Quantifying the Recovery of Cold-Worked Zr-2.5Nb using X-ray Diffraction Line Profile Analysis

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The recovery kinetics of dislocation structures formed by either cold-work or irradiation are expected to be different due to the dissimilar configuration of lattice dislocations and dislocation loops. Unirradiated Zr-2.5Nb pressure tube material was plastically deformed at 250 deg C to introduce a high density of cold-work dislocations at the same temperature at which dislocation loops form in the material while in service in nuclear reactors. Samples of the cold-worked Zr-2.5Nb were annealed isothermally for various lengths of time at multiple temperatures and were measured using high resolution synchrotron X-ray diffraction. The diffraction patterns were evaluated by Diffraction Line Profile Analysis (DLPA) using the Convolutional Multiple Whole Profile (CMWP) method to quantitatively characterize the dislocation density and character as a function of annealing time and temperature. Using this information, the activation energy and the pre-exponential factor of the recovery process was obtained for cold-work dislocations. The results will be compared to the recovery kinetics obtained for irradiated Zr-2.5Nb using neutron diffraction and the differences will be discussed.

Keywords: X-ray diffraction, line profile analysis, dislocations, recovery, zirconium, cold work.