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# "Practical Process Sequences and Controls for Plating Various Substrates in Rack and Barrel MID Applications "

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Abstract
Increasingly, end users are employing molded interconnect devices (MID) to simplify supply chains and add value and function to devices used as electronic components. Commonly, MID are plated sequentially with electroless copper, electroless nickel and immersion gold, either over all surfaces or selectively. Selective plating is achieved with double shot molding in which one shot contains a catalyst to initiate electroless copper plating as first layer. More recently, LPKF LLC has invented a LDS( Laser Direct Structuring) process which uses proprietary formulations of metal doped resin which when exposed to a laser beam forms both a catalytic surface at the site of radiation as well as producing morphology changes at the resin surface. Various resins have been used for these MID applications and a number of chemical processing schemes have been developed to improve the adhesion, smoothness, initiation time and rate of deposition of electroless layers on the catalyzed part.
This paper discusses the process cycles for plating various engineering resin substrates used in double shot and LDS applications for MID.

## Introduction

Since 1980, molded interconnect devices (MID) products with three-dimensional structures have been made with stamped metal foil and in two-component moldings (2K-technique, double-shot molding) followed by surface chemical activation and selective metallization - a process with high initial cost that makes economic sense for a high volume of parts. One shot is specially compounded to contain a dispersion of Pd metal catalytic particles. Upon exposure to an etching solution the surface is opened up and Pd particles are exposed. These particles, concentrated in the doped plastic area, initiate electroless copper deposition in this selective area. See Fig.1

 

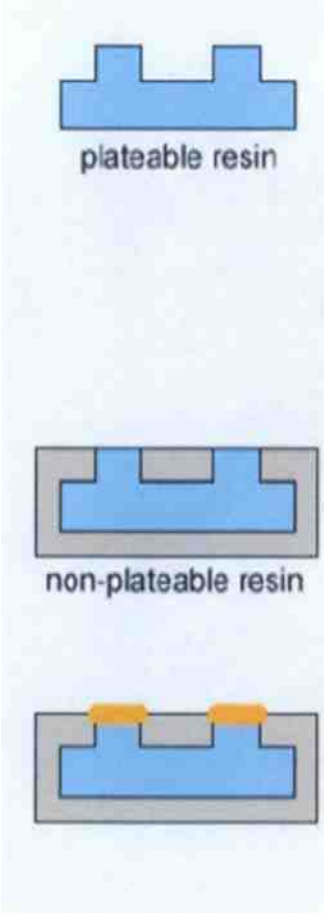


Figure 1. Two Shot Molding Processes

The plateable resins and non plateable resins can vary widely depending on physical properties and performance requirements of the final device. The concentration level of Pd in the compounded doped resin is also subject to variation for economic reasons.

The following table shows pairs of resins which have been processed successfully.

**Table 1. Type of resins used in 2 shot MID**

| | | | | | |
|---|---|---|---|---|---|
| Plateable Resin | ABS | ABS/PC | PBT | LCP | SPS |
| Non-plateable Resin | ABS/PC,PC | ABS/PC,PC | PBT | LCP | SPS |

Here is picture of phone antenna which has been molded in 2 shot process, the grey appearance of SPS contains Pd and after etching the part is placed into ECu and metallized.

Figure 2. **Two Shot Pd Catalyzed SPS resin antenna**

A practical sequence is shown in the following table.

| DESCRIPTION | TEMP/ °C | Time |
|---|---|---|
| **Chromic/Sulfuric Etch** | 70 | Depends on catalyst levels and resin type |
| **Neutralizer** | 25 | |
| **Electroless Copper high speed** | 56 | As req'd by rate & thickness |
| **Pd Activator** | 25 | 10 - 30 seconds |
| **Electroless Ni** | Varies by resin type and bath | As req. by rate & thickness |
| **Passivation** | 25 | 4 – 5 min. |

**Table 2. Cycle for 2 - shot selective plating**

Another technique which takes advantage of differences in etching and absorption of catalyst by dissimilar resins has been used for selective metallization. In this case, neither resin is doped with Pd particles, but since each reacts differently to etch, catalyst and accelerator steps a part can be metallized selectively on one of the two resin surfaces. For example, ABS is more effectively etched and catalyzed than PC. Thus, a two- shot part made with ABS in the area where metallization is desired and PC where no metallization is desired can be formed and plated. This is a most cost effective technique since it does not require doped Pd in the ABS section of the part. The process is similar to conventional POP electroless plating on plastic. Table 3 below, shows a sequence for this type of plating .

| DESCRIPTION | TEMP/ °C | Time |
|---|---|---|
| **Chromic/Sulfuric Etch** | 70 | Depends on catalyst levels and resin type |
| **Neutralizer** | 25 | |
| **Predip** | 25 | |
| **Catalyst** | 25 | |
| **Accelerator** | 25 | |
| **Electroless Copper high speed** | 56 | As req'd by rate & thickness |
| **Pd Activator** | 25 | 10 - 30 seco nds |
| **Electroless Ni** | Varies by resin type and bath | As req. by rate & thickness |
| **Passivation** | 25 | 4 – 5 min. |

**Table 3. Cycle for 2 - shot selective plating**

Another technique applied to functional applications of high temperature engineering resins for MID applications is overall plating of Cu/Ni/ Au, especially for high frequency connector applications. These parts are processed in bulk operations. A practical sequence is shown in the following table.

| DESCRIPTION | TEMP/ °C | Time minute |
|---|---|---|
| **Etch Conditioner** | 70 | 12 |
| **Neutralizer** | 25 | 6 |
| **Promoter** | 25 | 1 |
| **Predip** | 25 | 1 |
| **Cata lyst** | 43 | 5 |
| **Accelerator** | 25 | 5 |
| **Electroless Copper high speed** | 56 | As req. by rate & thickness |
| **Activator** | 25 | 1.5 |
| **Electro less Nickel** | 72 | As req. by rate & thickness |
| **Activator** | 25 | 1<br>2 |
| **Immersion Gold** | 72 | 0.1 |

**Table 4. Cycle for Non selective (overall plating) of LCP materials for 3 D connector applications**

Another technique which can produce selectively metallized parts begins with a resin that is etched and catalyzed as in Table 4 cycle where the part is plated overall up to the electroless copper stage. However, selective patterns are then formed on the part by laser ablation of the electroless layer and subsequent electroless nickel and immersion gold plating as final finish.

A variant of the above technique which does not use laser technology to remove metal, is the use of electrophoretic photoresists. The resist (especially negative working photoresist such as Eagle ED2100) is applied to the overall electroless copper coated part in a uniform thickness by electrodeposition. The resist is exposed to UV through a mask and then developed to strip away the resist in the non exposed area. The electroless copper layer under the exposed area of mask is removed by etching. The resist is stripped to reveal a pattern of ECu coating on the part. This ECu coating can subsequently be coated with Electroless nickel and immersion gold or other metal layers as required. This technique has great advantage when fine features are required at relatively low cost.

Lastly, another technique has been developed which allows designers to make smaller runs of complex parts with metallized patterns on 3 D surfaces without the use of 2 shot molding tools. This technique also allows for finer features than two shot molding. This

technique, known as Laser Direct Structuring for MID ( LDS), uses specially compounded resins with organo-metallic catalyst in the bulk of the resin.[1] Upon exposure to laser energy the surface structure and chemistry is changed to promote direct adhesion and selective catalyzation sites in a pattern which can be metallized. A practical sequence for LDS parts is given in Table 5.

| DESCRIPTION | TEMP/°C | Time minutes |
|---|---|---|
| **Acidic rinse plus ultrasonic** | 30 | 2 |
| **Electroless Copper high speed** | 56 | As req'd by rate & thickness |
| **Microetch** | 25 | 2 |
| **Activation I** | 25 | 0.5 |
| **Electroless Ni** | Depends on resin and ENi | As req. by rate & thickness |
| **Activation II** | 25 | 1 |
| **Immersion Gold** | 25 | 1 |

**Table 5. Process Cycle for Laser Structured parts**

Most common thickness of copper for MID applications is in the range of 8-12 microns. This requires an electroless copper with exceptional properties in balancing initiation, deposition rate, deposit stress, and smoothness. Achieving this balance provides users with a high yield solution for making these new 3D products.

It has been possible therefore to achieve a rate of 5 micron/hr, initiate on the various substrate surfaces as mentioned above without pre-dummying the bath or requiring a very active strike solution before the main ECu bath. This is achieved by balancing the stabilizer levels specifically for this type of bulk plating operation. Also adjustments of replenishment components of copper, caustic and formaldehyde and bath temperature are important to control within certain ranges.

Adjustments are made in the balance of conditions of activator/ accelerator in order to avoid extraneous plating on non catalyzed areas.

The following are examples of some parts which have been metallized with these new systems.

[1] Heininger, N, Naundorf,G.,John,W.,Talgner,F., and McCaskie, *J.E., J.Applied Surface Finishing* , 2(2),158-165 (2007).

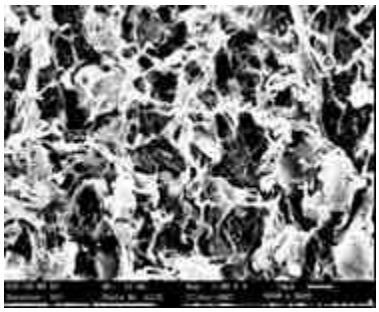

Fig 3. LCP after etch ( LDS) and before  plating

Fig. 4 LCP part processed in LDS after ECu HS, 10 micron

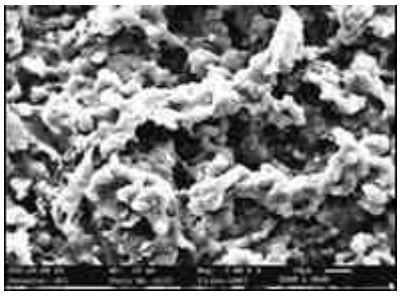

Fig.5. PBT LDS etched  before plating.

Fig 6. PBT part LDS process with 10 micron ECu HS

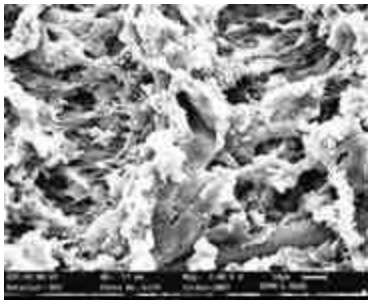

Fig. 7 PA6 after LDS etch

Fig 8. PA6 after LDS process and ECu HS 10 micron

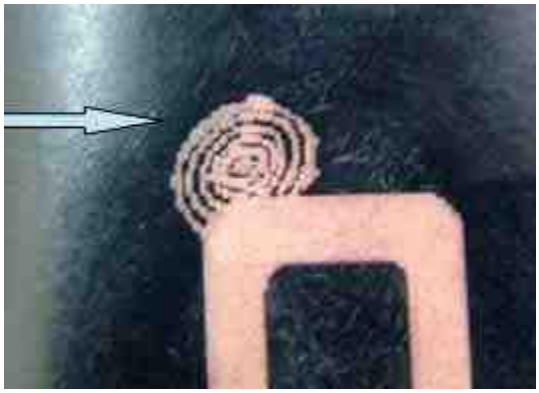

Fig. 9 Fine detail of ECu HS plated PA6 part after LDS process

Fig. 10 Detail of SPS/SPS 2 shot part plated with ECu HS, Ni, Au in barrel

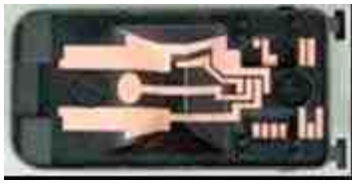

Fig 11. PBT/PET LDS part plated with ECu HS total coverage in 15min..

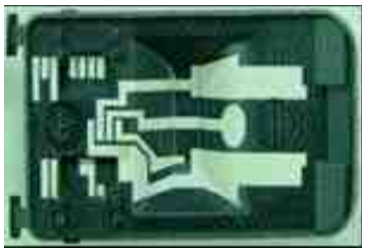

Fig. 12 PBT/PET LDS part after ECu HS and ENi plated at 83 C, 20 min. 6 micron NiP

Summary

Practical solutions for bulk plating small 3D parts with fine features for electronic applications is being achieved with new high speed electroless copper, electroless nickel and immersion gold systems which are designed specifically for these substrates and the new methods employed to plate them selectively and non-selectively.