DEVELOPMENT OF ELECTROPLATING SETUP FOR PLATING ABS PLASTICS

By

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ABSTRACT

Over the recent years there has been an ever-increasing trend to replace metals with plastics in the manufacture of computers, business and industrial machines, automotive and telecommunication components and other electronic equipments. Usually a plastic component will be lighter in weight which in aerospace Industry especially always has been an important consideration. Weight savings have assumed greater importance in other market for example, motor vehicles, where a key factor in achieving greater fuel economy has been reduction in weight overall brought about by changes from metals to plastics, ABS chrome plated parts are one such example for weight reduction in automobile components. Plating on plastics therefore has been developed and widely concerned in manufacturing printed circuit boards, automobile parts, in the electromagnetic interference (EMI) shielding application, regulator knobs for fan cooler, push buttons, etc. After plating there is no apparent difference visually between metal and plastic parts. For electroplating, the plastic model needs to be made electrically conductive in order for the electroplating process to work, and in this paper an attempt has been made to show and understand the development of electroplating setup for plating ABS plastics.

Keywords: Electroplating, Electroless Plating, Copper, Nickel, Plastics, ABS.

INTRODUCTION

The use of plastics has increased remarkably due to a systematic exploitation of their principal advantages, i.e. lightness, flexibility and toughness, ease of fabrication of complex components, and excellent surface quality as fabricated. This has led, in a very wide range of applications, to the replacement of metals with plastics as materials of construction.

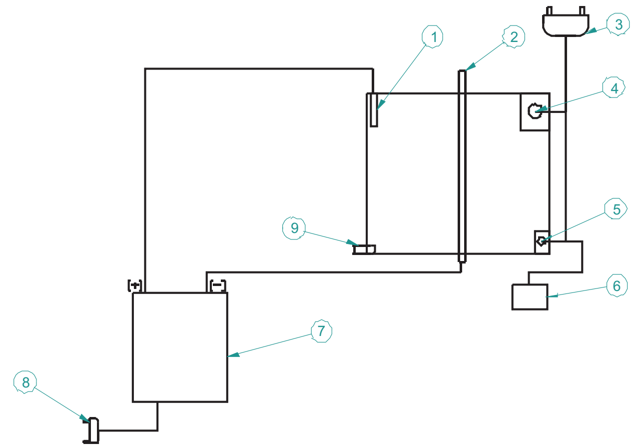
Metallization of non-conductive surfaces especially plastics is important in many industrial applications as it lowers cost, allows more flexibility in parts design, and reduces weight compared to its metal counterpart [Kuzmik JJ., 1990]. Plating on plastics (POP) therefore has been developed and widely involved in manufacturing printed circuit boards (PCBs) and automobile parts, and in the electromagnetic interference (EMI) shielding application [Kuzmik JJ., 1990, Viswanathan B., 1993]. Plastics that can be plated are phenol formaldehyde, melamine, acrylics epoxides and Acrylonitrile Butadiene Styrene (ABS).

Electroplating is an electrode deposition process for producing a thick, even, and adherent coating, usually of metal or alloys, upon a surface (conductor) by the act of electric current. Generally plating on plastics involves copper / Nickel plating. Copper is usually deposited via two routes viz., electroless route and direct electroplating route. For the first route, a regular electroless plating procedure is needed to place a thin conductive Cu layer on the plastic surface. Such a Cu layer provides sufficiently high conductivity required for the subsequent electroplating to complete the materialization finishing. However, the involvement of a regular electroless plating operation in POP is not desirable because of the disadvantages associated with electroless plating, including the complexity of the plating bath, a time consuming procedure, and the use of costly catalyst and environmentally unfriendly agents [Deckert CA, 1995., Hudd AB, Bentley P, Fox J, Robinson M, 2006]. Alternatively, direct Cu electroplating on plastics was proposed as a substitute to the electroless route, which involves an essential step of seeding the plastics surface with an electronically conductive catalyst or activator, typically a Palladium (Pd) and/or Tin (Sn) colloid. On adsorption of the catalyst on to the plastics surface, the seeded surface is subjected to a regular electroplating procedure to complete the metallization [Radovsky DA, Ronkese B J et al, 1963., Weng DC, Landau U, 1995].

The present work concentrates on developing a method to electroplate ABS Plastics. The procedure for ABS electroless plating was to first etch the surface of the substrate using chromic acid solution, for adhesion to the subsequent conductive layer. After the etching process, electroless copper plating is done thus forming a conductive layer on the ABS substrate. The substrate is then electroplated with copper. After copper plating, the material is nickel plated, which prevents corrosion of the copper layer. Once the plastic substrate has undergone this process, it is then plated with chrome solution using conventional electroplating methods.

Back Ground

The workpiece to be plated is the cathode (negative). The anode (Positive) is the metal that is to be deposited. Electrolyte is the electrical conductor in which current is carried by ions rather than by free electrons (as in a metal). Electrolyte completes an electric circuit between two electrodes. Upon application of electric current, the positive ions in the electrolyte will move toward the cathode and the negatively charged ions toward the anode. This migration of ions through the electrolyte constitutes the electric current in that part of the circuit. The migration of electrons into the anode through the wiring and an AC Transformer and then back to the cathode constitutes the current in the external circuit. The metallic ions of the salt in the electrolyte carry a positive charge and are thus attracted to the cathode. When they reach the negatively charged workpiece, it provides electrons to reduce those positively charged ions to metallic form, and then the metal atoms will be deposited onto the surface of the negatively charged workpiece. Figure 1 illustrates a typical line diagram of the plating unit for plating with copper and Nickel.



Part No	Description	Part No	Description
1	Anode (+)	6	Temperature Display
2	Cathode (-)	7	Transformer 0-12volt, 0-30amps
3	AC Supply to Heater (0-230v)	8	AC Supply to Transformer (0-230v)
4	Heater With Glass Cover	9	Air Pipe From Compressor
5	Sensor Which Senses Temperature of Electrolyte		

Figure 1. Line diagram of the Plating Unit

1. Experimental Work

1.1 Steps Involved in Electroplating Process

1.1.1 Surface Preparation

Work pieces to be plated may be put through a variety of pretreating processes, including surface cleaning, surface modification, and rinsing [Lowenheim, F.A., 1997]. The purpose of surface pretreatment is to remove contaminants, such as dust and films, from the substrate surface (Figure 5). The surface contamination can be extrinsic, composed of organic debris and mineral dust from the environment or preceding processes. Contaminants and films interfere with bonding, which can cause poor adhesion and even prevent deposition. Therefore, surface pretreatment is important to ensure plating quality. Most surface treatment operations have three basic steps: surface cleaning, surface treatment, and rinsing.

1.1.2 Etching Process

In this process, the Specimens are immersed in a tank containing concentrated chromic and sulphuric acid. The solution creates small microscopic holes on the surface of the specimens. These holes will later act as sites to hold the metallic particles. The solution is prepared as mentioned in Table 1. The sulphuric acid is first mixed with DM water. The mixing liberates heat and thus it should be allowed to cool

Chromic Acid	440gm / litre of DM H_2O
H_2SO_4	220gm / litre of DM H_2O

Table 1. Preparation of Etching Solution

down, later, the chromic acid in the required quantity is to be mixed with Sulphuric acid and DM water, to prepare the final etching solution. The temperature of the solution is to be maintained at around 80-85^0 C for etching process to take place. Once after the etching is over the specimens are to be rinsed with 30% HCL solution and later with DM water (Figure 6).

1.1.3 Activation Process

Also referred to as catalyzing process, is a process in which a catalytic film is deposited on the surface to prepare for electroless metal plating. The method of preparation of activation solution is as shown in the Table 2.

The etched specimens are dipped in solution A for about 2-3 minutes and later rinsed in DM water (Figure 7). The Specimens are then dipped in solution B for about 2-3 minutes and rinsed in DM water (Figure 8).

1.1.4 Electroless Plating Solution

Once after completing the activation process, a thin deposit of nickel or copper is deposited on the plastic part using the electroless solution. The solution preparation process is as shown Table 3.

The Solution is prepared by mixing the above chemicals in DM water in required quantity. The Specimens are rinsed in DM water after the electroless plating (Figure 9).

1.1.5 Acid Copper Plating

Also referred to as actual plating process / copper electroplating. In this process, a negative charge is applied to the part which is then dipped into a positively charged solution of the metal it is to be plated with. The positively charged metallic ions are attracted to the negatively charged part and then revert back to their metallic form. The part is removed from the solution and allowed to cool. The Solution for acid copper plating is prepared by mixing the chemicals in DM water as shown in Table 4. The solution prepared is left for 10-15 minutes to attain uniformity. Brighter and leveller solutions are also added to the prepared solution. The copper anode is immersed in the tub containing the solution (Figure 2)

Solution A	Tin Chloride 20gm / litre + HCL 15ml / litre
Solution B	Silver Nitrate 2ml / litre + Ammonia solution 5ml / litre

Table 2. Preparation of Activation Solution

Copper Sulphate	8gm / litre
Sodium Potassium Tartrate	35gm / litre
Formaldehyde	40ml / litre
Sodium Hydroxide	10gm / litre

Table 3. Preparation of Electroless Plating Solution

The Electroless plated specimens are then dipped in the prepared solution (Figure 4) for about 10-15 minutes or till the plating is complete. The electroplated specimens are then rinsed with 30% HCL solution to remove any excess material and also to obtain a uniform surface finish on the specimen. The specimens are then rinsed with DM water (Figure 10).

1.1.6 Nickel Plating

As in copper electroplating process copper is plated, in the same manner, a metallic coat of nickel is deposited, nickel electro plating is carried upon the copper plating which will increase the plating strength and also protects the copper layer. The Nickel solution is prepared by mixing the nickel salt (350-400 gm/litre) in DM water. The temperature of the solution should be maintained at around 40 - 50^0 C for the Nickel plating to take place, the Nickel anode (Figure 3) should also be placed in the tub containing the solution (Figure 3). The specimens should be then dipped in solution for about 5 minutes. Once the plating is over the specimens are rinsed with 30% HCL solution and then with DM water (Figure 11).

1.1.7 Bright Chrome Plating

A thin layer of chrome is deposited on the nickel surface. Chromium plating provides excellent hardness, bright appearance with no discoloration, and resistance to corrosive environments; it is easily applied and has a low cost. The solution for Nickel Plating is prepared using chrome salt (250 gm / litre) mixed with sulphuric acid (1 ml / litre). The solution prepared should be maintained around the temperature of 45 - 50^0 C. The holding time of the specimens (Figure 12) will be around 30 seconds.

Copper Sulphate	200gm/litre
H_2SO_4	30ml/litre

Table 4. Preparation of Acid Copper Plating Solution

Results and Discussions

The results of the electroplating on ABS material has been shown in Figures 2 to 13. It was observed that electro deposits tend to vary in thickness over the surface. All edges and corners attracted more metal. Very poor throwing power was observed in some regions. Throwing power of a plating solution refers to the measure of the ability of that solution to plate to a uniform thickness over a cathode of irregular shape. Some plating problems encountered were with chemical concentration, oxidation, current density, pollution of the solution and the temperature. As all the parameters discussed above have their own specific roles to play. When a current is applied to a load of work the distribution of current is not uniform over the whole area. The actual variation will depend on the shape of the part and the arrangement of the anodes. By using specially designed anodes the current distribution can be improved. Most of the problems or difficulties could be rectified with proper usage of current density. Pollution of the solution was also observed since the specimens had to be transferred from one solution to another hence rinsing in 30% HCL and DM water was adopted. Excessive temperature caused weakening of the specimen and at the same time evaporation of the solution. The copper plated specimens started to corrode with the exposure to the atmosphere hence they had to be coated with nickel within no time of copper plating.

Conclusion

The electroplating industry has been experiencing incessant innovations and also facing momentous challenges from economic and environmental viewpoints. The purpose of electroplating is to produce a qualified coating with the desirable traits. The electroplating of plastics, with usually ABS and ABS/PC blends as the substrate, is applied for decorative plating techniques in the industry, functional and ornamental coating of novel materials is increasingly gaining significance. This is a great Challenge for platers, since the employed basic materials cannot be coated satisfactorily using the conventional techniques. Therefore, innovative systems and processes which take into account these new challenges had to be developed. This means, apart from conventional coating technologies, alternative processes are available today

Figure 2. Copper Anode

Figure 3. Nickel anode

Figure 4. Acid Cu and Ni solutions

Figure 5. Basic ABS

Figure 6. ABS after Etching

Figure 7. Tin chloride Activitated ABS

Figure 8. Silver Nitrate activated ABS

Figure 9. Electroless Plated ABS

Figure 10. Acid Copper Plated ABS

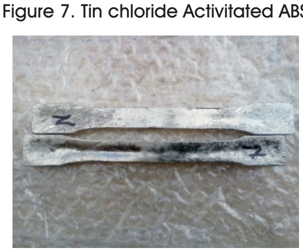


Figure 11. Nickel Plated ABS

Figure 12. Chrome Flased ABS

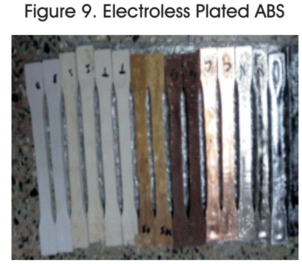


Figure 13. Specimens Before and after Electroless and Electroplating procedure

and one such attempt has been shown in this paper.

Implications

The following were the implications drawn from this study.

- Surface preparation of ABS material is vital to ensure adhesion of the metallic coatings.
- Any slight variation in chemical concentration and current density would lead to improper plating or uneven plating.
- Excessive current density causes plated material to burn out. The increase in the current density increases the temperature of the electrolyte, and thus causes peeling of the electroplated layers.
- The bonding of the succeeding layers is administered by oxidation of the deposited layers; the copper which is prone to oxidation has to be coated immediately with a layer of Nickel.
- Transferring of the samples from one solution to another leads to the pollution of the electrolyte. The pollution causes weakening of the electrolyte solution and hence causes improper plating.
- Electroplating improves the aesthetics of the products.
- Electroplated samples absorbs less water and thus making them useful in applications related to sanitary items like water taps, showers, toilet showers, etc.,

Recommendations for Future Research

Based on the results of this study, some recommendations for further research are offered below.

- The adhesion test could be carried out in order to evaluate the bonding of successive electroplated layers with the base material.
- SEM, and EDS techniques could be used to characterize the coated ABS surface before and after electroless Cu and Ni depositions.
- It is to be noted that with electroplating there could be a change in the chemical and mechanical properties of the work piece and hence it would be appropriate to carry out testing's related to chemical and mechanical properties.
- The electroplated materials could be subjected to EMI/RFI studies. EMI/RFI studies are important in Electronics and Telecommunication areas.

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