Materials Science & Engineering Doctoral Defense

Fracture of Nanoporous Gold

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abstract

This research examines several critical aspects of the so-called “film induced cleavage” model of stress corrosion cracking using silver-gold alloys as the parent-phase material. The model hypothesizes that the corrosion generates a brittle nanoporous film, which subsequently fractures forming a high-speed crack that is injected into the uncorroded parent-phase alloy. This high speed crack owing to its kinetic energy can penetrate beyond the corroded layer into the parent phase and thus effectively reducing strength of the parent phase. Silver-gold alloys provide an ideal system to study this effect, as hydrogen effect can be ruled out on thermodynamic basis. During corrosion of the silver-gold alloy, the less noble metal i.e. silver is removed from the system leaving behind a nanoporous gold layer. In the case of polycrystalline material, this corrosion process proceeds deeper along the grain boundary than the matrix grain. All of the cracks with apparent penetration beyond the corroded (dealloyed) layer are intergranular. Our aim was to study the crack penetration depth along the grain boundary to ascertain whether the penetration occurs past the grain-boundary dealloyed depth. EDS and imaging in the high-resolution aberration corrected scanning transmission electron (STEM) and atom probe tomography (APT) have been used to evaluate the grain boundary corrosion depth.

The mechanical properties of monolithic nanoporous gold are also studied. The motivation behind this is two-fold. The crack injection depth depends on the initial speed of the crack formed in the nanoporous layer which in turn depends on the mechanical properties of the nanoporous gold. Also nanoporous gold has potential applications in actuation, sensing and catalysis. This makes it an important material for future research.

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