

## Evolution of Al Corrosion at Engineered Cu Islands

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A complete description of Al corrosion at second phase particles in Al alloys is difficult to achieve due to the complexity of the materials systems and the dynamics of the corrosion process. The identification of precise initiation mechanisms and the ability to predict the morphology of corrosion propagation in the vicinity of these particles are still topics of considerable interest. One of the factors likely to influence corrosion propagation is the local heterogeneity in the solution environment, which develops as a result of the heterogeneous microstructure at the alloy surface. The local solution chemistry is a dynamic variable, determined by local ion concentration and species,

This work uses model, thin-film analogs of Al-Cu alloys, to study the evolution of corrosion in Al thin films at engineered Cu islands. (1), (2) The samples are fabricated by electron-beam deposition of a 200 nm Al film, followed by standard photolithography, and 10 nm Cu deposition, to create arrays of Cu islands on an Al thin-film matrix. The samples discussed here have island diameters ranging from 5 – 100  $\mu\text{m}$  and spacings between 10 – 1000  $\mu\text{m}$ . Individual arrays are exposed to aerated 50 mM NaCl solutions at open circuit in order to monitor the initial stages of corrosion. 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. In-situ fluorescence microscopy, using a fluorescein indicator, allows imaging of local OH<sup>-</sup> production in solution during the corrosion process (3) and of corrosion product deposition. (4)

The corrosion morphology is dominated by the gradual dissolution of Al beneath the Cu islands, as indicated by the Al K $\alpha$  signal in the EDS linescans (across a Cu island) at increasing stages of corrosion from top to bottom in Figure 1. Corrosion initiates at the island/matrix interface and proceeds towards the center, where the pit beneath the Cu film gradually deepens as corrosion progresses. In-situ fluorescence microscopy indicates OH<sup>-</sup> production at the surface of the Cu islands. Oxygen reduction on the Cu increases the local alkalinity in the solution layer, as imaged in Figure 2 using a confocal scanning laser microscope (CSLM). Over time, the OH<sup>-</sup> production rate fluctuates, and can be imaged in order to study how the dynamics of the Al oxidation – O<sub>2</sub> reduction reaction influences the corrosion rate of the Al matrix. The relation between the time dependence of OH<sup>-</sup> production and the open circuit potential and dissolved oxygen content in solution will be discussed.

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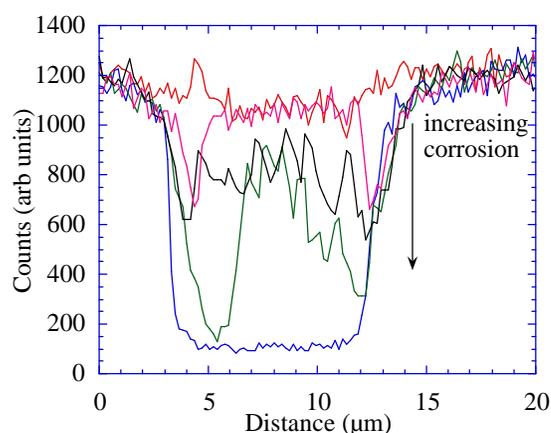


Fig. 1 Al K $\alpha$  EDS linescans showing increasing corrosion from top to bottom..

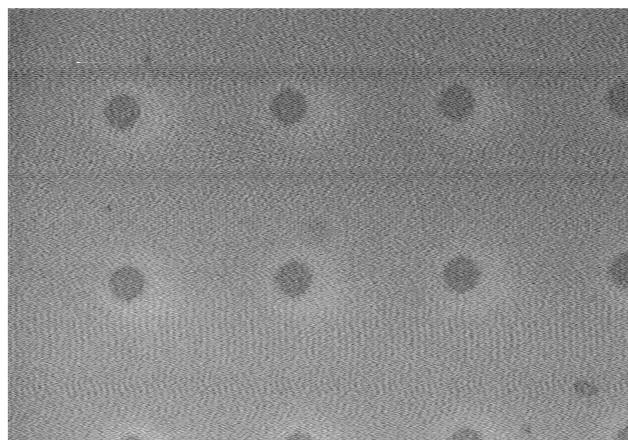


Fig. 2 CSLM image of OH<sup>-</sup> production in solution at Cu islands on Al thin film matrix.

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