

Materials Science & Engineering Dissertation Defense

Crack Injection as a Mechanism for Stress-Corrosion Cracking

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Abstract

Traditionally nanoporous gold is created by selective dissolution of silver or copper from a binary silver-gold or copper-gold alloy. These alloys serve as prototypical model systems for a phenomenon referred to as stress-corrosion cracking. Stress-corrosion cracking is the brittle failure of a normally ductile material occurring in a corrosive environment under a tensile stress. Silver-gold can experience this type of brittle fracture for a range of compositions. The corrosion process in this alloy results in a bicontinuous nanoscale morphology composed of gold-rich ligaments and voids often referred to as nanoporous gold.

Experiments have shown that monolithic nanoporous gold can sustain high speed cracks which can then be injected into parent-phase alloy. This work compares nanoporous gold created from ordered and disordered copper-gold using digital image analysis and electron backscatter diffraction. Nanoporous gold from both disordered copper-gold and silver-gold, and ordered copper-gold show grain orientation and shape remain largely unchanged by the dealloying process. Comparing the morphology of the nanoporous gold from ordered and disordered copper-gold with digital image analysis, minimal differences are found between the two and it is concluded that they are not statistically significant. This reveals the robust nature of nanoporous gold morphology against small variations in surface diffusion and parent-phase crystal structure. Then the corrosion penetration down the grain boundary is compared to the depth of crack injections in polycrystal silver-gold. Based on statistical comparison, the crack-injections penetrate into the parent-phase grain boundary beyond the corrosion-induced porosity. To compare crack injections to stress-corrosion cracking, single crystal silver-gold samples are employed. Due to the cleavage-like nature of the fracture surfaces, electron backscatter diffraction is possible and employed to compare the crystallography of stress-corrosion crack surfaces and crack-injection surfaces. From the crystallographic similarities of these fracture surfaces, it is concluded that stress-corrosion can occur via a series of crack-injection events. This relationship between crack injections and stress corrosion cracking is further examined using electrochemical data from polycrystal silver-gold samples during stress-corrosion cracking. Current transients seen during potentiostatically controlled stress-corrosion are attributed to the exposure of new surface during crack injection.



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