

Al Corrosion in Systems of Engineered Cu Particles

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Understanding corrosion at second phase particles in alloys has been the subject of considerable research for many years. Early work identified the importance of the galvanic relationship between the particles and the matrix (1-8), while more recent studies show that changes in particle composition and constituent redistribution during exposure can alter the particle/matrix galvanic relationship with time (9,10). Material dissolution and re-precipitation can lead to chemical and structural changes at the material/solution interfaces. In turn, these changes can alter the dynamics of the oxidation-reduction reactions and hence influence the extent and nature of the localized degradation. New tools have been developed to monitor changes in solution pH, in-situ, at small length scales, in order to understand the evolution of solution heterogeneity at individual particles during alloy corrosion (11-13). Recently, solution heterogeneities have been imaged in-situ, during corrosion in model systems of engineered Cu particles on an Al matrix (14). The local solution pH near the particles was observed to fluctuate with time during exposure to a dilute Cl solution. However, the nature of the interaction between particles is still not well understood. The goal of this work is to quantify particle-particle and particle-matrix interactions in order to form a deterministic description of corrosion in complex systems.

This work uses model, thin-film analogs of Al-Cu alloys, to study the evolution of solution heterogeneity and the possible interaction between particles during corrosion of Al thin films at engineered Cu islands (14). Single Cu islands are fabricated on single Al electrodes in a linear array, as shown in Figure 1, in order to allow measurement of the corrosion currents flowing between individual particles. The samples are fabricated by electron-beam deposition of a 200 nm Al film, which is patterned to form isolated electrodes. The Cu islands are defined using standard photolithography and Cu thin film deposition. The linear arrays are exposed to aqueous NaCl solutions.

Currents flowing between electrodes can be measured using a multi-channel microelectrode analyzer. In-situ fluorescence microscopy, using a fluorescein indicator, allows imaging of local OH⁻ production in solution during the corrosion process as shown in Figure 2. The corrosion morphology is determined by scanning electron microscopy combined with energy dispersive spectroscopy (SEM/EDS) and atomic force microscopy at various stages of propagation. These measurements allow a detailed investigation of corrosion in a controlled system of noble second-phase particles on an Al matrix.

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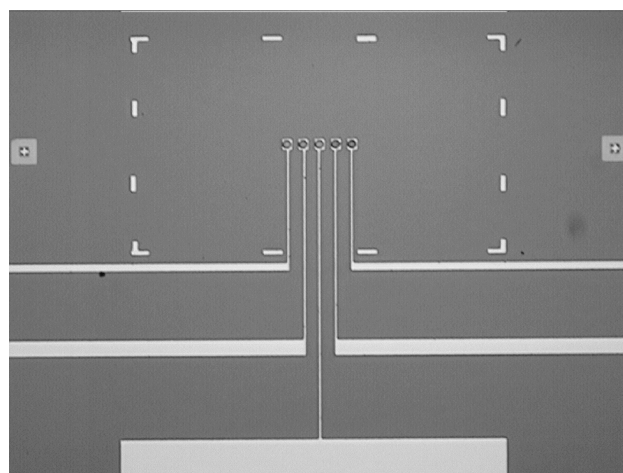


Fig. 1 Linear array of 5 Al microelectrodes containing individual Cu islands.



Fig. 2 Fluorescent microscopy image of OH⁻ production in solution at Cu islands on individual Al electrodes.

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