# Hands-on Management



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## Progressive POP (Plating on Plastics)

The modern history of plating on plastics (POP) and other nonconductors of electricity dates back to around 1960. Before 1960, the chemical nature of the nonconductor—anything from baby shoes to flowers—played virtually no role in the plating process. This is because the plated deposit had to be thick enough to provide adhesion by encapsulating the object being preserved.

The artsy, hand-crafted aspect of early nonconductor plating is not well represented in the 20th century, except for the occasional bronze- or gold-plated baby shoes. Some of the techniques of the time, however, have been updated and are still in use today. Techniques used to prepare objects for electroplating included bronzing, graphiting, metallic painting and metallizing. Bronzing uses a metallic dust, most often copper, in a shellac or glaze spread on by brush to make the object conductive. Powdered graphite is rubbed on surfaces to which the graphite will adhere, such as wax and rubber, making it ready to plate. The metallic paint process employs silver particles as the foundation of the paint. The paint usually includes a flux to activate the surface to be coated, allowing the silver to "stick."

This paint has a modern-day counterpart in the electronics industry. Hybrid ceramic circuits are manufactured in part by firing, at high temperature, a metallic paint that is silk-screened onto the ceramic to create the lines of the circuit. Metallizing produces a metallic coating– silver is the most common metal used—by chemical means (reduction). Parts to be metallized are first dipped in a stannous chloride solution, then brought into contact with the silvering solution. Contact could be by immersion or spray, and a thin silver coating would result. This process was used to produce the first high-quality silver-on-glass mirrors.

Improvements in POP What major changes in plastics and surface finishing fueled the developments in the field of plating on plastics to make it into a commercial possibility?

First, the plastic producers—most notably the producers of ABS (acrylonitrile butadiene styrene) resins—noticed that "both the composition of the copolymer and the molding conditions employed needed adaptation from conventional practice to lend themselves well to subsequent treatment in electrolytes used in preparing the surfaces of such resins for electroplating."<sup>1</sup> As the plastic melt is forced into the mold, the old materials change and the nonuniformity causes adhesion and appearance problems.

Second, the entire process of electroless plating-including conditioners and etchants-improved. The electroless bath was now far more stable and allowed for the replenishment of the metal and reducer chemistry. The phrase "number of bath turnovers" is used as a measure of quality to indicate the economy/stability of operating the bath. One bath turnover is equal to replenishment of the solution components in the amount used in the original makeup. It is not unusual to get up to 10 turnovers with today's electroless chemistry, or about nine more than in the "old days." Enhanced conditioners and etchants increased the bond strength of the

metal to the substrate. Bonds to the plastic as strong as 20 pounds per square inch are now routinely produced.

The third major improvement was made possible by the advances in the organic chemistry for acid copper plating. Our own metal finishing suppliers answered the challenge of the printed circuit industry in dazzling fashion. Because the new solutions offered both a brilliant appearance and excellent leveling, only very thin platings of copper were needed to provide a beautifully finished product.

All of the following factors became the reasons various industries are now interested in the new plating on plastics industry:

- Lower cost
- Better molding; no secondary operations needed (*i.e.*, no deflashing or buffing to ready the parts for plating)
- Design freedom (*i.e.*, the ability to mold large and complex parts)
- Weight reduction, which was a very real benefit to the automotive industry during the gasoline crunch of the early '70s.<sup>2</sup>

A Prime Example

Of Progressive POP Let's take a quick look at the production of a plastic watch circuit in order to tie together all of these progressions in POP technologies. The key factor needed in the watch circuit is smoothness of the plating. Integrated circuits are ultrasonically bonded to the watch circuit using very fine gold wire. The wire would break over time if the circuit line is too rough.

First, the watch board design is reproduced in a mold so that each mold had the image reproduced about 36 times. A good design includes the gates through which the plastic flows, holes for the electronics, punch-outs so that each part serrates easily from the background, and raised bumps to make contact with the batteries. Next, the injection molding operation is optimized in order to have reproducible dimensions across the length and width of the large 36-piece array.

Using this "master" 36-piece molded part, the circuit artwork would be aligned (step and repeat) with each watch board. The artwork is then pasted to the top and bottom of a hinged, clear plastic book (photo-tool) that uses three pins in the corners to align the molded arrays to the artwork. After molding, the parts are cleaned in a mild soak cleaner before processing in a solvent that slightly swells/softens the surface. This allows the etchant to uniformly attack the rubber (butadiene) sites on the surface of the part.

## Timing is Everything!

Under-etching yields a surface that is too smooth to bond with the metal; over-etching gives a sandy surface that breaks off with the metal still attached. Activating the etched surface with a palladium/tin catalyst is the next step in the process before electroless copper plating.

The electroless copper is plated to a thickness of about 40-millionths of an inch. A dry film photoresist is applied to both sides of the coppered array. Using the custom-made artwork, the parts are exposed to a timed UV light source to cross-link and harden the photoresists. This reaction takes about five to 10 minutes to complete after the exposure. Following the exposure, the parts are developed in a semiaqueous solution (a water and solvent mixture) to remove the unexposed photoresist. In this case, it is the lines of the circuit that are dissolved/cleaned down to the electroless copper.

#### Ready to Plate

After a light prep, the parts are copper-plated in an acid copper bath. The key point here is the control of the leveler. In a 200-gal bath, the initial charge was only nine mL, and adds were made by an eyedropper. A small square placed in the artwork serves as a control. The surface roughness can be measured with a surface profiler. Popping the small square off the part and measuring its thickness with a micrometer controls the current density. Using these two measures together allow for a very fine control over the leveling of the bath chemistry. Two drops make a measurable difference in this system. After nickel, gold-plating the photoresist is removed and the parts were ready for inspection and packaging.

## Sticking with POP Plating on plastics peaked in the late 1970s and early 1980s, but with the

"death" of chrome in consumer products, its use slowed. Now that chrome has been resurrected particularly in the automotive industry—POP is also returning to near-record levels. With all the improvements in quality, let's hope that this time it sticks. PREF

#### References & Bibliography

- 1. F.A. Lowenheim, *Modern Electroplating*, Wiley-Interscience.
- 2. J. Kuzmik, "Plating on Plastics," *Electroless Plating: Fundmentals & Applications*, J. Hajdu & G. Mallory, eds. (1990).