Engineering neutron diffraction for the study of displacive phase transformations

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This talk provides an overview of the application of engineering neutron diffraction instruments such as Salsa at ILL and ENGIN-X at ISIS to the study of displacive phase transformations. Such transformations are responsible for important aspects of material behaviour, such as work hardening of TRIP steels and superelasticity in shape memory alloys. Neutron diffraction is a useful tool for investigating these effects because it enables the sampling of large volumes of bulk material in situ whilst subjecting a specimen to different external conditions of temperature, stress, electric field, etc.

One key issue for which neutron diffraction is valuable is the examination of variant selection, whereby the action of a directional external load causes certain variants of a lower symmetry daughter phase to be formed preferentially from a higher symmetry parent phase. This phenomenon can be investigated by measuring the evolution of crystallographic texture as loading progresses. This subject is discussed for a range of materials including Fe-Pd shape memory alloy [1] and tetragonal PZT ceramic [2]. A strong analogy exists between the stress-induced variant changes exhibited by the former and electric field-induced variant changes exhibited by the latter material. This analogy is explored and a common method of analysis presented.

The application of the neutron diffraction method of internal stress measurement is also relevant for relating displacive transformations to mechanical behaviour. An example is presented of Fe-Ni-C TRIP steel [3]. Neutron measurements reveal load transfer from the parent to evolving daughter phase, suggesting that the phase transformation makes a significant contribution to the stabilization of plastic flow. In shape memory materials, it is demonstrated that internal stresses also play a role in reversing variant changes and encouraging superelasticity.

References

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