Local texture measurements with high-energy synchrotron radiation on NiAl deformed in torsion

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Plastic deformation leads to crystallographic preferred orientations (texture) of the grains in a polycrystalline sample. Therefore, the study of these textures gives informations about the slip systems activated during the deformation. In this study the deformation of polycrystalline NiAl was done by torsion under confining pressure leading to crack-free samples with a well-defined strain gradient. NiAl, an ordered intermetallic alloy with B2 structure, is a potential material candidate for high-temperature applications.

Polycrystalline NiAl cylindrical samples with two different initial textures were deformed in torsion tests at 1000 K and 1273 K, respectively, in a Paterson-type rock deformation machine [1] under 400 MPa argon confining pressure. The diameter and height of the samples were 10 mm. The applied torsion leads to a simple shear in the tangential direction in a plane normal to the torsion axis. The shear strain and the shear strain rate in the samples increase linearly from zero at the torsion axis to a maximum ($\gamma_{\max} \cong 3$, $\dot{\gamma}_{\max} \cong 2 \cdot 10^{-4} s^{-1}$) at the sample edge. To investigate the local textures between the torsion axis and the edge, small pins with a diameter of 1 mm were prepared in the radial direction for each of the four deformed samples (Fig. 1).

Quantitative texture measurements were performed with high-energy (100 keV) synchrotron radiation at the beamline BW5 [2], [3]. The synchrotron radiation opens a possibility to investigate small sample volumes (local studies). Unlike electron back-scattering diffraction, the synchrotron beam method does not fail for materials deformed to high strains. Since the penetration depth of synchrotron radiation is much higher compared to conventional X-ray and electron beams, not only the sample surface but also the volume can be examined and thus a much better grain statistics is achieved.

The incident monochromatic beam was defined by a slit system to 1 mm x 2 mm. The small pins were mounted in the Eulerian cradle parallel to the rotation axis ω. An image plate detector was positioned perpendicularly to the diffracted beam at a distance from the sample of about 1.3 m. Thus, the Debye-Scherrer rings with the indices (100), (110) and (111) could be registered simultaneously. The pins were rotated around the ω-axis from 0° to 90° in steps of 3° resulting in 31 diffraction images. The integral intensities along the diffraction rings were determined using peak profile analysis [4] and then transformed into the corresponding pole figures.

The texture was measured as a function of the shear strain at five different positions between $\gamma = 0$ and 3. The samples deformed at 1273 K showed a poor grain statistics due to a large grain size. The corresponding pole figures are not shown here. The torsion deformation at 1000 K leads to much smaller grains. The corresponding (100) pole figures are shown for $\gamma = 1.5$; 2.3 and 3 and two different initial textures (Figs. 2a, b). With increasing strain the sample with initial <111> type preferred orientation parallel to the torsion axis develops a {110}<100> texture (notation: {shear plane}<shear direction>). The other sample, initially with the orientation <100> parallel to the torsion axis, shows a different type of texture characterized by {110}<110>. This indicates that the initial sample texture prior to the deformation influences the activation of slip systems contributing to strain. Further investigations of samples deformed to lower shear strains at lower temperatures are of particular interest for the investigated material and they will be continued.

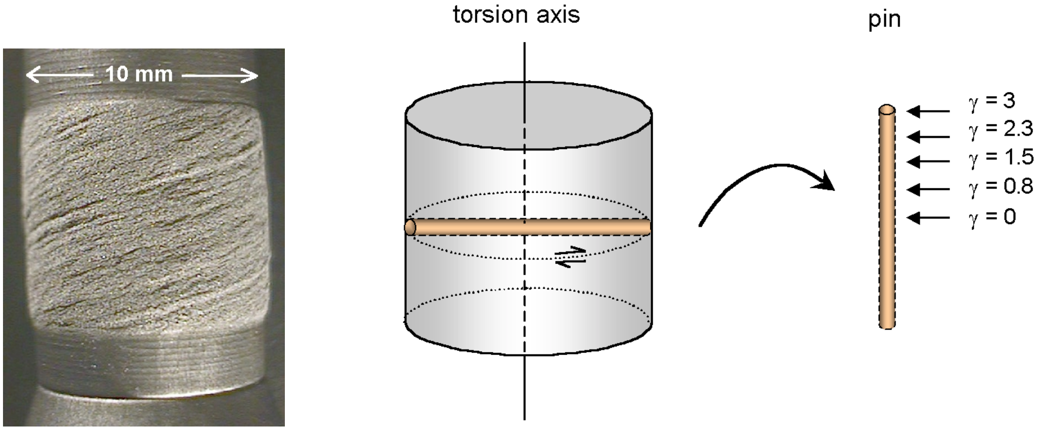

Figure 1: NiAl sample deformed in the torsion test with a sketch of the position of the pin taken for texture analysis. Different shear strains are indicated

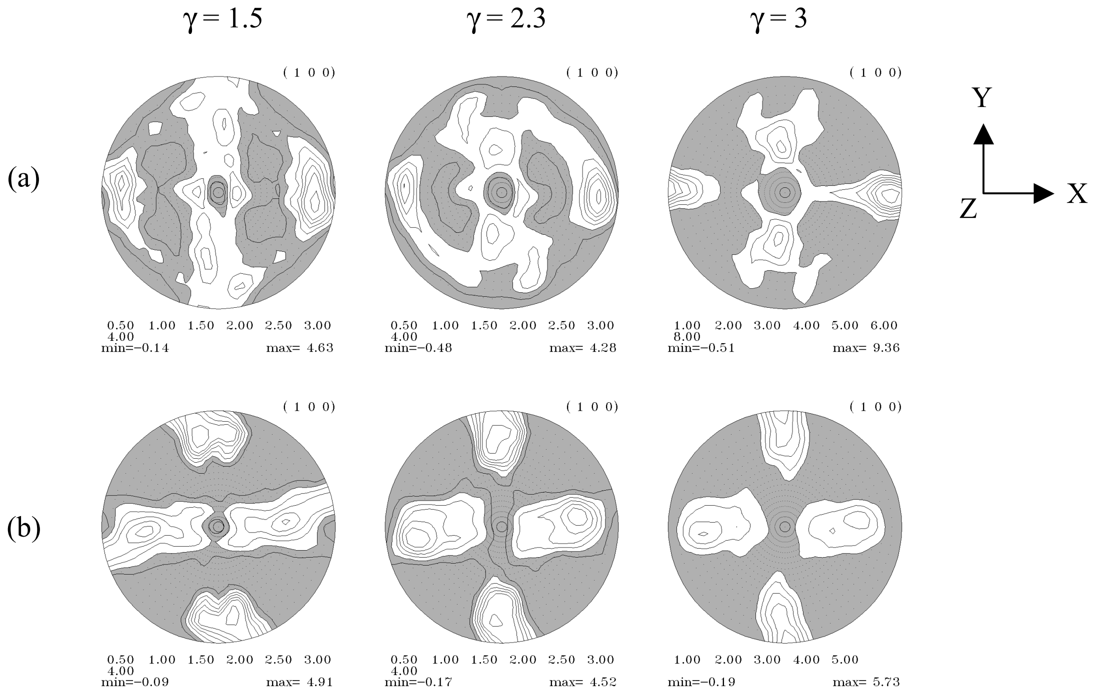

Figure 2: Shear textures represented by the (100) pole figures measured along the pin axis at different shear strains for initial textures with <111> (a) and <100> (b) parallel to the torsion axis, respectively. (Z: shear plane normal; X: shear direction; grey areas are below the level 1.0 of m.r.d.)

References

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