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EBSD Analysis for Microstructure Characterization of Zr-based Bulk Metallic Glass Composites

Jessica Booth[1], John Lewandowski[1], Jennifer Carter[1]

[1]Dept. of Mat. Sci. and Eng., Case Western Reserve University, Cleveland, OH, 44106

Bulk metallic glasses (BMG's) have long been materials of interest due to their high strength, high elastic limit, wear and corrosion resistance, and ease of thermoforming above the glass transition temperature [1]. The primary technical challenge of implementing BMG's in engineering applications is their tendency to fail catastrophically via highly localized shear banding events. Though the elastic limit of BMG's approaches 2% [2], the ductility in uniaxial tension is negligible. One way to improve ductility in these materials is to allow the *in-situ* precipitation of a crystalline phase within the BMG alloy matrix. The ductile second phase acts to both arrest and initiate multiple shear bands, improving toughness by increasing the fracture surface area and preventing failure by a single shear band [3].

Bulk metallic glass matrix composites (BMGMC's) are a class of materials designed to utilize the strength and elasticity of monolithic bulk metallic glasses (BMG's), as well as the ductility and fracture predictability of crystalline materials. Many studies have characterized the mechanical properties of BMGMC's [4], [5], but the active deformation mechanisms in these newer materials is not fully understood.

The goal of this research is to apply electron backscatter diffraction (EBSD) methods to study the deformation mechanisms of the crystalline dendrites of a BMGMC alloy with a composition of $Zr_{41.2}Ti_{13.8}Cu_{12.5}Ni_{10}Be_{22.5}$ (at%) deformed at different temperatures. EBSD analysis is routinely used to characterize the microstructure of crystalline materials, including quantitative measures of crystalline orientations, phase fractions, grain boundary morphologies and qualitative measures of residual strain through misorientation measurements [6].

The material studied consists of an amorphous matrix with approximately 40 vol% secondary phase (Zr-Ti-Nb dendrites with a body centered cubic crystalline structure). Specimens were tested in tension at temperatures of -70°C, 25°C, and 330°C, resulting in true failure strains between 0.14 and 17.5. Specimens were then sectioned along the tension axis and polished using mechanical and chemical methods to produce a deformation free surface. Systematic variations in localized deformation in dendrites were observed as a function of temperature/failure strains. EBSD scans were taken at regular intervals along the gage length of each specimen to quantify the differences in dendrite shape, texture, and local misorientation with progressing deformation.

Preliminary results suggest that deformation accumulation is dependent on crystallographic orientation of dendrites with respect to the tensile axis. Dendrites oriented with a <101> direction parallel to the tensile axis produced indexable Kikuchi patterns even in highly deformed regions (Fig 2). This would indicate that these dendrites experience little plastic deformation. In undeformed samples, Fig 1, all dendrites produced indexable Kikuchi patterns and almost 40% of the area of the sample produced data; this is approximately equal to the specimen dendrite volume fraction. The undeformed scan area shows no measureable texture; the orientation of dendrites appeared to be evenly distributed between the <100>, <111>, and <101> directions. In the most highly deformed region, only 0.38% of the area

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scanned produced usable patterns, while the dendrite content remained constant. In intermediate strain regions (Fig 2), 18% of the scanned area produced indexable patterns and there is a preferred texture, most dendrites indexed have a <101> direction parallel to the tensile axis. This indicates that dendrites oriented with a <101> parallel to the tensile axis are least likely to experience plastic deformation that would result in Kikuchi pattern degradation.

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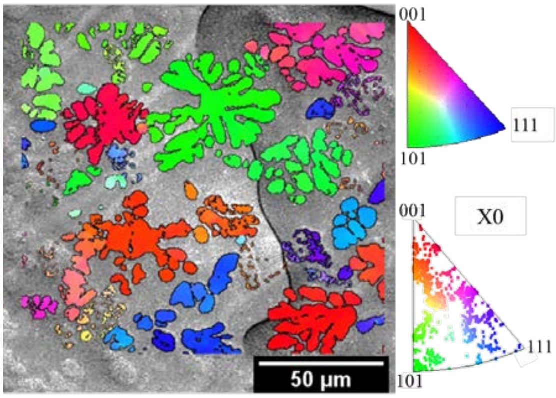

Figure 1: SEM image of nominally undeformed deformed region overlaid with EBSD data to show complete mapping of existing dendrites in the gage section of a sample tested at 330°C. IPF map on bottom right shows the nominally even distribution of orientations.

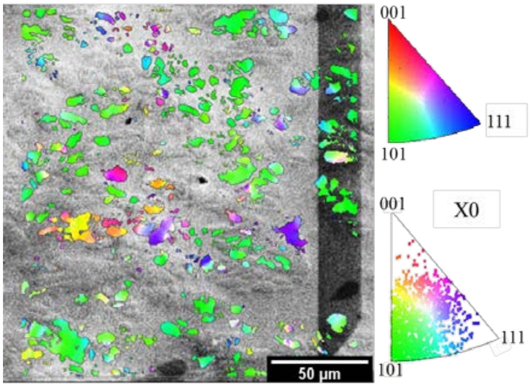

Figure 2: SEM image of deformed region (0.75 strain) overlaid with EBSD data to show incomplete mapping (18.4%) of existing dendrites in same sample. IPF map on bottom right shows predominant direction parallel to <101> direction.

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