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Comparison of OIM and XRD Texture Determinations in a Deformation Processed β-Ti +Y Metal-Metal Composite

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The preferred orientation of a heavily deformed Ti-V-Y metal-metal composite was measured by both orientation imaging microscopy (OIM) and by θ–2θ X-ray diffraction (XRD). The two methods gave conflicting results. OIM showed a strong <111> fiber texture in certain regions of the BCC Ti matrix, while XRD indicated that the Ti matrix had a <110> fiber texture. In the Y phase, OIM gave no usable information about preferred orientation, while XRD indicated a $< 10\bar{1}0 >$ fiber texture.

A deformation processed metal-metal composite was produced from a cast ingot of 60% Ti, 20% V, and 20 weight % Y (Figure 1). Y is immiscible in solid Ti and V, so this alloy solidifies with a matrix phase of β-Ti (a metastable BCC solid solution of 75%Ti and 25%V) containing a Y second phase. Although the binary equilibrium phase diagram for Ti-V predicts a two-phase HCP-Ti + BCC-V structure for a 75Ti-25V alloy below 950 K, the transformation to the equilibrium two-phase structure during cooling is sluggish. X-ray diffraction of the material at room temperature showed the matrix to be a metastable single-phase BCC Ti-V solid solution; no HCP α-Ti XRD peaks were detected in the as-cast or the deformation processed material.

X-ray texture analysis for these specimens was done by a simple comparison of XRD peak intensities from randomly oriented grains of Ti-V solid solution and pure Y with the peak intensities obtained by XRD θ-2θ scans on the DMMC. The XRD patterns in Figure 2 indicate the HCP Y second phase had the expected $< 10\bar{1}0 >$ fiber texture, and the BCC matrix had the expected <110> fiber texture. Although XRD θ-2θ scans can indicate the presence of texture, they do not give accurate quantitative information about the degree of preferred orientation; in an attempt to obtain that information, OIM analysis was performed on the Ti-20V-20Y (η= 2.6) specimen.

The initial OIM analysis of a transverse section of the as-extruded material produced texture determinations with unacceptably low confidence factors (.08) and showed no reproducible texture determinations from one scan to the next. Since residual stresses in the specimen can degrade the quality of OIM data, the specimen was then given a 1.8 ks stress relief anneal at 900 K *in vacuo*. Prior work with Ti DMMC's has shown recrystallization does not occur below 1000 K for this time interval; so this anneal was intended to provide stress relief without recrystallizing the material. After annealing, OIM analysis of the specimen showed regions a few micrometers across with a strong <111> fiber texture, but all other areas displayed the same low confidence factors that had been observed prior to the anneal (Figure 3).

The contradictory results from XRD θ-2θ scans and OIM are presumably attributable to the sample volumes examined by the two methods. For XRD using Cu X-rays incident on a Ti sample, the diffracted signal emanates from a depth of 0 to 20 µm below the sample surface; however, the back-scattered electrons used for OIM analysis emanate from a depth of only 0 to 0.3 µm. The thin specimen volume probed by OIM below the surface carries residual stresses from metallographic polishing and may experience recrystallization at anomalously low temperatures due to the ease of nucleation at the free surface. It is noteworthy that a 900 K anneal changed the OIM result but had no effect on the XRD pattern; however, the much deeper specimen volume probed by XRD is more representative of the overall texture in the specimen.

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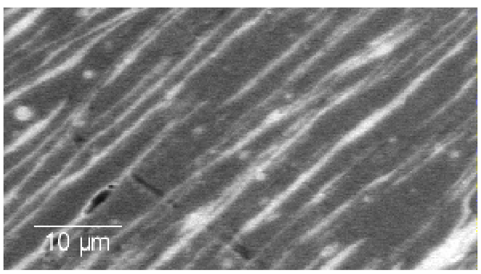


Figure 1 - SEM back-scattered electron micrographs of a longitudinal section (left image) and a transverse section (right image) of the filamentary microstructure in Ti-20V-20Y extruded at 1150 K to η = 2.6. Dark gray areas are Ti-V solid solution; light gray areas are Y.

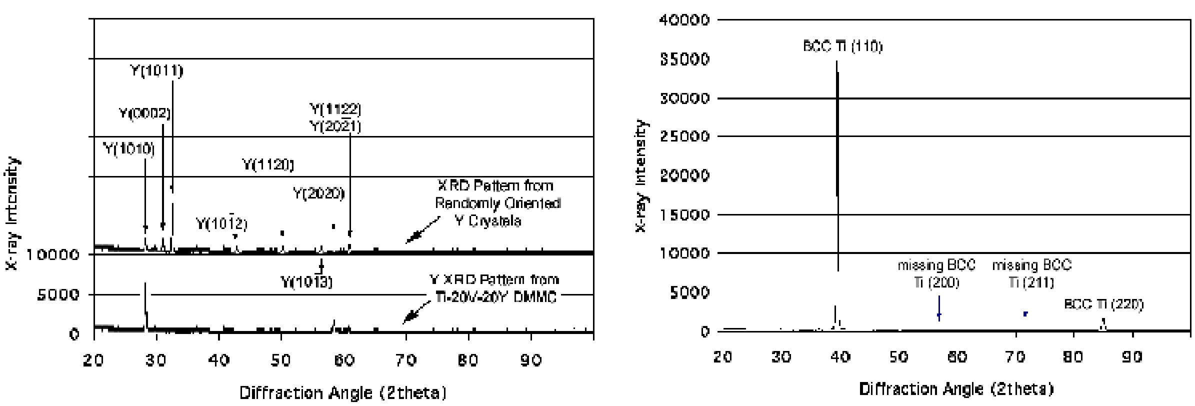
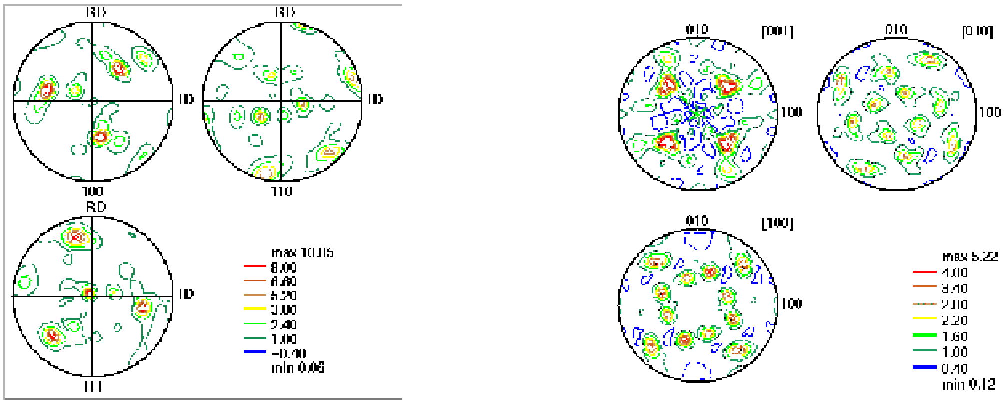


Figure 2. XRD patterns from Ti on the right and randomly oriented Y grains and heavily textured Ti-20V-20Y DMMC on the left. Note: Due to the dominant $< 10\bar{1}0 >$ fiber texture in the DMMC, only the (1010) and the (2020) Y peaks are apparent.



Figures 3. OIM pole figure and inverse pole figure indicating a <111> fiber texture in the Ti phase of the composite after a 1.8 ks stress relief anneal.

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