Corrosion Behavior of Nanocrystalline Al-Mg-based Alloys

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In the last few years, nanocrystalline materials have received extensive attention as a result of their unique physical, chemical and mechanical properties. Recent advancements in nanocrystalline material manufacturing and processing enabled production of bulk nanoscale structural materials [1]. The properties of these materials cannot be predicted from those observed for their conventional polycrystalline counterparts. This is due to the unique structure of nanocrystalline materials with a large number of grain boundaries, which may represent close to 50% of the total volume of the material. It has also been shown that the structure-property relationship of bulk nanocrystalline materials differ considerably from those observed for thin-films nanocrystalline materials [2,3]. The differences are mainly attributed to microstructural differences including crystallographic texture, porosity, impurities, grain boundary and triple junctions.

From the very limited data available in the literature, improved corrosion resistance has been reported for nanocrystalline $Fe_{32}Ni_{36}Cr_{14}P_{12}B_6$, $Fe_{72}Si_{10}B_{15}Cr_{13}$ sputtered films [4], nanocrystalline 304 SS [5] and nanocrystalline Ni-5Cr-5Al coating [6]. The enhanced corrosion resistance was attributed to fine grain size and homogenity of nanocrystalline material. On the other hand, decreased corrosion resistance reported for a nanostructured $Cu_{90}Ni_{10}$ alloy [7] and for nanostructured 99%Ni [8] was attributed to reduced passivation kinetics and instabilities of the passive film.

In the present work, the corrosion behavior of a series of nanocrystalline Al-Mg based alloys is investigated and compared with the corrosion behavior of conventional AA 5083. In order to understand the influence of alloying, extrusion rate and microstructure on the corrosion behavior, electrochemical characterization of the alloy was carried out by AC impedance spectroscopy, electrochemical noise measurements, and potentiodynamic and potentiostatic polarization experiments in neutral solution with various chloride concentrations.

In neutral (0.1 M Na_2SO_4) Cl^- containing solutions, all investigated alloys are passive but susceptible to pitting corrosion. The pitting potential strongly depends on the composition of the alloy, its mechanical treatment and obviously on the aggressiveness of the chemical environment. In the solution with lowest chloride concentration (0.005 M NaCl) alloys Al-7.5Mg and Al-8.6Mg were more resistant to localized corrosion than their commercial polycrystalline counterpart, and the most extruded one was the least susceptible to corrosion attack. However, as the aggressiveness of the solution increased, the differences in breakdown potential of studied alloys became smaller and the nanocrystalline alloys and a polycrystalline one exhibited similar corrosion resistance.

The obtained results clearly indicate the importance of microstructure and mechanical treatment of Al-Mg-based alloys in their corrosion behavior. Therefore, new processing can be designed to significantly improve the corrosion resistance. Nevertheless, depending on the environmental conditions (presence or absence of Cl^-) the influence of the alloy composition and their microstructures strongly vary.

Literature

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