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Transient liquid phase bonding between Mg alloys and steels

T. Araki [(1)*], M. Koba [(1)], J. Inoue [(1)] and T. Koseki [(1)]

(1) Department of Materials Engineering, The University of Tokyo, 7-3-1 Hongo, Bunkyo, Tokyo 113-8656, Japan, e-mail: araki@metall.t.u-tokyo.ac.jp
* Corresponding author.

Abstract – Liquid phase bonding was applied to bond Mg alloys and steels. Liquid phase was employed to efficiently control the formation of reaction products at the bonding interface. The liquid phase is produced by eutectic reaction of Mg and Ag, and disappears through isothermal solidification. Mg alloy AZ31 and Interstitial Free steel were successfully bonded. Tiny and uniform reaction products consisted of iron and aluminum were formed throughout the bonding interface. The bonding strength was higher than the yield strength of AZ31 base metal.

Since Mg alloys are the lightest commercial structural alloys exhibiting excellent specific strength, there exists increasing demands for the application of Mg alloys to many lightweight structures. Moreover, assembling with steels, which are the strongest commercial structural alloy, will enable Mg alloys to be applied for structures with even higher strength. For that purpose, it is inevitable and important to develop a practical bonding method between Mg alloys and steels. However, due to the large difference in melting point and hardness, little reactivity, and diffusivity between Mg and Fe, bonding Mg alloys and steels is considered difficult, and thus there has been only limited number of research about it[1,2]. The purpose of this study is to develop a new method for bonding Mg alloys and steels.

In this study, it is suggested that high strength bonding can be achieved by tiny reaction products of Mg alloying elements and iron uniformly formed at bonding interface. The formation of reaction products are performed in the presence of liquid phase, which is formed by eutectic reaction of Mg and insert-metal and disappears through isothermal solidification [3].

Materials were Mg alloy AZ31(Mg-3mass%Al-1mass%Zn) and IF steel (very low carbon and Interstitial Free). Pure Ag was inserted between AZ31 and IF steel, which has eutectic reaction with Mg at lower temperature than Mg melting temperature. Under fixed load, bonding specimens (steel/Ag/AZ31/Ag/steel) were heated at 500°C for 10s~10000s. The specimens were subsequently quenched by He gas. Bonding strength was measured by tensile test. Fig.1 shows the microstructure of the bonding interface. At the interface of AZ31/IF steel, the reaction products were formed, and grew with heating time. EDS analysis revealed that the reaction products consist of iron and aluminum. These reaction products were revealed to be Al-Fe intermetallic compounds consisting of Al5Fe2 in short time and both Al5Fe2 and AlFe in long time by XRD analysis. Fig.2 shows the bonding strengths of AZ31/IF steel with and without liquid phase accompanied by that of pureMg/IF steel with liquid phase under same experimental condition. High strength bonding over the yield strength of AZ31 base metal was achieved by the formation of tiny and uniform reaction products in the presence of liquid phase.

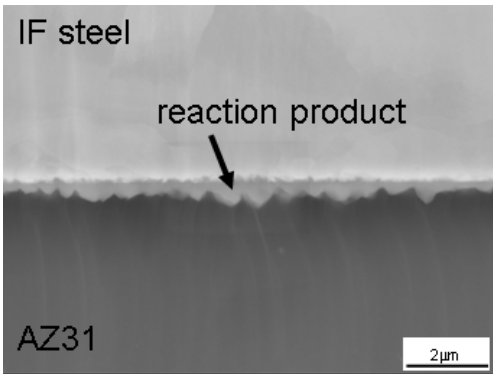

Fig.1: Microstructure of bonding interface at 500°C for 1000s

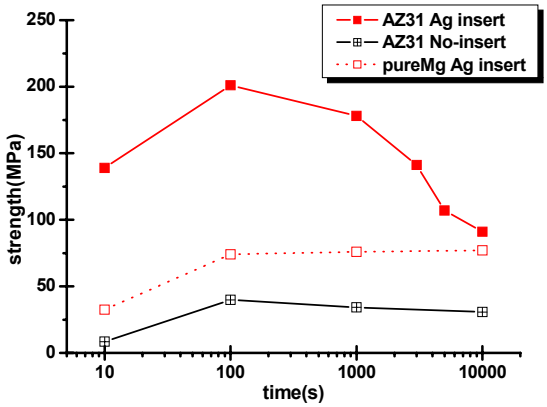

Fig.2: Bonding strength of AZ31/IF steel with Ag insert without Ag insert and pureMg/IF steel with Ag insert

References

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