Deformation/transformation processes in NiTi revealed by in-situ neutron diffraction and modelling

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Smart materials as shape memory alloys (SMA) are being developed not for only their structural properties but for mainly the unique functions they perform under thermal and mechanical loads. These functions - basically reversible stress-strain-temperature responses due to deformation/transformation processes deriving from martensitic transformations - are therefore of major research interest from the SMA engineering application point of view. In order to be successfully utilized in engineering applications these functions need to be understood, modelled and precisely predicted. In this respect, the fact that multiple reversible hysteretic deformation processes become activated in SMA polycrystals exposed to thermomechanical loads seriously complicates the modelling. The only way one can experimentally detect the action of these processes in bulk SMA samples exposed to thermomechanical loads is to use dedicated in-situ observation techniques which detect the processes, but do not interfere with them.

We will try to demonstrate that a combination of in-situ neutron diffraction experiments [1] and micromechanics modelling [2] is a very efficient tool for such purpose. The main advantages of the in-situ neutron diffraction method in this respect are its bulk penetrability and sensitivity to structural and textural changes and to the lattice strain variations accompanying the reversible deformation processes in phase transforming materials. It will be shown that activity of individual deformation/transformation processes during various thermomechanical load cycles can be unambiguously recognized. Furthermore, the observed evolution of the peak intensities and positions can be interpreted with the help of micromechanics modelling as the evolution of the phase and martensite variant fractions and phase stresses in families of particularly oriented grains. The application of the method to the most successful shape memory alloy NiTi will be surveyed [1,2] (ENGIN-X at ISIS RAL Chilton, NPI Rez near Prague).

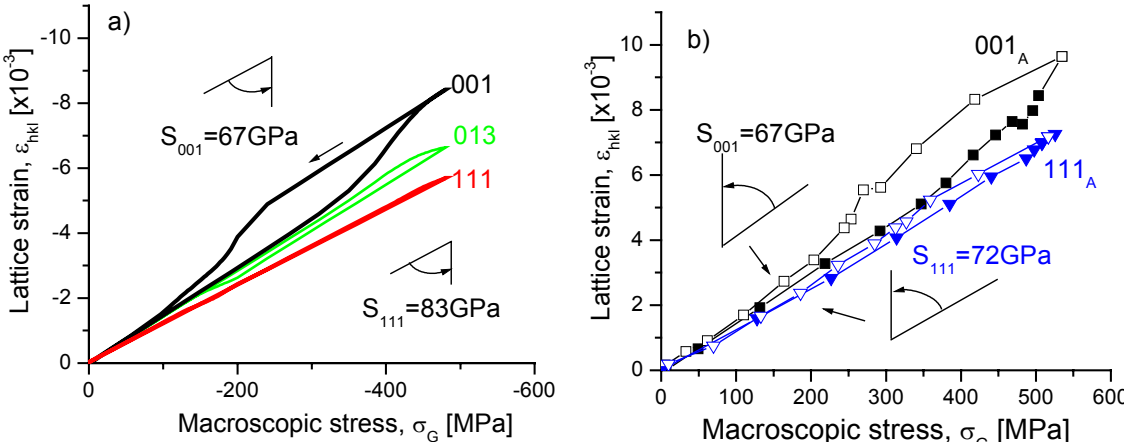

Figure 1: A comparison of simulated (a) and experimentally determined (b) lattice plane responses of selected austenite hkl reflections of pseudoelastic NiTi polycrystal deformed in compression [1,2]

References

[1] - P. Šittner, P. Lukáš, V. Novák, M.R. Daymond, G.M. Swallowe, Mater. Sci. Eng. A **378/1-2**, 97, (2004)
[2] - V. Novák and P. Šittner, Mater. Sci. Eng. A, **378/1-2**, 490, (2004)