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Surface potential analysis on initial galvanic corrosion of Ti/Mg-Al dissimilar material

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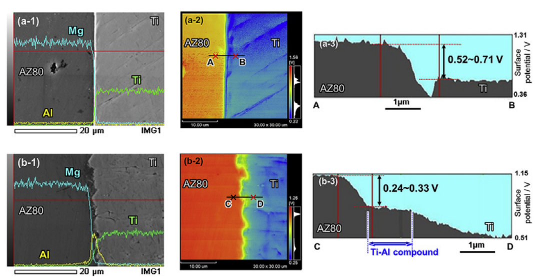
HIGHLIGHTS

- Pure Ti/AZ80 Mg alloy dissimilar material was prepared by spark plasm sintering.
- Additional heat treatment caused a formation of Ti-Al interlayer.
- Significant decrease of potential difference of 0.24–0.33 V was found at interface.
- Heat treated dissimilar material showed very few $Mg(OH)_2$ debris after salt water immersion test.

GRAPHICAL ABSTRACT



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ABSTRACT

A surface potential analysis was carried out to establish a new materials design of pure Ti/Mg-Al alloy dissimilar materials with an excellent galvanic corrosion resistance. The formation of Ti-Al intermetallic interlayer and Al diffusion layer at interface effectively reduced the surface potential difference at the interface. As a result, a formation of local cells, causing a galvanic corrosion phenomenon of Ti/Mg alloy dissimilar material, was prevented because the potential difference of Mg alloy with Ti-Al interlayer completely decreased. A salt water immersion test obviously indicated no $Mg(OH)_2$ corrosion product on Mg alloy surface due to Ti-Al interlayer formation, and the initial galvanic corrosion phenomenon was effectively obstructed.

1. Introduction

A multi-materials design is widely applied to automotive and aerospace components to realize both significant weight reduction and strength improvement at the same time. The dissimilar material by joining the different materials plays an important role to obtain many advantages such as downsizing, cost reduction, and high-performance of the components. Al/steel [1], Mg/steel [2], and Ti/steel [3] dissimilar jointed materials are representative combinations in the industrial application. A dissimilar material consisting of Ti and Mg alloys has a large potential for weight reduction because both metals show high specific strength and specific Young's modulus compared to the other industrial metals. This also has a possibility to be employed as lightweight reinforcements of aircrafts. With regard to the bonding ability of Ti to Mg, the previous study shows a good wettability of pure Ti by molten pure Mg because of Ti plate surface modification after TiO_2 layer chemically reduced by contact with molten Mg [4]. A fibre laser welding process was one of the suitable joining techniques to prepare this unique dissimilar material [5]. In this combination, however, there are two important problems in joining; a small solid

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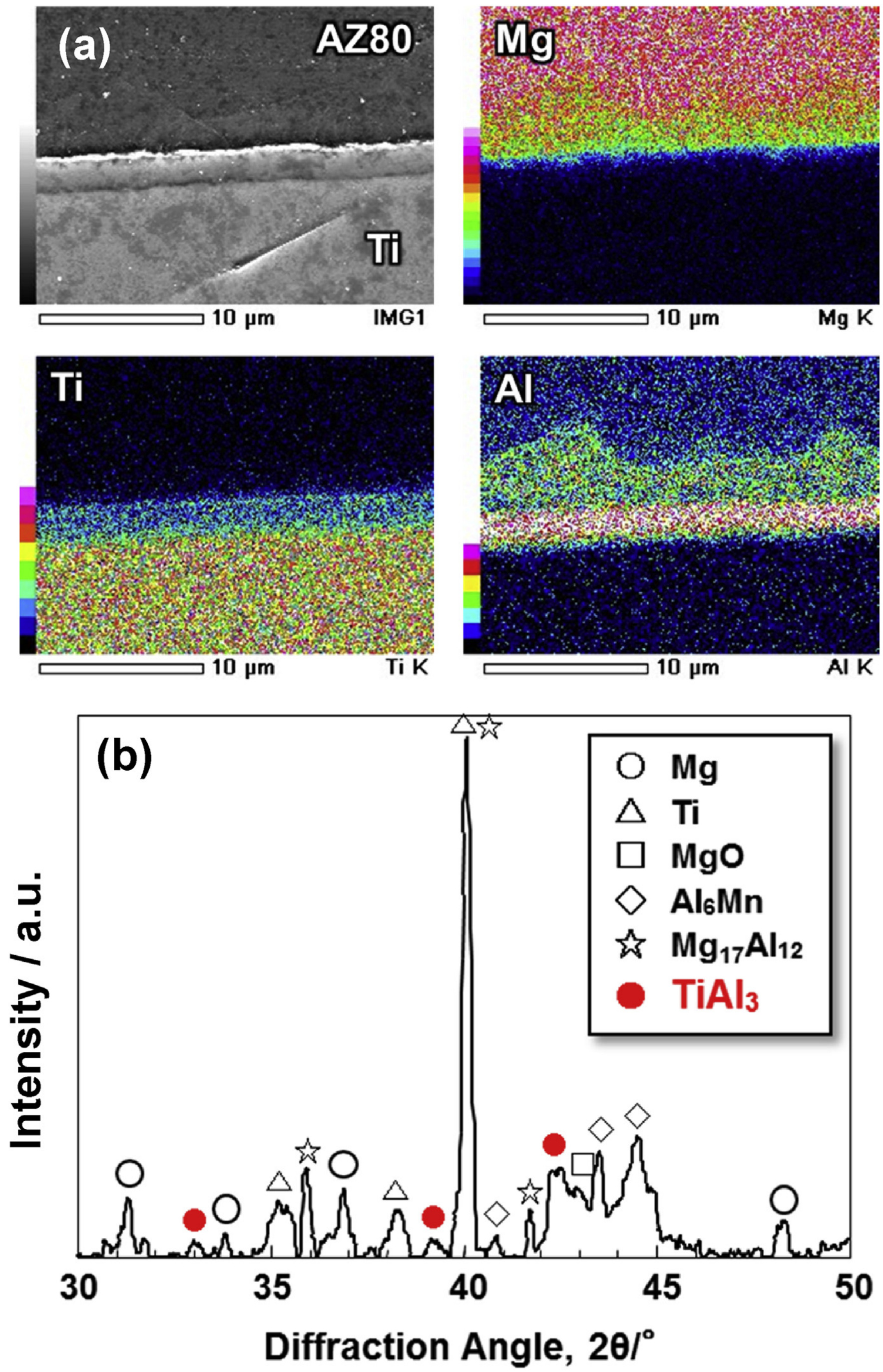

Fig. 1. SEM-EDS analysis results (a) and XRD profile (b) near interface of pure Ti/AZ80 dissimilar material after heat treatment at 1073 K for 1.8 ks in vacuum (~6 Pa). $TiAl_3$ intermetallic compound inter layer and Al concentrated area are formed via reaction between Ti and Al elements from molten AZ80 alloy.

solubility of Ti in Mg and that of Mg in Ti, and a large melting point difference between pure Mg and pure Ti (1019 K) [6]. In addition, the Al content contained as a strengthening alloying element in Ti and Mg alloys has a significant effect on the interfacial properties of the dissimilar material. For example, microstructures and mechanical strength depend on the formation of Mg-Al eutectic phases [7] and Ti-Al intermetallic compounds [8] near the interface of the Ti/Mg dissimilar material. From a viewpoint of galvanic corrosion originated in the local cells at interfaces of the dissimilar material, a large difference of the standard electrode potential between Ti (−1.63 V) and Mg (−2.35 V) possibly causes a galvanic corrosion phenomenon [9]. The galvanic corrosion is also influenced by the Al concentration near the interface because of Mg-Al phase formation and Al solid-solution into α-Mg matrix [10].

In this study, the initial galvanic corrosion behavior at the interface of pure Ti/AZ80 (Mg-Al) alloy dissimilar material prepared by spark plasm sintering (SPS) in solid-state and the following heat treatment was investigated by surface potential difference measurement using scanning Kelvin prove force microscopy (SKPFM) system [11–13]. The previous study showed that SKPFM measurement results were useful to estimate the corrosion potentials of materials because a linear relationship between the work functions