Corrosion Films on Single Crystal Magnesium

Elizabeth A. McNally, Joseph R. Kish
GM Centre for Automotive Materials & Corrosion
McMaster University, Hamilton, ON, Canada

There are numerous studies examining the corrosion behaviour of bulk magnesium, however minimal work has been done on corrosion of specific surfaces of magnesium. As a hexagonal crystal, the spacing of atoms at the surface varies widely depending on which crystal face is exposed at the surface.

Work by Shin et al.[1] shows that the basal and prismatic planes of magnesium have different corrosion properties. The basal plane exhibits a lower E_{CORR} than the prismatic plane, both of which are lower than surfaces cut at angles between the two extremes. Similarly, the pitting potential was highest for the basal plane followed by the prismatic plane, with the angles between the two falling below the reported values for the prismatic plane.

Liu et al.[2] report that the depth of corrosion varies by 10% depending on the orientation of a grain exposed to a 0.1 N HCl for 15 hours. They explain that the different corrosion rates are due to differences in packing between different planes. Different packing leads to varying binding energy. Higher binding energy means higher activation energy for dissolution of the metal and therefore lower corrosion rates.

Work by Song and Xu[3] also shows that the basal plane is more resistant to corrosion than non-basal orientations. Interestingly they also report that the surface film thickness varies with preexisting grain structures in their sample and not with areas of different activity on the surface. They state that “the surface film formation is to some extent affected by the Mg substrate” and show that the surface film is almost doubly thick on same grains than on others.

In this study, we examine different magnesium surfaces to understand how the corrosion products, mainly MgO and $Mg(OH)_2$ form on the surface. Single crystals with different exposed surface planes will undergo corrosion experiments to determine is the corrosion parameters vary by with surface orientation. Then FIB and TEM will be used to examine the interface between the metal and the film gives data about the orientation of the oxide on the metallic substrate, the degree of epitaxy of the film, and the ability to calculate the maximum film thickness prior to spalling. Also, comparison of the cross sections of localized pits with those from areas of uniform corrosion gives insight into the differences in these two corrosion processes in magnesium.

A second series of experiments will expose only portions of a single grain within a polycrystalline matrix of pure Mg. Similar corrosion experiments will be undertaken, followed by microscopic examination of the interface between the corrosion product and the metal to understand if being part of a polycrystalline matrix affects the corrosion behavior of a grain.

1. Shin, KS, Ming, ZB, Nam, ND. JOM. Vol 64. No. 6. 2012.
2. Liu, M, Dong, Q, Zhao, M-C, Song, G, and Atrens, A. Scripta Materialia 58 (2008) 421-424.
3. Song, GL, Xu, Z. Corrosion Science 63 (2012) 100-112.