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The Technology of Tiny Parts

Plating miniscule parts requires precision and control, something Professional Plating has developed and marketed as its niche…

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A small barrel of parts rotates in the silver bath. Silver is the most conductive metal, however, it requires a copper or nickel undercoat.

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Plating electronic parts smaller than a baby's eyelash requires precision, control, engineering and an appreciation for the delicate nature of these minuscule parts. This is particularly true if the parts are going into aerospace assemblies, hearing aids, telecommunication devices or other electronic systems, because even a difference of a thousandth of a micron in thickness is reason for rejecting a part.

This concept of precision and focus fit perfectly into Craig Ingall's, president of Professional Plating (Anoka, MN), plan for the company when he purchased it in 1997. Rather than concentrate on a small group of customers, adding finishes and services to meet their needs, Mr. Ingalls decided to focus on what Professional Plating (ProPlate) did best, which was plate small parts with precision. "We are a technology company. We do engineered plating, which includes a lot of very small connector pins. There is a lot of micro miniaturization going on in the electronics world. We develop the finishing processes for these tiny parts and find the customers that need this type of plating," stated Mr. Ingalls. "We tend to be second tier. Our customers manufacture the parts for the bigger name companies, such as Motorola, Compaq Computer, IBM and other telecommunications companies."

ProPlate specializes in plating small parts and large quantities of small parts as well as customized plating and prototype work. The finishes include gold, palladium, rhodium, silver, nickel, copper, tin and tin alloys.

Engineers at ProPlate work with the customers to determine the best finish for their parts. What type of hardness is required? How much ductility is needed? How conductive must the part be? How will the part be used? These and other questions help the engineers determine the best finish and the best finishing process for each part.

In order to fulfill its commitment to precise plating control, ProPlate realized that the key would be to control the process to a higher degree than what historically had been the norm. Several systems have been installed during the past four years. The first was a proactive, periodic maintenance protocol for all of the chemistries in the plant. A survey of the finishing industry for an effective software package to facilitate this goal led Mr. Ingalls to the realization that there is a crucial link between software and the physical plant. This link is continuous and timely inputs were necessary to the monitoring software of the current aging of each chemical bath. So, before any software package could be successfully implemented, ProPlate developed the tools, procedures and training required to maintain a timely flow of data into software.

Subsequently, Mr. Ingalls decided to develop his own software package that would be tailored exactly to the unique needs of ProPlate's plating processes. "We wrote our own software. It's unsophisticated but completely effective. Software generally has become so complicated. It seems commercial software developers have a natural incentive to continuously innovate and add features. As the computing power of hardware grows, it facilitates the growth of the software. I personally have a need for only a fraction of the

features contained in the word processor or spreadsheet that I use. So we went back to basics without bath maintenance software, writing it in our spare time. It's based on the Access database from Microsoft. The beauty of developing your own program is the complete flexibility and control you have over what it will do for you. As our process understanding grows, we constantly find opportunities to save chemical maintenance labor. Our maintenance system currently tracks about 550 chemical parameters. Each parameter is a control charted and automatically reviewed each day for trends toward a control limit. Four years ago our internal rework rate was averaging about 15% of production, now it is less than 2%. I believe that is a result of improved bath maintenance."

Another aspect of the ProPlate culture is the belief that there is a reason for every problem. Repeating mistakes is a waste of precious resources. The company spends a lot of time understanding what is happening at a detailed level in its baths. "We cannot cost effectively achieve our desired results if we are reduced to guessing about what is going on in the baths. We need to know the facts to be able to control the process," stated Mr. Ingalls, who also expects the staff, from the platers and inspectors on up to the vice president and himself, to fully commit to the continuous pursuit of learning and improvement. Mr. Ingalls compares ProPlate's culture to sports, "We are not gymnasts or golfers, each competing against individuals to be the single champion. We are much more like a football team where there is one first place, and we all share the common victory."

Gold

The most commonly plated metal at ProPlate is gold. Parts can be plated in barrels, on racks or specially wired. Because gold is a precious metal, it does not oxidize (rust); therefore it maintains its electrical conductivity. The company uses Type III gold, which is 99.9% pure. The gold is alloyed with a diminishing amount of cobalt to provide hardness and is plated per Mil-G-45204C. This type of gold is plated on semiconductor components, parts for nuclear engineering, parts for thermocompression bonding and parts that will be used in high temperature applications.

When gold is applied to a copper-rich substrate such as brass, bronze or beryllium copper, metal ions from the substrates diffuse into the gold layer and degrade its hardness and non-oxidizing properties. An anti-diffusion underplate, such as nickel, is applied to prevent this. Electroless nickel is used where part flexibility is not an issue and a bright finish is required. Sulfamate nickel is used when greater ductility is needed.

Palladium

Palladium is harder than cobalt gold, and, because it is a precious metal, it will not oxidize. Palladium has greater ductility than gold, allowing for greater contact bending tolerance, lower porosity and better corrosion resistance than hard gold. This makes palladium a prime candidate for reed switches or relay contacts. But essentially, palladium is comparable to gold, and they are interchangeable metals. "Palladium became popular 10 or 15 years ago when the price of gold climbed higher than palladium," explained Mr. Ingalls. "When gold prices went down, a certain number of customers continued to use palladium because they liked the white color, in spite of the higher price. Actually, because so little metal is actually plated, the difference in cost is fractions of a penny in a big assembly." Small parts also make for light shipping loads. Two bags

containing thousands of dollars worth of parts can be shipped across the country for less than $25.

Palladium has lower wear resistance than gold in sliding contact in areas such as pin/socket interfaces. Palladium mated against itself has less wear resistance than when mated against gold or a palladium surface with a thin gold overlay. Underplating palladium with gold gives it excellent solderability.

Rhodium

Rhodium is the third precious metal plated at ProPlate. Rhodium, like palladium, is white and non-oxidizing; however, it is the hardest of the three precious metals plated at ProPlate. It provides the most wear resistant finish; therefore, it is best used on parts such as sliding electrical contacts that require protection from corrosion or galling. When underplated with a layer of nickel, the rhodium provides a mirror surface that is highly reflective. Surfaces other than nickel, silver, gold or platinum should be either nickel plated or nickel plate over copper plate. Underplating nickel should be used when parts are corrosion- or heat-resistant steels.

Silver

Although silver is not a precious metal, since it tarnishes, it has the highest electrical conductivity of all metals. Silver is excellent for soldering applications and applications that require high electrical and thermal conductivity, thermocompression bonding, wear resistance of load-bearing surfaces and spectral reflectivity.

Several options are available to handle silver tarnish. They depend on the solderability or subsequent finishing steps, such as painting or powder coating. A thickness of 0.0003 inch is recommended for terminals that are to be soldered. A thickness of 0.0005 inch is recommended for corrosion protection of nonferrous substrates or for increasing the electrical conductivity of substrates. A thickness of 0.005-0.01 inch is recommended for electrical contacts, depending on pressure, friction and electrical load.

When corrosion protection is essential, nickel is plated underneath the silver. All silver plate on steel, zinc and zinc-based alloys receive an undercoat of nickel plate over copper plate.

Copper and copper alloys that will be silver plated also receive an undercoating of electroplated nickel. Copper and copper alloy substrates without a nickel undercoat or other base metals where a copper undercoat is used prior to silver plating, should not be used for continuous service at temperatures exceeding 300F. Silver adhesion is adversely affected because of a weak silver/copper intermetallic layer.

Nickel

ProPlate provides two nickel finishes, sulfamate nickel and electroless nickel. Its SuperBrightTM decorative nickel finish uses a proprietary plating process as well as a comprehensive range of engineered nickel systems to meet high performance requirements. The SuperBright process uses a Watts nickel bath, which provides a bright finish and good corrosion and abrasion resistance as well as a low coefficient of thermal expansion. ProPlate applies the finish to specification QQ-N0-290A.

Nickel is most often applied as the base layer because of its leveling properties. The leveling properties make it an excellent undercoat for precious metals, reducing the amount of the precious metal needed to achieve performance specifications.

Nickel is also used because of its barrier properties, which provide resistance to metals such as cyanide copper or silver. It protects iron, copper or zinc alloys against corrosion, depending on the thickness of the deposit.

Often, nickel plate is specified for engineering purposes, such as wear resistance, abrasion resistance and corrosion protection of parts. Heavy deposits may be used for buildup of worn or undersized parts, or for salvage to provide protection against corrosive chemical environments.

ProPlate also undercoats parts with medium- and high-phosphorus electroless nickel. Electroless nickel has superior leveling characteristics, making it ideal as a first layer for almost all the electroplated finishes at ProPlate. Electroless nickel is applied per specification Mil-C-26074.

The sulfamate nickel provides the lowest hardness, lowest internal stress and highest ductility of all the nickel plating options. With its dull finish and high ductility, it is excellent for applications where flexibility is required.

Copper

ProPlate applies copper to specification Mil-C-14550. It, like nickel, has excellent leveling properties, however it also has high throwing efficiency and is ductile. Its throwing efficiency enables it to fill sharp corners and surface imperfections and ensures that pinholes and subsequent blistering of the finished metal will be avoided. It is applied 100-200 microinches thick.

Tin

ProPlate also plates bright acid tin per specifications Mil-T-10727; alkaline tin to specification Mil-T-10727, Type I; and 60/40 and 90/10 tin/lead to specification Mil-P-81728A. Tin is a good electrical conductor and is used for its combined corrosion protection and conductivity in aerospace avionics radio frequency applications.

The finish ProPlate engineers recommend is usually not a single finish. It is usually a combination of finishes. It all depends on the customers' requirements. For example, one small part, a test probe, is made up of three smaller parts, a plunger, a barrel and a spring. Although all three pieces have a gold plated final finish, each piece has a different set of finish requirements. Obviously, the spring is going to need a finish that allows for flexibility and wear resistance, so a sulfamate nickel finish is used as an underplate. The plunger and barrel also need strong wear resistance and hardness because of the sliding motion.

These probes are arrayed within an assembly that descends onto a printed circuit board. As the plunger pushes the notched top of the barrel into contact with the board, information is transmitted about the makeup of the board to a computer. Because of sensitivity of the board, the plating on the notched tips of the plunger

is critical. “We have to measure a cross sectional area of the point,” noted Mr. Ingalls. “The customer does not want that to change, even after a million cycles. Therefore, we have to have tight control over the hardness and thickness of what we are plating.”

This control and refinement of its plating processes has helped the company survive. Craig Ingalls knew that he couldn’t be a “typical” plater when he bought ProPlate. He had to do something different from all the rest. “It was clear we wouldn’t survive operating as a typical plating shop,” stated Mr. Ingalls. “We decided to be more focused, narrow the product offering and develop the processes to a high degree. We offer a high degree of technical expertise.

“As time went on I became pleasantly surprised and somewhat alarmed at the risk I had taken in purchasing the company,” laughed Mr. Ingalls. There are always the waste treatment issues, particularly with cyanide, which he sees as simply the cost of doing business. ProPlate has a creative waste treatment manager who understands how to prevent waste generation in the first place. For example, the company has set up dead rinses after its plating baths rather than flowing rinses. Because of this, cyanide does not have to be continuously treated, and the flowing rinses simply go through ion exchange. This cuts down on waste treatment costs as well as water use.

This creativity fits in with the whole method of operation at ProPlate. They have to be creative because they deal with small parts. The shape of the parts cannot change and many of the parts are fragile. So not only do you consider the finish, you consider the method. Even parts as tiny as a baby’s eyelash can be finished, and not by magic, but by refining the finishing process and developing process expertise.

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