In-situ Measurements of Magnetically Driven Motion of Specific Individual Grain Boundaries in Zn with a High Field Magnet Microscopy Probe

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Introduction

Experiments with a space-resolving high magnetic field polarization microscopy probe were conducted [1]. This high field probe represents a unique means to collect data about grain boundary kinetics and energy by continuously tracking the position and the shape of a grain boundary in magnetically anisotropic, crystalline materials.

Experimental

Samples of 99,995% pure Zinc bicrystals containing <10$\underline{1}$0> grain boundaries were annealed with sample axis perpendicular to the magnetic field. Bicrystals containing either tilt or twist boundaries with misorientation angles in the range between 40° and 88° were examined. One of the two grains in the samples had its c-axis aligned parallel to the field, while the c-axis in the other grain was inclined to field direction. Due to the different alignment of c-axes in adjacent grains with respect to the magnetic field, a driving force for grain boundary motion is induced by the field, which is caused by different magnetic susceptibilities parallel and perpendicular to the c-axis in Zn. The grains with c-axis perpendicular to the field are energetically favored, which allows them to grow at the expense of grains with energetically disfavored orientations.

Results

During experiments at the NHMFL in March and October 2008, the kinetics of individual twist and tilt boundaries in high purity zinc were addressed. A mobility of different tilt grain boundaries was measured in the range between 340 and 385°C and the activation parameters for their migration were determined (Fig. 1a). Most notably, for the first time the motion of pure twist boundaries was measured in specially grown bicrystals. Twist boundaries are by definition planar boundaries. Their motion, therefore, cannot be investigated by conventional methods (capillary driven curved boundary motion).

In contrast, the magnetic driving force provides the opportunity to measure the motion of a boundary with a well defined structure. The results prove that contrary to previous conception <10$\underline{1}$0> twist boundaries in Zn are at least as mobile as <10$\underline{1}$0> tilt boundaries. Further experiments with various twist and tilt boundaries are necessary to obtain a larger set of kinetics data at different temperatures. The misorientation dependence of grain boundary mobility then can be determined and compared for boundaries with twist and tilt character, which will lead to a better understanding of the mechanisms of grain boundary migration.

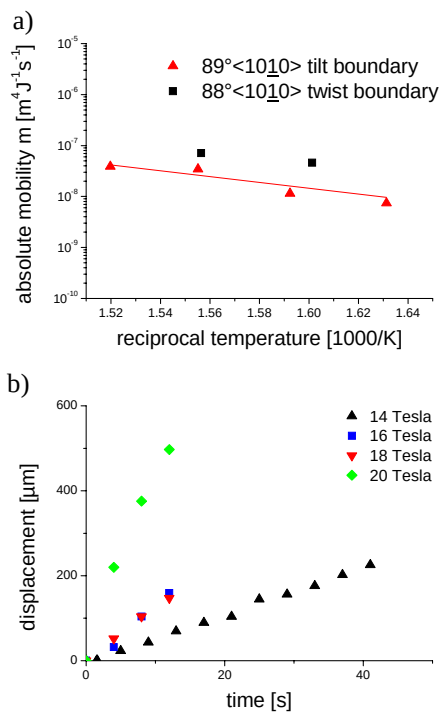

Fig. 1: a) Mobility of 89°<10$\underline{1}$0> tilt and 88°<10$\underline{1}$0> twist boundary
b) Boundary displacement versus time for a 88°<10$\underline{1}$0> twist boundary at temperature 350°C in a magnetic field of different strength

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References

[1] P. J. Konijnenberg et al., Rev. Sci. Inst. 79, 013701 (2008)