

THIN FOIL EFFECTS ON DIFFRACTION RINGS IN CuZr BASED BULK METALLIC GLASS

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Bulk metallic glass (BMG) is an amorphous material with no long-range order. Still, topological and chemical short-range or medium-range order is expected to occur. The unique atomic structures of BMG lead to interesting physical and mechanical properties that make them useful for potential applications. In order to obtain structural information transmission electron microscopy (TEM) methods as electron diffraction or fluctuation electron microscopy can be applied. In all cases thin TEM specimens need to be prepared using various preparation methods such as ion milling or electro polishing.

In this work using Cu₃₆Zr₄₈Al₈Ag₈ BMG, changes in the selected area electron diffraction (SAED) pattern as a consequence of structural heterogeneities were observed while comparing sites of different specimen thickness. As-cast samples and samples deformed by rolling were prepared by procedures including ion milling or electro polishing using a solution of 33% nitric acid and 66% methanol. The samples were studied in a Philips CM200 operating at 200kV. The used apertures select areas of diameter 300 or 1200 nm. While the bulk material is characterized by a single intense diffraction ring at small scattering vector (ring C in Figure 1(c)), thin areas like the edges of holes exhibit two diffraction rings of less intensity (A and B in Figure 1(a)). Figure 1(b) shows the transition state. Using the software PASAD [1] the integration of the intensity along diffraction rings yields intensity profiles as shown in Figure 1(d). Peak C corresponding to the bulk state arises between the two diffuse rings when the thickness increases.

The maxima of intensity are located at about 3.6, 4.7 and 4.3 nm⁻¹ for peaks A, B and C. Energy-dispersive x-ray spectroscopy shows a significant concentration of oxygen correlated to thin areas with peaks A and B dominant. Also, the position of peak A is equal to that of amorphous zirconia. In literature, similar double diffraction rings in a Cu₃₂Zr₅₁Al₉Ni₈ alloy are formed during in-situ heating and result from the formation of heterogeneities due to the annealing process [2]. Here, due to the observation of double rings also in samples prepared by electro polishing, heating effects by ion milling can be excluded as a cause.

Based on our results, it is concluded that the oxidation of Zr leads to the formation of three layers in CuZr-based materials. A surface layer consisting of amorphous zirconia causes peak A. The layer beneath is an amorphous CuZr structure with less Zr content (peak B) due to the oxidation of Zr in the top layer while the inner layer remains with the original CuZr ratio (peak C). The shift of the maximum from B to C when the Zr content is changed is supported in literature by X-ray studies [3].

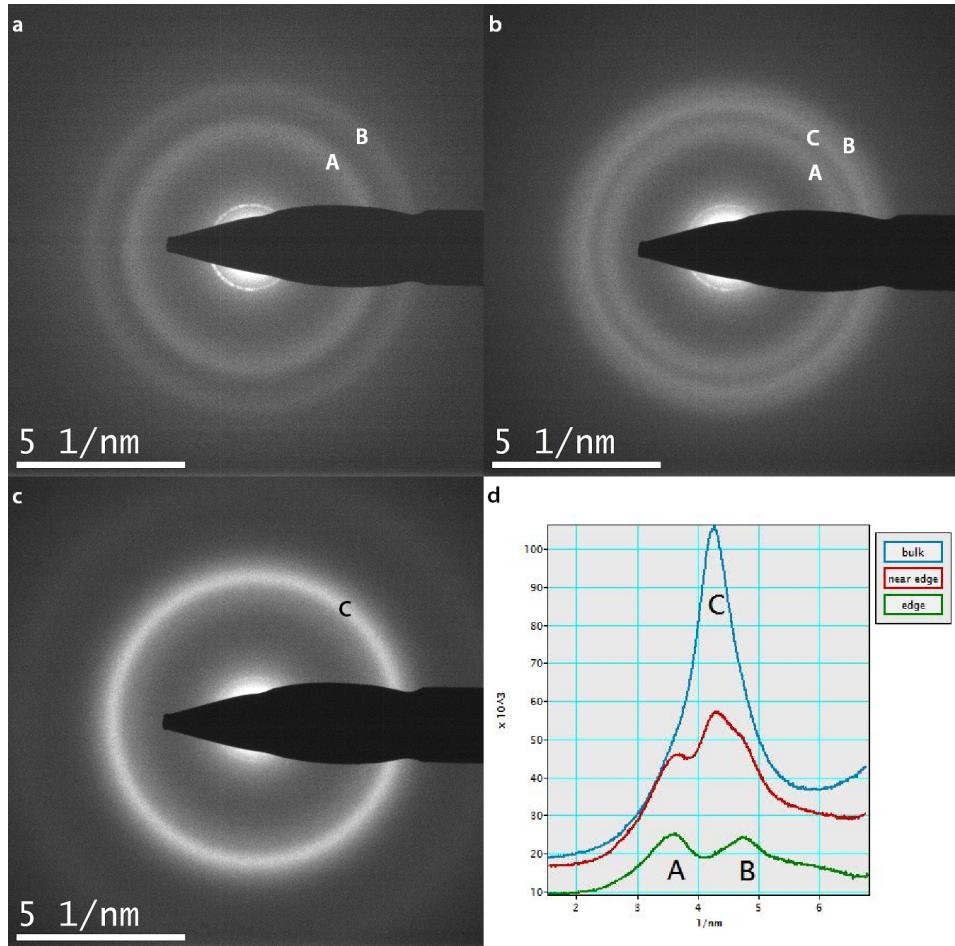


Figure 1: (a) SAED pattern of $\text{Cu}_{36}\text{Zr}_{48}\text{Al}_8\text{Ag}_8$ taken at the edge of the sample exhibits 2 diffuse diffraction rings A and B at small scattering vector. (b) Observation of diffraction rings A, B and C in sample areas near the edge. (c) SAED pattern showing an intense ring C corresponding to the bulk state. (d) Integrated intensities of the diffraction rings shown in Figures (a), (b) and (c).

References

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