

## Corrosion Behavior of AZ31B Friction Stir Welds

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The multi-national MFERD (Magnesium Front End Research and Development) project is a major effort towards increasing the utilization of Mg alloys in automotive assemblies. Friction stir welding (FSW) is a promising joining technology for this effort. One of the many advantages to using FSW is that the weld zone, created below the melting point of the material, contains a fine equiaxed grain structure without many of the metallurgical problems associated with the solidification process.<sup>1</sup> Among other factors, the corrosion performance of the Mg intensive front end assembly has been identified for targeted study.

This presentation summarizes the on-going research investigating the corrosion behavior of friction stir welded joints used to fabricate the Mg-intensive front end “demonstrator” sub-assembly, with particular focus on Mg alloy AZ31B lap joints. The intrinsic corrosion resistance is being evaluated by exposing welded samples in salt fog (ASTM B117) and bulk aqueous NaCl solutions. Electrochemical techniques including potentiodynamic polarization, electrochemical impedance spectroscopy (EIS) and scanning vibrating electrode technique (SVET) are used to provide insight into the controlling mechanism and kinetics in bulk aqueous NaCl solutions.

Exposure in both salt fog and bulk aqueous NaCl solutions reveal no significant variation in the corrosion resistance observed across the FSW joint (as shown in Fig. 1), despite the difference in the grain size. These observations agree well with the potentiodynamic polarization behavior and EIS response of the isolated zones (base metal vs. stir zone). Therefore, it is concluded that differences in grain size alone, do not lead to a different corrosion resistance, as reported in the literature.<sup>2,3</sup>

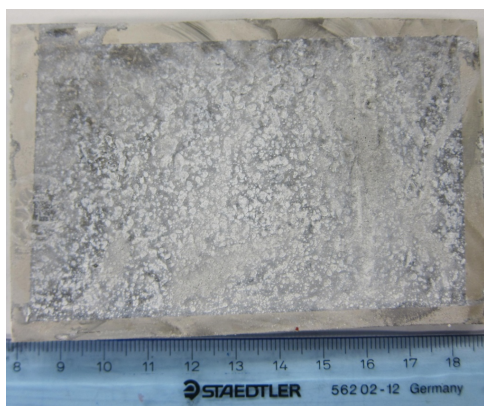


Fig. 1 Appearance of an AZ31B FSW sample after exposure in 5 wt.% NaCl salt fog for 24 h

The sequence of SVET derived current density maps obtained by scanning the exposed surface of a welded sample in 5 wt.% NaCl solution revealed some

unique features in the initiation and propagation of corrosion. Localized corrosion appears to initiate on the base metal either side of the weld, and is characterized by the appearance of several local anodes. As these propagate away from their respective initiation sites, they leave behind dark, cathodically activated tracks in their wake regardless of the location on the weld zone where they propagate. The filaments moving from right to left and vice versa meet in the vicinity of the weld and appear to coalesce, giving one large local anode which then dominates. This then sweeps backwards and forwards over the exposed area, again leaving what appears to be freshly cathodically activated corroded surface in its trail. Time lapse imaging is found to correlate with the SVET sequence (Fig. 2). The filament-like feature is distinctly different to the radial features observed on commercially pure Mg.<sup>4</sup>

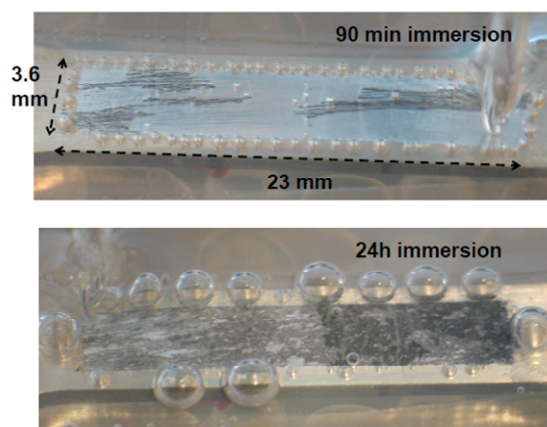


Fig. 2. Appearance of an AZ31B FSW sample after 1.5 h and 24 h exposure in 5 wt.% NaCl solution.

The role played by microstructure and the surface film in the initiation and propagation stages of this filament-type corrosion mechanism is being investigated by examining using electron microscopy. Focused ion beam milling is used to prepare thin cross-section foils of the surface film/substrate interface that are subsequently examined using transmission electron microscopy (TEM) coupled with energy dispersive spectroscopy (EDS).

### References:

1. E.A. Nyberg, A.A. Luo, K. Sadayappan, W. Shi, *Adv. Mater. Processes*, **166**(10), 35 (2008).
2. Y.H. Jang, S.S. Kim, C.D. Yim, C.G. Lee, S.J. Kim, *Corros. Eng. Sci. Technol.*, **42**(2), 119 (2007).
3. M.B. Kannan, W. Dietzel, R. Zeng, R. Zettler, J.F. dos Santos, *Mater. Sci. Eng. A*, **460-461**, 243, (2007).
4. G. Williams, H.N. McMurray, *J. Electrochem. Soc.* **155**(7), C340 (2008).