doi:10.1017/S1431927610058496
Microsc. Microanal. 16 (Suppl 2), 2010

Fringe Contrasted Images of Grain Boundaries in $Fe_{81}Ga_{19}$ Thin Films

M. Shamsuzzoha

School of Mines and Energy Development, University of Alabama, Tuscaloosa, AL 35487, USA

Fringe contrast microscopy is routinely applied to characterize defects in crystals such as those shown in Figure 1. The process has been applied to reveal grain boundary morphology in $Fe_{81}Ga_{19}$ thin films. Typical TEM images taken from thin films of $Fe_{81}Ga_{19}$ [1] prepared by a magnetron sputtering technique were found to reveal very little grain boundary morphology. Figure 2 shows a typical bright field image of the film in which no grain boundary is visible. Diffraction patterns taken from the film always yielded well-defined diffraction arcs at certain positions of related but rather weak diffraction rings. This characteristic of diffraction patterns is only found in textured material. This suggests that the thin film of $Fe_{81}Ga_{19}$ is well-textured with a microstructure that contains a large number of at least small-angle grain boundaries.

Fringe contrast microscopy is based upon kinematical and dynamical contrast theories of image contrast [2, 3] for which imaging is procured with only one diffracted beam. In a single crystal, the image contrast is dependent upon the movement of the associated Kikuchi line that is normal to the line joining the spot with the origin. A diffraction pattern of a well-textured thin film taken with an electron beam normal to the texture plane is similar to an otherwise a single crystal of the same material. Only the texture film shows an arc at the position of the spot of otherwise a single crystal. For this multiple-beam condition, the Kikuchi line for each spot in the arc present in the pattern of textured film is not parallel to each other. So qualitatively it can be stated that the movement of the Kikuchi lines belonging to every spot present in the arc results in a variation of contrast that is different than that of a single spot of the arc. Consequently the image contrast for this diffraction condition can not be interpreted, as evident in figure 2.

If the film is spherically symmetric in bending, then Kikuchi lines for each of the spot present in the diffraction arc of a zone axis diffraction pattern are not only uniformly dispersed over the spot but also normal to the line that joins the spot to the origin. Such dispersed Kikuchi lines for all spots of the arc are superimposed on each other. The combination of such a large number of Kikuchi lines forms a more or less uniform dispersion cloud of diffuse scattering and results in overall image contrast that appears more or less uniform. This uniformity in contrast can reveal many features of the film, such as interfaces in thin film. Figures 3a and 3b are such TEM image and diffraction patterns that were taken from a spherically symmetric bent region of $Fe_{81}Ga_{19}$ thin film. Presence of symmetry in the visibility of grain boundaries in Figure 3a is suggested to be observed by such image contrast.

References

[1]. J. L. Weston, A. Butera, T. Lograsso, M. Shamsuzzoha, I. Zana, G. Zangari, and J. Barnard, IEEE Transactions on Magnetics, 38, No 5, (2002) 2832.
[2]. G. Thomas and M. J. Corrings, *Transmission Electron Microscopy of Materials*, John Wiley. New York, 1979-
[3]. J. M. Cowley, A. F. Moodie, Proc. R. Society London, Ser. A76 (1960) 3378.

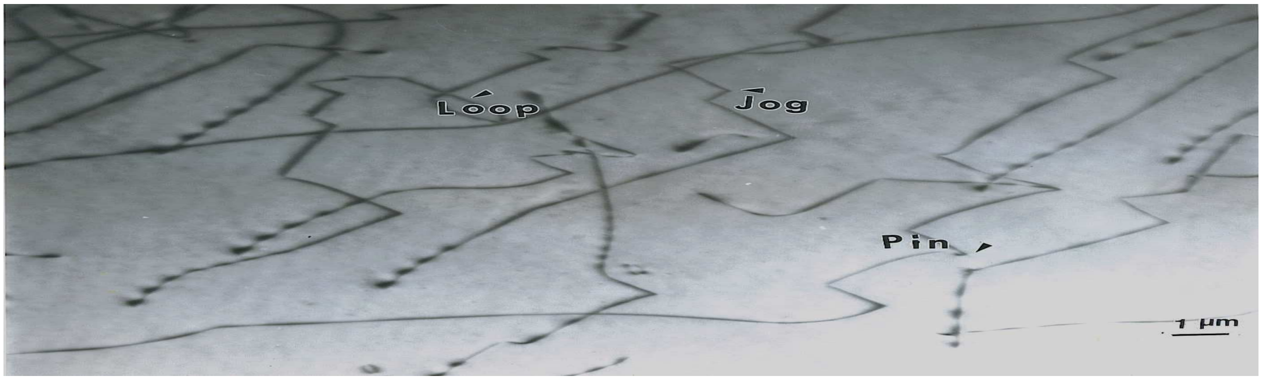


Figure1. TEM bright field image showing various defects mainly of dislocations present in a grain of 99.999% pure Al that was cold rolled to 99%, and then annealed at 300°C for 24 hours.

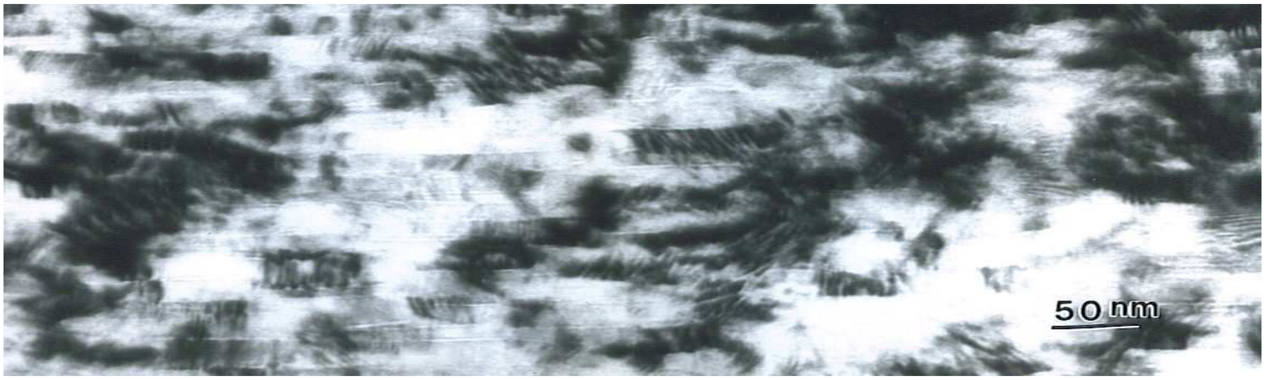
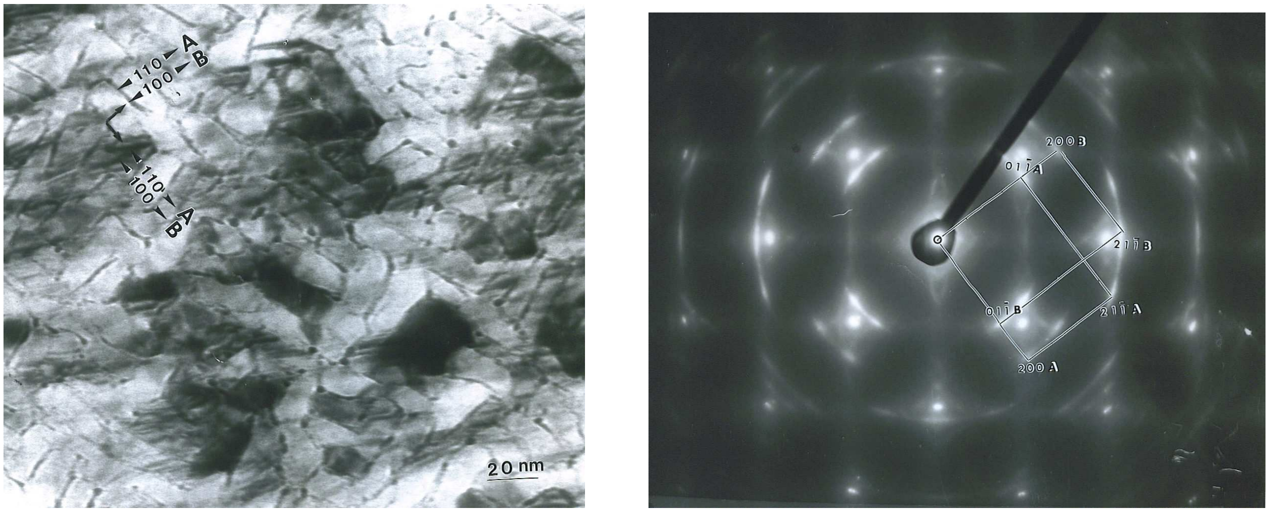


Figure2. TEM image of the grain structure of 160 nm $Fe_{81}Ga_{19}$ deposited onto 90 nm Cu underlayer. Note the absences of grain boundaries in the image.



(a) (b)

Figure (3a). TEM image of the grain structure of 160 nm $Fe_{81}Ga_{19}$ deposited onto a 90 nm Cu underlayer. Note the presences and uniformity of the grains in the film, (3b).Selected area diffraction pattern from the thin film of Figure 3a.