IN SITU MEASUREMENTS OF GRAIN BOUNDARY MIGRATION WITH A HIGH MAGNETIC FIELD POLARIZATION MICROSCOPY PROBE

P.J. Konijnenberg, D.A. Molodov and G. Gottstein, (RWTH-Aachen University, Institute of Physical Metallurgy and Metal Physics)

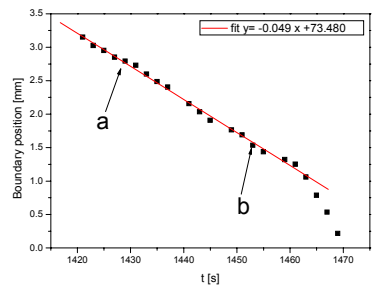
Introduction

A space resolving high magnetic field polarization microscopy probe has been developed to track grain boundaries at the surface of magnetically anisotropic metals during magnetic annealing at high field strengths. It is known from experiments that also in non-ferromagnetic anisotropic materials a sufficient driving force for grain boundary migration can be provided by external high magnetic fields [1,2,3]. Two major advantages in this approach to measure boundary properties are a constant, adjustable and accurately known driving force and the possibility to drive plane grain boundaries with a uniform and well defined boundary structure.

Experimental and Results

In essence this probe comprises a conventional polar magneto-optic Kerr setup. An incident light polarizing microscope with CCD camera in field direction is arranged over a sample chamber at the field center. The gas tight sample chamber is equipped with a quarts window and an adjustable DC resistance heated sample stage perpendicular to the field direction. The heater temperature is gauged by two platinum resistance sensors to avoid malicious magnetic drift effects on usual thermocouples. The sample temperature is derived from a calibration curve and accurate within 1K. For lower than cubic crystal symmetries, grain boundaries become visual as a contrast between differently orientated crystallites due to a plane polarized LED-illumination in combination with an analyzing filter in front of the CCD. A large Faraday rotation of the polarisation plane in the field can be anticipated to thanks to a spectral half width of 20-30nm. With a remote head camera, microscope images are digitally stored at regular instances. Focus and both polarizing filters are remote controlled by three DC stepper motors on top of the magnet, 1.4m off axis. The current configuration was successfully tested at sample temperatures up to 673K and fields of 25T in the 50mm Keck magnet.

Exemplary in fig.1 the boundary position is shown versus annealing time of an individual nearly plane high angle boundary in Zn (99.99+%) at about 603K and 25T in a bicrystalline sample (2x4x15mm^3). It shows a constant boundary velocity (0.049x10^{-3}m/s) over a macroscopic distance of 2mm. The difference in free energy density due to the misalignment of both grains with the field is approximately 1.2KJ/m^3 (<5141> 81° asymmetric tilt grain boundary). From this the absolute mobility of this boundary structure at this temperature (m=v/p) becomes 4.1x10^{-8} m^4/Js.



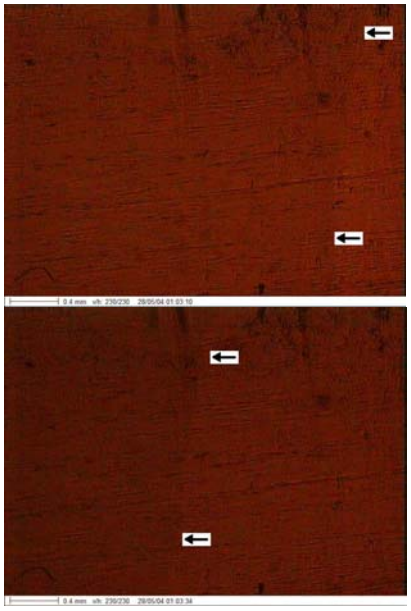


Fig. 1 Boundary position vs. time. Data points: a - upper image, b - lower image.

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