Relationship of Grain Boundary Structure and Mechanical Properties of Inconel 690

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Stress corrosion cracking, the failure of a material due to environmentally assisted crack nucleation and propagation, is a serious metallurgical problem with impact on current and future designs of ship structural components and nuclear reactors. Stress corrosion cracking results from the combination of a material with known susceptibility, the presence of tensile stress and a corrosive environment. Initiation of stress corrosion cracking is difficult to detect and highly localized conditions that cause this phenomenon to occur can be difficult to control through the life of components in systems with long designed service lives in harsh environments. As a result, inhibition of stress corrosion cracking is a particularly challenging problem. Stress corrosion cracking occurs intergranularly, or along grain boundaries. The mechanism of stress corrosion cracking is thus considered to be highly dependent on microstructure and alloy composition. Therefore, inhibition can be achieved through a better fundamental understanding of the microstructural characteristics at the material's grain boundaries.

This thesis identifies the relationship between the microscale structural nature of grain boundaries and their mechanical properties in relation to their impact on the resistance to stress corrosion cracking in Inconel 690. The approach combines the use of nanoindentation, electron backscatter diffraction, and grain boundary engineering to study the properties of grain boundaries as a function of their structure. First, grain boundary engineering is accomplished on Inconel 690 through thermomechanical processing to produce samples with a variety of grain boundary structures. Next, grain boundaries of interest are identified using electron backscatter diffraction analysis. Finally, nanoindentation is used to extract mechanical properties at and near the selected grain boundaries, providing data for analysis of nanomechanical and structural properties in Inconel 690.

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