temperature on deformation twinning.

USING A LARGE SCALE INFRASTRUCTURE

In-situ neutron or synchrotron diffraction experiment under tensile loading are well-established techniques for studying micromechanics and deformation induced phase transformation by analysing the changes of diffraction peak position, intensity, and peak width with the applied load. The ENGIN-X neutron diffractometer at ISIS Neutron and Muon Source in UK is dedicated to engineering science with test rig for in situ experiments at cryogenic temperatures. Together with its double detector banks, diffraction spectra containing a number of diffraction peaks can be obtained simultaneously along the loading axis and a transverse direction to the loading axis. It was therefore chosen for the wanted in situ neutron diffraction tests under tensile loading.

RESULTS AND IMPACT

A high Ni alloy (Sanicro 28) and a Ni based superalloy (Sanicro 60) were investigated for their deformation behaviour by. A Dog Bone type of sample with a diameter of 8 mm and a loading rate of $8x10^{-4}$/s were used. The test was controlled by position. The tests were originally planned to be carried out at 298 K and 77 K, however, an extra temperature, 30K, was also included for the effect of varying cryogenic temperatures. From the neutron diffraction patterns and strain behaviours, the followings have been obtained.

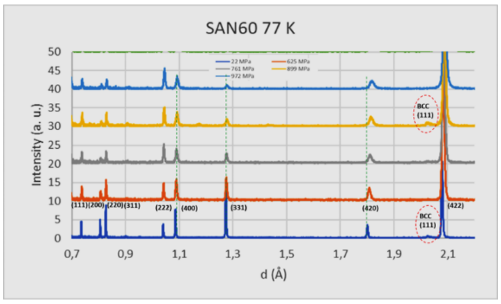
1. Advanced methodologies for have been learnt to characterize deformation twinning and TWIP effects in the materials during the deformation process.

2.Lattice strain and Young´s modulus obtained from the neutron diffraction patterns can correlate to the deformation and total fracture strain in the lattice plane that can predict if there is some deformation twinning occurred during the process.

3.Integral intensity ratio of the diffraction patterns, the integral intensity under loading normalized by the integral intensity before the loading, can predict the occurrence and amount of deformation twins. The amount of twins increases with increasing of integral intensity ratio.

4.The neutron diffraction results can predict the differences in in Sanicro 28 and Sanicro 60. Sanicro 28 has a higher integral intensity ratio of (111) lattice direction than Sanicro 60, indicating a high amount of deformation twins. Sanicro 28 has a (311) diffraction, but not Sanicro 60 (see Figure).

5.With the powerful neutron diffraction, very small amount of martensitic phase transformation can be observed in Sanicro 60, an unexpected result (see Figure).



The project has increased the knowledge and experience to use the neutron diffraction to study the deformation twinning behaviours in the important commercial alloys. With this powerful method, some unexpected results have been obtained.

The results can be used as recommendations or guides for the material applications in cryogenic temperature area, material development and production.

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