Lectures - Session II, Monday, June 20

L5

ANALYSIS OF HIGHLY MOBILE TWIN BOUNDARY IN NIMNGA MARTENSITE BY X-RAY DIFFRACTION

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Introduction

Ni-Mn-Ga alloys close to stoichiometric $NINi_{50}$ $M_{25}Ga_{25}$ (at. %) composition have recently gained considerable interest due to the possibility of rearrangement of their martensite microstructure in magnetic field [1]. The five-layered martensite (10M or 5M) is usually considered as approximately tetragonal a=b > c with structure described by the lattice corresponding to original austenite. It serves well for describing magnetic shape memory effect and particularly for magnetic experiments and phenomenological modeling. More precise approach shows that 5M martensite can be described using monoclinic unit with small deviation between a and b and monoclinic distortion of about 0.3 deg [2]. In the following text the tetragonal description of diffraction lines will be used.

Sample

The single crystal of $Ni_{50.2}Mn_{28.3}$ $Ga_{21.5}$ (at.%) from AdaptMat Ltd was investigated. The sample faces are approximately parallel to {100} planes of austenite.The optical micrograph of studied boundary is plotted on Fig. 1. This single interface (twin boundary) is highly movable under the stress less than 0.2 MPa! One is able to move the twin boundary easily only by applying small stress by hands. Some more details about the studied material can be found in [3].

Experimental

The X-ray diffraction measurements were performed using X'Pert PRO PANalytical horizontal powder diffractometer. The Co anode (= 1.78901 Å) with point focus was used as an X-ray source. The irradiated volume was defined by a monocapillary with inner radius 0.1 mm, the approximate beam size is shown on the left-hand side of Fig. 1. This small beam makes possible a relatively precise x-direction mapping along the boundary. The sample was attached to ATC-3 texture cradle enabling rotation, inclination ( ) and *x*-movement of the sample. Simultaneous movement of the tube and detector allows for precise change of incident angle ( ). The diffracted beam was either limited by Soller slits (0.02 rad) to confine the -range of diffracting planes (up to 1°) or the slit were removed to allow simultaneous detection of two diffraction lines whose positions differs by as much as 3°. The X'Celerator multiple strip detector was used to detect the diffracted beam.

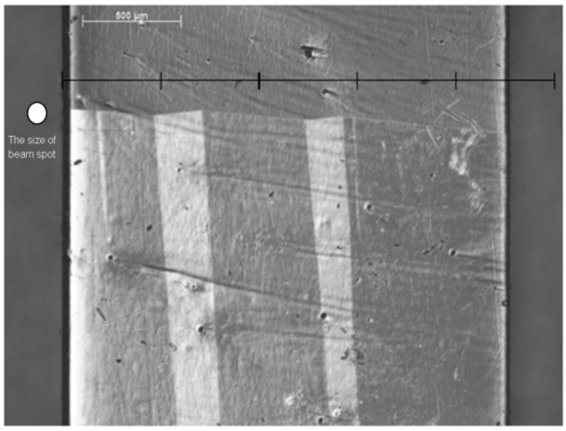

Figure 1. Highly mobile twin interface and associated domains in Ni-Mn-Ga single crystal observed using interference contrast (Nomarski contrast) with a Zeiss microscope. The XRD scans were performed horizontally along the macroscopic twin boundary. The size of the X-ray beam spot is marked on the left. Width of the sample is about 2.3 mm.

Firstly the sample is preoriented towards the laboratory system. Several -scans are performed for various angles until the values of and of any strong reflection are found. At the beginning the Soller slits are not used, when approximation position of is founded, then the Soller slit can be inserted and the -scan can be performed for previously found .

Results and discusion

Relating to Fig. 1, the X-ray diffraction confirmed that the upper part is c oriented and the lower part is *a* or *b* oriented perpendicularly to the plane. Since the lattice parameters *a* and *b* are very close, so their corresponding diffraction are not well resolved. Fortunately high angle diffraction (600) and (060) can be observed. Although these diffractions are very weak (more than 100 times in comparison to (400)!), in the case of monocrystal they have sufficient intensity to be detectable, see Fig. 2, and the *x*-direction mapping is possible to be made, see Fig. 3.

The x-direction mapping shows that in diffraction volume limited by monocapilary (~ 0.12 x 0.14 x 0.01 mm) occurs both a and b oriented variants. And that the period of possible a-b twinning is under spatial resolution of laboratory experimental conditions.

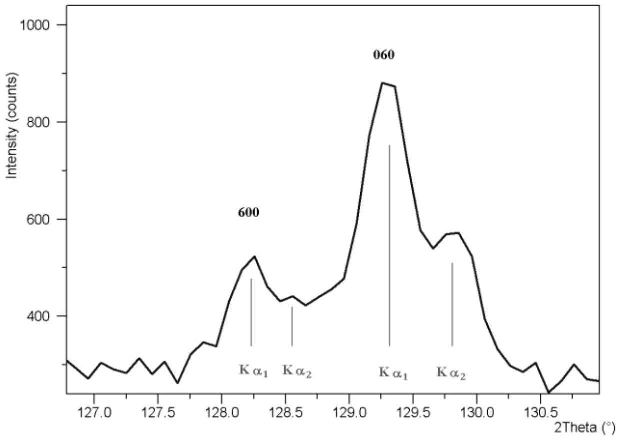

Figure 2. Simultaneous presence of and 600 orientations in diffracting volume. These two diffractions are relatively well separable. To avoid possible confusion, the spectral components of wavelength distribution K 1 and K 2 are marked by vertical lines.

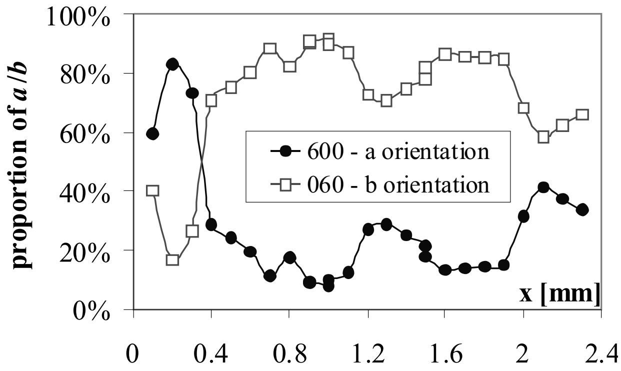

Figure 3. The x-direction mapping of ratios between *a* and *b* orientations. For two maxima in -scan also two 2 -scans were done for each position *x*.

References

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L6

COBALT BASED FERROMAGNETIC SHAPE MEMORY ALLOYS

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Great success in Ni_2MnGa derived alloys attracted attention to similar Heusler alloys including cobalt based alloys. The article describes the progress in work on $Co_{38}Ni_{33}Al_{29}$ alloy. After long struggle the defined crystals with single-crystalline matrix were prepared. The influence of annealing on martensitic transformation in these crystals was investigated. The martensitic transformation using magnetic susceptibility measurements we found to be $M_S \sim -73$ °C. The complex interaction between martensitic lathes and A2 particles was found. The discrepancy between transformation temperatures obtained by magnetic susceptibility measurements and resonant ultrasound spectroscopy will be discussed together with the results of the quasistatic and dynamic nanoindentation.

Extended contribution submitted.

L7

THE EXPLOITATION OF X-RAY DIFFRACTION IN CHARACTERISATION OF STRENGTH OF HOT-ROLLED AND COLD-DRAWN FERRITIC-PEARLITIC STEEL

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A series of samples of the C45 (0.45 wt.% C) steel was prepared by hot rolling with different thermomechanical history in an industrial-type rolling stage (e.g. rolling temperature and speed, cooling rate). The microstructure of resulting material was ferritic-pearlitic with a pearlite volume fraction ranging from 57 to 90%; the mean interlamellar spacing in the pearlite varied between 180 and 270 nm. An equally-spaced arrangement of misfit dislocations was found at the ferrite/cementite interfaces. The microstrain they generate was observed in the X-ray diffraction by means of anisotropic line broadening; the density of the dislocations was proved to be proportional to the density of the lamellas. The dislocation density was found to correlate with the ultimate tensile strength (UTS) of the steel in the tensile test as well as the density of the lamellas. Upon gradual cold drawing through conical dies, the dislocation density observed in X-ray increased up to about 50% of elongation, the UTS was still well-following its dependence on the dislocation density, while the density of pearlitic lamellas remained intact. The X-ray diffraction can thus be utilised for an instant and non-destructive estimation of UTS of hot-rolled ferritic-pearlitic steels and cold-drawn steels with moderate grade of cold deformation.

Extended contribution submitted.

L8

RÖNTGENOVÁ DIFRAKČNÁ ANALÝZA TROSIEK. EBSD ANALÝZA OBALOVÝCH PLECHOV

Martin Černík

US Steel Košice

Extended contribution to be submitted.

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NOVÉ MOŽNOSTI DIFRAKTOMETRU RIGAKU SMARTLAB

Jiří Maršík

Rigaku Innovative Technologies Europe

Lectures - Session III, Tuesday, June 21

L10

KVALITATIVNÍ A KVANTITATIVNÍ FÁZOVÁ ANALÝZA

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