Strain dependent texture measurements with synchrotron radiation on torsion-deformed NiAl


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In torsion-deformed samples the shear strain increases linearly from the center to the sample edge. Therefore, to measure textures strain dependent, methods with high spatial resolution have to be applied. The method generally used to measure local textures is electron backscatter diffraction (EBSD) allowing orientation measurements of single grains. Although spatial resolution has been steadily improved in the past, limits are given for very small grain size and/or high strains and poor grain statistics. A new method to measure textures locally is to use synchrotron radiation, which has advantages compared to EBSD e.g. in terms of grain statistics. This is, because of the much higher penetration depth of synchrotron radiation compared to electron beams, not only the surface of the sample but also the volume can be examined.

Cylindrical polycrystalline NiAl samples with two different initial orientations (<111> and <100> preferred orientation parallel to the torsion axis) were deformed in torsion at temperatures of 527°C to 727°C to shear strains \( \gamma \approx 15.6 \) at the sample edges (for details see [1]). Small pins with diameter of 1 mm and height of 10 mm were prepared in the radial direction. Quantitative texture measurements on these pins were performed at the beamline W2. The texture was measured at five to seven different positions along the pin axis between the middle and the edge, corresponding to certain strain intervals. For every position, the pin was moved around the rotation axis \( \omega \) from 0° to 180° in intervals of 3°, resulting in 61 diffraction patterns. Each diffraction pattern consists of Debye-Scherrer rings with indices (100), (110) and (111), which were registered simultaneously using an image plate detector. This integral measurement over intervals \( \Delta \omega = 3° \) leads to an improvement of the grain statistics, especially if a sample predominantly consists of large grains (see [2]).

The Debye-Scherrer-rings were transformed into the corresponding pole figures as follows. First, the intensity along every ring has been read out in steps of 1° using fixed integration intervals. In the second step, the intensity values were copied into the corresponding pole figures on a 1° x 3° grid, which in the last step has been interpolated onto a grid of 5° x 5°.

The (100) pole figures are shown for six different shear strains \( \gamma \) and two different initial textures for a deformation temperature of 727°C (Fig. 1). The pole figures have been recalculated from the orientation distribution function. The <111> sample develops a {110}<100> shear texture (notation: {shear plane}<shear direction}). For the sample with <100> as initial preferred orientation, there is no similar texture development. At low strains, the {100}<100> component develops whereas for higher strains {110}<100> appears, too. The texture development primarily depends on the initial orientation. {110}<100> is a likely type of texture, since it represents the alignment of the primary slip system of NiAl with the slip plane {110} parallel to the shear plane and the Burgers vector <100> parallel to the shear direction. The tendency of formation of this texture is seen for both initial orientations. For the sample with <100> as initial orientation, the texture development indicates the additional activation of the{100}<100> slip system. Whether this has taken place will be checked by transmission electron microscopy. Further measurements will also concentrate on samples, which have been deformed in torsion at room temperature (high pressure torsion) in order to extend the temperature range to be investigated.
Figure 1: Recalculated (100) pole figures of samples deformed at 727°C for different shear strains (shear strain interval: $\Delta \gamma = \pm 1$ and $\pm 0.6$ for $<111>$ and $<100>$ sample, respectively). The projection plane is the shear plane (SD = shear direction, SPN = shear plane normal, TD = transverse direction). Maxima are given in m.r.d.

References