TECHNICALLY speaking

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Decorative Plating Processes for Common Plastic Resins

Resin selection as well as plastic part design is critical to matching the right finishing method with the intended application.

Over the past 20 years, plated plastic components have become widely used in numerous industries, including electronics, automotive, aerospace, medical, industrial, and defense. Plated plastic is used to address a variety of needs, from decorative finishes such as chrome-plated automotive trim used in interior and exterior applications, to functional requirements such as controlling electro-magnetic emissions from electronic devices.

More recently, innovations in plating-on-plastics technology—such as selective plating on two-shot molded plastic parts, peelable plating resist, and precise three-dimensional circuitry on plastics—have expanded applications for plated plastics into connectors, antennas, thermal barriers (to protect the underlying plastic from melting or deforming under intense heat conditions), and wear-resistant coatings, to name a few. In combination with innovative plastic resin development and creative molded part design, today's plated plastic parts offer cost-effective, lightweight solutions with unique features that can greatly enhance product design and performance.

However, plastics present a challenge: they cannot be plated using conventional plating processes commonly used to plate metal parts. Plating processes developed for plastic resins have greatly enhanced the option for incorporating plastic parts into system designs that, in the past, were the sole domain of metals. This article will focus on plating processes, plateable resins, part design considerations, and review examples of successful plating on plastic applications.

PLATING PROCESSES

The starting point for plating on plastic is electroless plating whereby an initial layer of metal (typically copper or nickel) is deposited onto the plastic part. Electroless plating is an autocatalytic, chemical plating process that deposits a pure, continuous metal layer onto the plastic part. To prepare the injection molded part for electroless plating and achieve robust plating adhesion, the part is subjected to several process steps prior to deposition of the initial electroless plating layer. The parts are immersed into a series of process tanks, including chemical etch to roughen the surface and activation to deposit a catalyst onto the part.

Each plastic resin grade has a unique plating process through which the sequence of preparation steps and time in each plating process tank is optimized for the specific resin grade. Resins that are more chemically resistant will typically require a longer time in the etch process in order to roughen the surface. Different resins may also require different types of etchants to roughen the surface. Some resins may even require mechanical abrading or grit blasting to roughen the surface prior to the chemical etch step, and the most chemically resistant resins are not plateable. The etch and activation steps impact only the outer skin of the plastic at a depth measured in millionths of an inch. The bulk material properties of the plastic are not affected.

Following etching and activating, copper or nickel is deposited. Electroless plating produces uniform thickness on all surfaces of the plastic part, even in recesses and holes. Controlling the plastic plating process entails monitoring and managing the chemical composition and temperature in each process tank using standard sensing devices and chemical analysis methods common in most plating operations.

Once the initial plating layer is deposited onto the plastic part, additional electroless plating of copper, nickel, tin, or gold can be deposited to meet the full range of mechanical, electrical, environmental, and appearance requirements for the application. Typically, electroless plating is used to deposit thin metal coatings, <500 microinches (12.5 µm) total metal thickness, or in applications where the plating film thickness must be very uniform, such as antennas, for example.

Alternatively, if thicker coatings are required, electroplating processes can be used to deposit copper, nickel, tin, chrome, silver, and gold layers. Electroplating will deposit at faster rates and lower costs compared to the same thickness of electroless plating. However, electroplating is a line-of-sight process that will yield wider thickness variation over a part than would electroless plating. (With electroplating, plating thick-

Widely Plateable			
Acrylonitrile butadiene styrene (ABS)	Polycarbonate (PC)	PC/ABS	Polyetherimide (PEI)

Selected or Custom-Blended Plateable Grades			
Polyphenylene ether (PPO)	Epoxy	Graphite	PC/polyester
Polypropylene	PEEK	PPS	Liquid-crystal polymer
Polystyrene	Urethane	Nylon	Polyphthalamide (PPA)

Not Plateable		
Polyvinyl chloride (PVC)	Polyethylene	Polybutylene terephthalate (PBT), except for laser activation process

Table I: Plateability of Resins

ness can exceed 0.003″ or 75 μm.) Electroplating is used to produce decoratively plated plastic parts with available finishes, including nickel, bright and matte chrome, gold, copper, and brass.

A key decision that must be made early in the design cycle is resin selection. This is due to the fact that not all plastic resins are plateable. Generally, as the chemical resistance of the plastic resin increases, it is more difficult to plate (see Table I). It is also important to note that plateable plastics span a wide range of resin grades. At one end are easy-to-plate acrylonitrile butadiene styrene (ABS) and polycarbonate/ABS (PC/ABS) blends, which have been used in decoratively plated parts in the automotive sector, as well as in other industries. These materials etch easily and attain robust plating adhesion strength, often exceeding 5 lbs/inch width bond strength.

Difficult-to-plate resins—such as polyetherimide (PEI), polyetherketone (PEEK), polyphthalamide (PPA), and polypropylene—can be plated with alternative chemical etchants, or the resins can be custom compounded to include additives that promote plateability. Some difficult-to-plate resins, such as polyphenylene sulfide (PPS), resist chemical etching and require grit blasting to sufficiently roughen the surface for it to become plateable. The most chemically resistant grades—such as polyethylene, PVC, and polybutylene terephthalate (PBT)—are generally not plateable.

SELECTIVE PLATING PROCESSES

Plating can be applied over the entire part or, selectively, onto specified areas. There are now several options for selective plating, depending on the precision required for the selective plating, overall part size and design, and the plastic resin. The options for selective plating include the following:

Autocatalytic Plating Catalyst. First, spray an autocatalytic plating catalyst onto the areas of the plastic part to be plated. The chemical make-up of the catalyst draws copper metal out of the plating solution and deposits copper uniformly onto the catalyst. Following electroless copper plating, electroless nickel plating can be applied to protect the copper from corrosion and abrasion. Throughout this plating process, the plastic parts are never exposed to aggressive chemistries. Therefore, the molded-in color and texture of the plastic are maintained throughout the process. This selective plating method is most often used to apply thin electroless copper and nickel plating onto interior surfaces of plastic enclosures.

Selectively plated covers.

This coating shields against electromagnetic and radiofrequency interference (EMI/RFI) from escaping from the electronic device and interfering with other devices or from entering the electronic device and affecting operation. Another use is to provide a conductive coating that dissipates electro-static discharge (ESD).

Two-Shot Molding. Mold a two-shot plastic part with one shot being a plateable resin and the other shot a non-plateable resin. The plateable resin in the two-shot molded part is plated using normal electroless plating processes and materials. The mold tool must be specially designed for the two-shot molding process, and both plastic resins selected must have compatible molding parameters. Additionally, the plateable resin is a readily plateable material, such as ABS or PC/ABS, or a custom-blended resin with a plating catalyst additive. The non-plateable resin must be highly resistant to plating, which can include certain polycarbonate grades as well as generally non-plateable materials, such as PBT.

Two-shot molding. *(Image courtesy of Laird Technologies.)*

Peelable Plating Resist. Peelable plating resist can be used to mask defined areas of a part and produce complex masking patterns that are not feasible or cost effective with alternative processes. The plating resist is applied onto the required areas by dispensing or spraying, followed by UV curing to harden the resist. The part is subjected to conventional electroless plating to apply an initial copper layer; the resist is then peeled off the part. Subsequent electroless or electroplating can be used to finish the part to the final requirements.

Laser Direct Structuring. Using custom-blended resins and proprietary laser equipment, precise metal patterns in two and three dimensions can be deposited onto molded plastic parts. The metal pattern is defined by the laser activation process, which "writes" the pattern directly onto the plastic part. Using conventional electroless plating processes, the metals are deposited onto the laser-activated areas to yield precise metal patterns directly onto a molded plastic part. The typical plating system comprises electroless copper, nickel, and gold. However, it is feasible to electroplate over the initial electroless copper plating if added metal thickness is required to carry a current or dissipate heat. The metal pattern can be modified by making changes to the laser programming, which is similar to changing CNC programming.

Laser activation. *(Image Courtesy of LPKF Laser & Electronics.)*

Additionally, solderable circuits on plastic can be achieved by utilizing plastic resins, such as liquid-crystal polymer (LCP) and PPA, which have heat deflection properties suitable for soldering electronic components to the metalized plastic part, including a lead-free soldering process.

An important design factor for the laser activation procedure is that it is a line-of-sight process. Vertical walls, holes, and crevices that are difficult to reach with a laser can require multiple fixturing operations and laser activation steps—all of which impact cost. It is recommended to taper walls, avoid 90° bends, and avoid shadowing circuit pattern areas in the design of the part.

The selective plating process options all offer advantages that make each suitable for specific applications and requirements. Table III summarizes

Design Don'ts	Design Alternative
Five-sided box or cup design that can trap air and drag out plating chemicals, impacting plating quality and cost	Include drain holes or design the part to prevent entrapment of air or plating solution.
Tight crevices that can trap plating solution	Eliminate crevices in the design or include drain hole(s)
Small blind holes with an aspect ratio >5:1. Small holes can trap plating solution that later weeps out and can damage the plating.	Utilize through-holes if possible. Note that blind holes can be plugged to prevent plating solution entrapment. However, this operation adds cost.

Table II: Part Design Impact on Plating

Process	Candidate Resins	Part Size Limitations	Plating Options	Plating Precision	Comments
Plating catalyst	Primarily ABS and PC/ABS and selected PC resins	Up to 3' × 3'	Electroless plating only, typically copper/nickel	Plating tolerance of ±0.025"	Plating interior surfaces of enclosures for EMI shielding or grounding surface
Two-shot molding	Plateable resins: ABS, PC/ABS, or a custom-blended resins with plating catalyst additive. Non-plateable resins need to be compatible in molding process to plateable resin.	Subject to mold press and tool size	Electroless followed by electroplating, if required. Available metals include copper, nickel, tin, gold, and chrome.	Tolerance function of two-shot molding capability. Can attain line width of <0.020" (0.5 mm).	Applications include connector antennas, IC packaging, and sensors
Peelable plating resist	Plateable resins, including ABS, PC/ABS, Polycarbonate, PEI, PPO, LCP, PPA, etc.	Restricted to plating tank size	Electroless followed by electroplating, if required. Available metals include copper, nickel, tin, gold, and chrome.	Subject to part design	Suitable for complex part design where two-shot or laser activation process is not feasible
Laser activation	Several proprietary resins, including ABS, PC/ABS, polycarbonate, PBT, PPA, LCP	Up to 8" × 8"	Electroless followed by electroplating, if required. Typical metals include copper, nickel, tin, and gold.	Line width from 0.004" (0.10 mm). Line spacing from 0.006" (0.15 mm). Vias with minimum 0.008" (0.20 mm) diameter with minimum 30° draft angle.	Applications include precise 3D circuitry on plastic molded parts, connectors, antennas, IC packaging, and sensors

Table III: Selective Plating Processes

the process capabilities of each option.

PART DESIGN CONSIDERATIONS

As with resin selection, plastic part design is critical to successful application. There are design approaches that should be avoided if possible. Table II summarizes design for plating considerations.

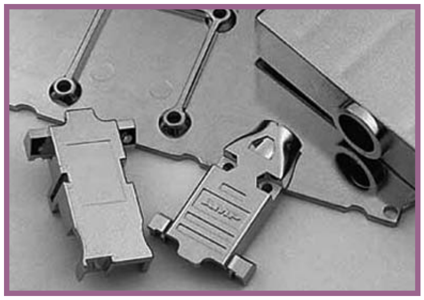
Another issue includes inserts, which can be molded into the part or installed by heat staking or ultrasonic insertion prior to or after plating. If specifying a <100 micro-inches (2.5 μm) electroless plating thickness, inserts can be installed before or after plating. If plating thickness is >100 micro-inches (2.5 μm), inserts should be installed prior to plating. Inserts installed prior to plating need to be masked during the plating operation with a plug or screw to prevent plating on the threads. Standard boss and insert design guidelines should be followed for plated plastic parts with inserts, and brass inserts are compatible with electroless and electroplating processes.

Conventional finishing operations—such as gasket installation for environmental or EMI/RFI seal, decorative paint, and part labeling—can be used to finish the plated plastic part to final OEM specifications. Material selection for gaskets, decorative paint, and label ink are determined by the final plated metal layer on the part.

Specifying the plating system includes the following elements:

- **Thickness is usually defined as a minimum. If required due to part function or fit, plating can be specified as a thickness range. Plating thickness is commonly measured using X-ray fluorescence, a non-destructive test with accuracy down to 2 × 10^{-7} inches (0.005 μm). Note: modern X-ray equipment can measure up to three unique metal layers on a plated plastic part.**
- **Where surface conductivity is critical due to application as EMI/RFI shield or ESD coating, the coating resistance should be specified, either in ohms per square or point-to-point ohms resistance. In this case, plating thickness does not need to be specified.**
- **Plating adhesion is commonly measured according to ASTM D3359 Standard. This standard is based on tape test (either destructive or non-destructive) and a 1–5 scale for amount of plating removed during the tape test (5 means no metal removed, while 1 denotes complete removal of the plating).**

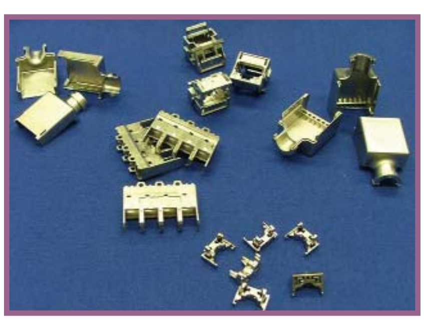
PLATING ON PLASTICS APPLICATIONS



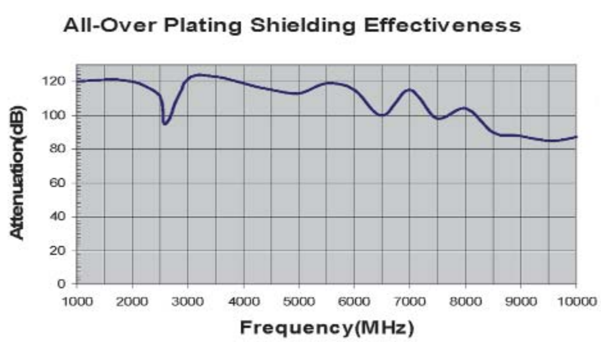
Chrome-plated plastic.

Decorative Plating. Decorative finishes for plastic can match that which is attained with metal parts. Finishes include copper, nickel, bright, matte, brushed, and black chrome, brass, and gold.

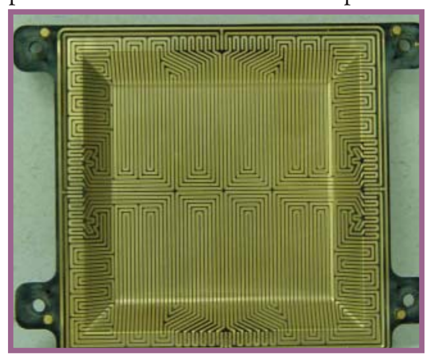
Shielded Connectors. Connector designs in today's electronic equipment face competing demands for a smaller form factor, lighter weight, improved mechanical performance, increasing need for EMI shielding, and lower cost. Metal shells, used to shield connectors, add weight, cost, and space. Plated plastic connectors are being used to meet the EMI/RFI shielding requirements and reduce weight and space. The chart below shows EMI/RFI shielding effectiveness of plated plastic connectors over a wide frequency range. Additionally, nickel thickness can vary between 50 and 600 micro-inches (1.25–15.0 μm) to meet mechanical and environmental requirements.



Plated plastic connector.



Laser Direct Structuring Security Cover. The laser direct structuring process has been used to deposit a precise pattern of circuits onto the interior surface of a security cover. The gold-plated circuits mate to contacts on the PCB connector. Applied onto the interior surface of the cover and invisible from the outside, the circuits have 0.010″ (0.25 mm) spacing. If the cover is removed, the circuit is broken, which signals the device that security is breached and to shut down, while recording intrusion and/or dump data to protect the system against unauthorized access.



ATM security cover. *(Image courtesy of NCR.)*

Military system. *(Image courtesy of DRS Tactical Systems.)*

Military Electronic Equipment. The modern-day battlefield is noisy, and military electronic systems need to be shielded against EMI/RFI noise. With the move to rapid force deployment, this drives the need for lightweight, mobile electronic systems. Plastics have made significant inroads into the electronic battlefield. Because plastics do not shield against EMI/RFI, they are usually plated with copper and nickel, often with thick electroplated coatings to protect against a wide EMI/RFI frequency range that may be encountered in the field. The plated plastic components can then be coated with MIL-spec finishes, including latest-generation waterborne chemical agent–resistant coating (CARC) paint.

SUMMARY

Plating on plastics has become a widely used technology that provides decorative and functional finishes on injection-molded components. Innovations in plating and plastic technology over the past 20 years have extended the application of plated plastics into highly cost-competitive electronic devices, automotive hardware, critical performance applications, medical devices, and military electronics. Plating-on-plastics processes have been developed to address present-day design challenges while also providing functional cost-effective and reliable solutions.

BIO

Jim Skelly is the president of Lufkin, Texas–based Cybershield, which applies functional and decorative metal coatings onto plastic parts for a wide range of applications and industries. Skelly received an industrial engineering degree from the University of Rhode Island and an MBA from Northeastern University. He worked for Texas Instruments (TI) for more than 20 years in sales, marketing, and program management positions. Since leaving TI, he served as president of Thermalloy, an electronic component manufacturer, and EL Specialists, a start-up that developed an innovative electroluminescent technology. He may be reached at (214) 227-3680 or via e-mail at jim.skelly@cybershieldinc.com.