# ELECTROLESS SILVER PLATING OF Al-Mg FILLER WIRE USED IN GMAW PROCESS

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**ABSTRACT**

*Silver plating of 1.6 mm diameter Al-Mg filler wire of MIG welding process has been carried out by electroless plating method. The plating has been performed by dipping the wire in a cyanide bath of suitable composition. The effect of plating parameters such as the bath temperature and plating time on the characteristics of Silver plating has been studied. Microstructure studies on transverse section of the plated filler has been carried out under optical microscope to study the nature of plating and its adherence with the substrate at different plating parameters. The plated silver layer has been found well adhered with the Al-Mg substrate. The optimum plating parameters giving rise to significant amount of silver plating on the filler wire has been qualitatively identified. The amount of silver plating on the 1.6mm diameter Al-Mg filler wire, obtained by this process, has been analysed to be sufficient to introduce the minimum amount of silver required in Al-Mg MIG weld deposit to improve its resistance to stress corrosion cracking (SCC) susceptibility.*

## INTRODUCTION

The Al-Zn-Mg alloy for its high strength to weight ratio is being largely used in fabrication of portable bridge girders and automobile components [1, 2]. During fabrication of various structures of this alloy the metal inert gas (MIG) and Tungsten inert gas (TIG) welding are commonly used for joining of structural components. The welding of Al-Zn-Mg alloy is generally performed by using Al-Mg filler wire containing about 4-5 wt% Mg [3]. The weld deposit of this alloy has been found to be sensitive to stress corrosion cracking (SCC) especially in the region adjacent to the fusion line with base material. The presence of silver of the order of about 0.3 - 0.5 wt.% in the Al-Mg and Al-Mg-Zn alloys containing Mg:Ag > 5 and/or Mg:Zn = 1:3 - 1:6 has been found to enhance their strength and fatigue resistance moderately along with a significant reduction in their stress corrosion cracking susceptibility primarily due to acceleration of finer precipitation of intermediate phase $\beta^1$ and $Mg_5Al_8$ or $MgZn_2$ and reduction of precipitate free zone (PFZ) at the grain boundary under proper heat treatment respectively [4]. Thus, during welding of Al-Zn-Mg alloy the addition of silver in Al-Mg weld deposit, which is predominantly an Al-Mg alloy confirming the above condition having certain amount of Zn due to dilution with the base metal, may be beneficial to improve its mechanical and stress corrosion cracking properties. However, this phenomenon has not yet been technologically exploited in the area of MIG or TIG welding of Al-Zn-Mg alloy possibly due to high cost of silver, which is required in lump for silver alloying of Al-Mg filler wire during its production.

In view of the importance of silver alloying of the weld deposit during welding of Al-Zn-Mg alloy and the difficulties in production of silver alloyed Al-Mg filler wire an investigation was planned to study the feasibility of plating the Al-Mg filler wire by silver. But, the plating of aluminium alloys using conventional plating processes has been found difficult due to readily oxidising nature of this alloy. However, to overcome these difficulties an effort has been made to silver plate the Al-Mg filler wire using electroless deposition process where, instead of silver lump some suitable compound of silver can be used. The electroless plating (or chemical plating) is a method for obtaining a thin metallic film on metals, ceramics or plastics just immersing the substrate into an electrolyte solution at suitable moderate bath temperature [5]. The electroless plating follows a electrochemical mechanism where a simultaneous reaction of cathodic metal deposition and anodic oxidation of reductants takes place according to the mixed potential theory [6]. The feasibility of introducing the required amount of silver to the weld deposit by carrying out MIG welding using the silver plated filler wire of commonly applied diameter of 1.6 mm has also been evaluated. The success of this effort may lead to a technology development for producing Al-Mg weld deposit having silver at a low cost and subsequently start a new era in welding of Al-Zn-Mg alloy by improving the stress corrosion cracking properties of the weldment.

## EXPERIMENTAL PROCEDURE

The deposition of silver on 1.6 mm diameter Al-4.5Mg-0.65Mn filler wire was carried out by electroless plating method by dipping the wire in a cyanide bath of suitable composition. During plating the bath temperature was varied to three different levels of 55, 60 and 65°C and at a given bath temperature the influence of dipping time on the characteristics of deposition was studied. The transverse section of the plated filler wire was cold mounted and prepared metallographically. The polished specimens were etched in an aqueous solution of 5% hydrofluoric acid to develop a microstructural contrast between the Al-Mg substrate and the plated silver by selective attack of the matrix. The microstructure of the plated specimens were studied under optical microscope to examine the response of each parameter on thickness and uniformity of the silver deposition as well as its adherence with the matrix. The thickness of plating was measured with the help of a micro scale fitted in an optical microscope having a least count of 1.0 mm.

## RESULTS AND DISCUSSION

The influence of bath temperature and dipping time on the deposition characteristics of silver on Al-Mg filler wire has been shown in Table I. The table depicts that the bath

**Table I :** The effect of bath temperature and plating time on electroless plating of silver on the Al-Mg filler wire of GMAW process.

| Bath Temperature (C°) | Plating Time (min) | Observations Under Microscope |
|---|---|---|
| 55 | 15 | Plating not observed |
| 55 | 30 | Plating not observed |
| 55 | 45 | Plating not observed |
| 55 | 60 | Slight amount non-uniform plating |
| 60 | 15 | Plating not observed |
| 60 | 30 | Slight amount non-uniform plating |
| 60 | 45 | Little amount non-uniform plating |
| 60 | 60 | Good amount non-uniform plating |
| 65 | 15 | Plating not observed |
| 65 | 30 | Little amount non-uniform plating |
| 65 | 45 | Good amount non-uniform plating |
| 65 | 60 | Heavy amount non-uniform plating |

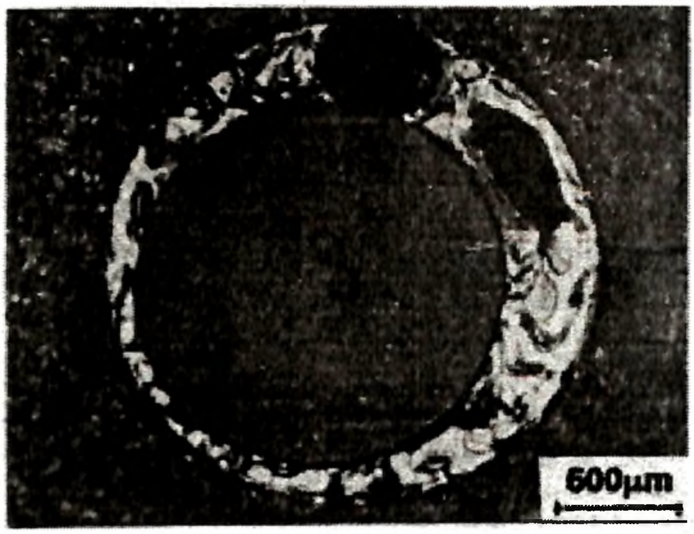


**Fig. 1** : Micrograph showing the silver plating on Al-Mg filler wire

temperature of 55°C is not suitable for the electroless plating as it takes long time of exposure. However, at the temperatures of 60°C and 65°C a significant deposition of silver on the filler wire was observed at a comparatively shorter period of exposure in the plating bath of the order of 45-60 minutes. The amount of deposition was found to be enhanced with the increase of dipping time.

The typical micrograph of the etched silver plated Al-Mg filler wire has been shown in Fig. 1. The selective attack of the etchant on Al(Mg) substrate and the silver plating clearly reveals the presence of plating on the filler wire, appeared as a comparatively brighter layer on it. The micrograph reveals that the thickness of the silver plating is non uniform; as qualitatively described in Table - I, and having some voids in it However, in well plated filler wire the average thickness of plating has been found to be raised up to a level of the order of about 200 mm as shown in Fig. 1. The high magnification microstructural studies carried out at the Al(Mg)-plating interface show (Fig. 2) that the silver plating is satisfactorily adhered with the Al-Mg filler wire.

During electroless plating of silver on the Al-Mg substrate the electrochemical condition favouring the deposition of silver is largely governed by the rate of anodic oxidation of the substrate. In the present process sufficient care was taken on this aspect by maintaining a palladium-activated suitable bath composition to obtain a suitable rate of anodic oxidation of the substrate resulting into a smooth and uniform deposition of silver on it. However, the function of the palladium nuclei as the sites for anodic oxidation of the reductants or substrate to a great extent depends on size and distribution of the palladium nuclei (5]. Electroless deposition generally involves hydrogen evolution originated mainly from the reductant molecule and the plating proceeds mostly on hydrogenation-dehydrogenation catalysts [7, 8,] . In this work the poison for hydrogenation catalyst such as thiourea [9, 10] was added to the plating bath as stabiliser towards dehydrogenation of the reductant. However, in spite of all these precautions the non-uniformity in thickness of silver plating on the substrate and the formation of voids in it may be primarily caused by the following reasons.

1. Absence of a mechanical stirring facility in the bath resulting into development of a high concentration gradient of silver in it causing a non uniformity in required concentration of silver throughout the bath during plating.

2. A non-uniform distribution of palladium nuclei on the substrate in absence of mechanical stirring of the plating bath.

3. Adherence of gas bubbles, evolved during plating, on the substrate and its entrapment in the plating in absence of mechanical stirring in the plating bath.

However, a detail work should be carried out further on the polarisation behaviour of the plating bath having mechanical stirring facility in it to improve the conditions of plating so that a uniform flawless plating of silver of desired thickness can be obtained on Al-Mg filler wire.

It is estimated that for improving the SCC properties of Al-Mg weld deposit by alloying it with 0.5 wt% silver a silver plating of thickness about 7-8 mm is necessary on 1.6 mm diameter Al-Mg filler wire. The present work infers that a silver plating of such a thickness on Al-Mg filler wire can be adequately produced by electroless plating method. Thus, the idea of present approach, that is examining the possibility of economic silver alloying of Al-Mg weld deposit by using silver plated filler wire during MIG or TIG welding of Al-Zn Mg alloy is justified. However, a further effort in this area is necessary for standardisation of this process towards technology development for production of the suitable silver plated Al-Mg filler wire by the electroless plating process. Some work should also be carried out on welding of components using the silver plated filler wire to develop suitable welding technology in this regard.

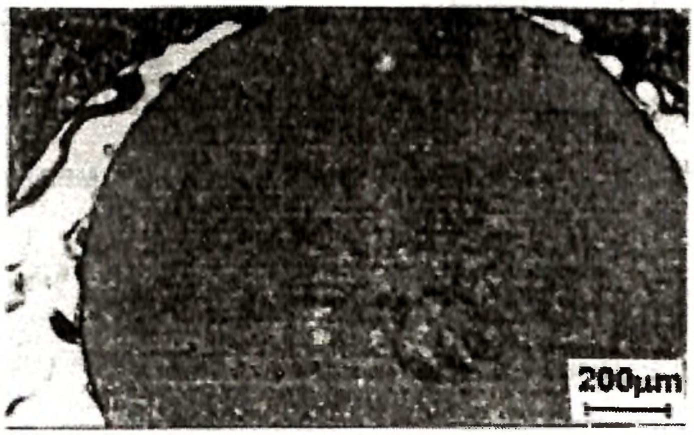


**Fig. 2 :** Microstructure at higher magnification showing good adherence of silver plating on the Al-Mg alloy substrate.

## CONCLUSIONS

The electroless plating process has been found suitable for silver plating of 1.6 mm diameter Al-Mg filler wire up to a desired thickness, which is necessary to introduce required amount of silver in MIG weld deposit of Al-Mg alloy to improve its resistance to stress corrosion cracking (SCC) susceptibility. Satisfactory amount of silver plating having good adherence or bonding with the substrate can be obtained by maintaining a plating time of 60 min at the cyanide bath temperature at 60°C. To avoid non uniformity in plating thickness and formation of void in the plating suitable stirring arrangement should be introduced in the plating bath.

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