Recovery and Recrystallization Behavior of Nb-1Zr and Group VB Metals

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As part of the SP-100 program, attempts were made to correlate the creep properties of Nb-1Zr with alloy composition and grain size in annealed microstructures. Although an extensive number of creep tests had been performed in this program, several anomalies were observed which could not be correlated with either composition or grain size. In studies at ORNL, recent insights into the recovery and recrystallization behavior of Nb-1Zr have been achieved, which may explain some of the anomalies. A preliminary Transmission Electron Microscopy (TEM) study of archived material from the SP-100 and CANEL programs suggested that recovery of the as-deformed microstructure occurred instead of recrystallization in various Nb-1Zr heats following final heat treatments at temperatures up to 1400ºC. Following these observations, a study was conducted to gain a better understanding of several factors that may affect the recovery and recrystallization behavior of Nb-1Zr. These factors included the magnitude of cold-deformation, annealing temperature, heating rate, and texture in the microstructure. It has been found that the archived Nb-1Zr material (SP-100 heat 531027) used in this study appears resistant to recrystallization at temperatures up to 1650ºC. A rapid heating rate to the annealing temperature was found to have some beneficial effect on recrystallizing grains. In this presentation, the results of the analysis of the microstructure texture, grain size, and grain structure in annealed microstructures using advanced microstructural characterization including X-ray diffraction (XRD) pole mapping, back-scattered electron pattern (EBSP) mapping, and TEM will be shown for specimens of Nb-1Zr that were cold-rolled to 20%, 50%, 80%, and 95% reduction-in-thickness and heat treated at temperature ranging from 1500 to 1650ºC with different heating rates. It will be shown that detailed microstructural characterization using TEM and possibly high-resolution back-scattered electron pattern (EBSP) mapping are essential for assessing the recrystallization of grains in the Nb-1Zr alloy. An overview comparing these results with those obtained from studies of the similar group VB metals V, Nb, and Ta will also be presented.

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