ROLE OF LOCAL MICROSTRUCTURE AND MICROMECHANICS IN GALVANIC CORROSION

Michael D. Sangid, Purdue University
msangid@purdue.edu
Andrea Nicolas, Purdue University
Alberto Mello, Purdue University

Key Words: Galvanic Corrosion, AA7050, Microstructure, Strain Localization, Constituent Particles

Present modeling approaches for galvanic corrosion include theories based on mechanics (relying on stress-state and deformation as the driving force for corrosion) and chemistry (relying on local chemical potentials for the basis of a galvanic reaction), although a unifying platform or set of experiments is needed to directly compare these two methods. In the present work, a set of experiments are conducted that combine chemistry and mechanics approaches in conjunction with simulations of the underlying mechanical behavior of the materials, and the results are used for statistical analyses to view correlations between these disparate techniques. This work includes detailed characterization of the material's grain structure via electron backscatter diffraction (EBSD) and constitutive particles through energy dispersive spectroscopy (EDS), followed by creation of strain maps relative to the microstructure during loading from digital image correlation (DIC), and subsequent galvanic corrosion as spatially measured from a confocal microscope or optical profilometry. As shown in Fig. 1, this is performed spatially across the same region of interest on a specimen. Detailed statistical analyses, based on Gaussian Process modeling, are used to identify spatial locations of corrosion relative to microstructural features and high strain.

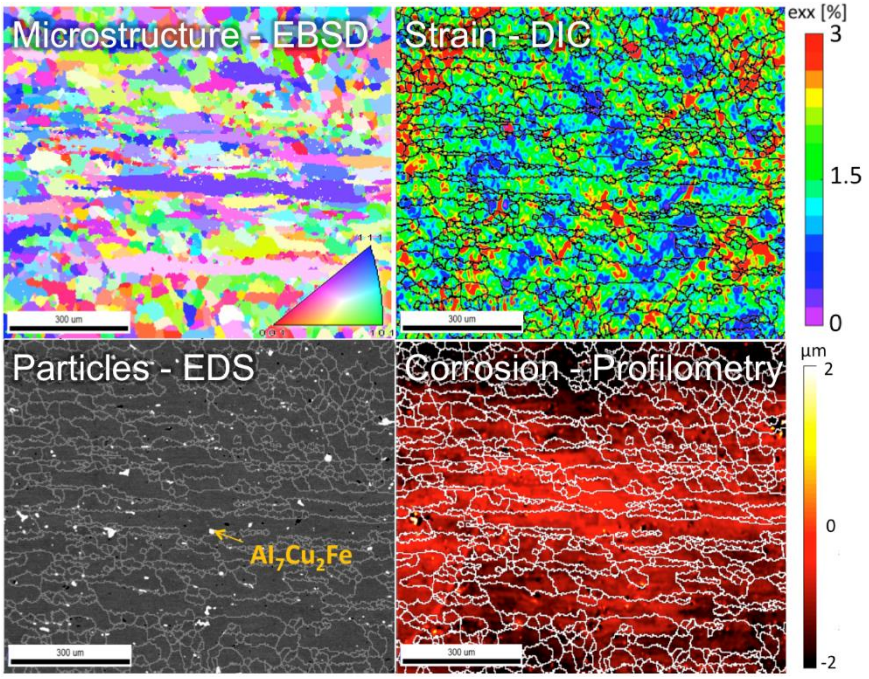

Figure 1 – Experimental characterization for a region of interest of a pre-strain specimen subjected to a galvanic environment.

Strain localization is viewed in various orientations of highly textured AA7050 rolled plate and compared with the results of simulations. To identify the role of the sub-surface microstructure, a similar procedure is performed on columnar AA7050 material, as well as simulated sub-surface grain structures. A detailed galvanic corrosion procedure is followed on pre-strained samples, in which the localized corrosion is tracked every 24 hrs for 20 days. The results show that highly localized strain is not a sufficient condition for corrosion of constituent particles. Yet, a cracked particle resulting in the highest strain accumulation provided the largest corrosion pit. The experiments were repeated on several additional specimens, in which the samples were subjected to a galvanic environment under loading, to segment the driving force for galvanic corrosion as stress-mediated versus strain-mediated. The results will be discussed during the presentation.

Finally, in collaboration with Prof. J. Burns and N. Co of the University of Virginia, the surface topologies of specimens that have been exposed to a galvanic environment are characterized via tomography. Afterwards, the specimens were cyclically loaded to identify the location of crack initiation. Using crystal plasticity simulations, virtual instantiations of the microstructures and specimen's morphologies are created, in order to identify the root cause of crack initiation and potential driving force for short cracks, using a series of fatigue indicator parameters.