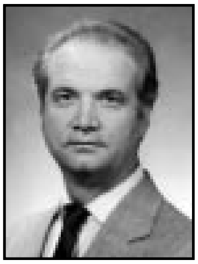

Advice & Counsel

Frank Altmayer, CEF
AESF Technical Director
Scientific Control Laboratories, Inc.
3158 Kolin Avenue
Chicago, IL 60623-4889

Keeping It Simple, Part III

Editor's Note: *This month's column concludes the answer to a letter from an eighth-grade student who is planning a science project on electroplating. The information contained here is excerpted from a new interactive CD, "Electroplating for Beginners," which may be purchased by contacting AESF Publications Sales at 407/281-6441.*

Anodes

The anodes in a plating system are the key part of a plating tank, used along with the rectifier to provide DC electricity to the part we are plating. The anode(s) are always connected to the terminal of the rectifier marked "+" or "positive." This terminal is also marked in red or, on smaller rectifiers, a red cable will be connected to this terminal. To rectifier manufacturers and platers, red means a positive electrode. This assures that electricity will flow in the proper direction. If electricity does not flow in the proper direction, our part might dissolve instead of be plated!

There are two basic kinds of anodes used in plating: Those that slowly dissolve and those that don't dissolve. Anodes that dissolve when we plate are called soluble anodes. Anodes that don't dissolve are called "inert" or "dimensionally stable" anodes.

Soluble Anodes

Soluble anodes dissolve slowly, when the rectifier is turned on, and enough voltage is applied to start plating. As the soluble anode dissolves it does two things:

1. It produces a flow of electrons from the anode through the rectifier, and eventually to the part we are plating. This flow of electrons makes plating of metal onto our parts possible. We will explain how this happens shortly.
2. In the plating solution, it replaces the metal being plated-out onto our part. This saves us money, because this is the cheapest way to replace the metal we are plating onto our parts.

To keep the anodes dissolving at the proper rate, just the right amount of electricity must be applied. If too much electricity is applied to our anodes, they will form scale and not dissolve properly. We call this "polarized" anodes. If anodes are polarized, they no longer replace the metal that is plated onto our parts, and over a period of time, there won't be enough dissolved metal in our plating solution for plating to continue. Plating will stop. For this reason, operators of plating tanks are usually very careful to keep anode baskets full or, if anode bars are used, operators make sure that there are enough of them hanging on the bus bar so that the plating current won't be too high for the area of anodes in the tank.

Insoluble Anodes

In certain plating solutions we use insoluble anodes. These are made of materials that don't dissolve when the rectifier is turned on and the voltage is increased to provide plating amperage. Insoluble anodes still provide electrons that make plating possible, but because they don't dissolve, the metal that is plated onto our parts must be replaced by adding metal-bearing chemicals to the plating solution. For example, chromium plating is typically done with lead anodes, which don't dissolve. The chromium being plated onto the parts must be replaced by adding chromic acid to the plating solution on a regular basis. We don't use chromium for anodes because it won't dissolve properly. (It actually would dissolve if we tried to use chromium as an anode, but it would make a contaminant instead of the right chemical for plating.)

There are other special cases where other types of insoluble anodes are used. Some inert anodes and the types of solutions they are used in are:

Carbon (graphite)—trivalent chromium plating, Wood's nickel strike
Stainless steel—silver plating
Platinum, platinized titanium, platinized niobium, platinized tantalum—gold plating
Solid platinum—gold plating, palladium plating, platinum plating, rhodium plating
Rare Earth proprietary—electrolytic recovery cells

Insoluble anodes can sometimes get coated over with a film that doesn't conduct electricity very well. This reduces the plating efficiency by increasing the resistance between the plating solution and the anode. Undesirable coatings must be regularly cleaned off, to keep the process at peak efficiency.

There are exceptions, however. For example, lead anodes in chromium plating solutions generate a brown coating that is highly desirable, because the brown coating keeps down contamination of the solution. Lead anodes can also develop an orange coating that is not desirable and should be cleaned off if it gets too thick. Insoluble anodes should be inspected frequently to see if undesirable coatings are forming, and should be cleaned off when such coatings are found.

Anode Bags

Anodes may not dissolve efficiently or might react to form coatings during use. As the anode is used, it generates very small solid particles. It is the job of the filter to remove such particles, but the filter may not be able to catch the particles before they are incorporated into the plated coating, making the surface of the plated part rough, like sandpaper. The best way to eliminate the roughness of particles trapped in the plated deposit is to put the anode inside a bag. The bag allows dissolved metal to soak through the woven fibers, but holds back the solids.

Bagging the anodes is common in plating solutions that are acidic. It is less common in alkaline solutions, because such solutions tend to be slippery, and don't allow the particles to stick in the first place.

It is important to use the right kind of bag. The bag must be made from a fabric that will not be chemically attacked by the plating solution. Also, the bag must be woven with the right number of threads per inch.

Anode Baskets

The anodes used in plating can come in a lot of different shapes and sizes. Some shapes are less expensive to use than others. For example, if we start with a soluble copper anode that is shaped like a rod, the rod will dissolve faster at the end than it will near the top, as the anode hangs in the plating tank. This is because electricity concentrates at points and sharp edges. The end of the rod is like a point. As the rod dissolves, it will change shape into a sharp, pointy "sword-like" shape. The exposed surface area of the rod will be reduced, and now the applied current might be too high, causing the anode to form undesirable coatings and oxygen gas. Such an anode is called a "polarized" anode. To correct this problem, we now would have to send the "sword" off to the scrap dealer and put in a new rod. This is not economical.

A better way to use metals as anode material is to buy small chips or other shapes, and put them into a basket. The basket is made from a material that won't dissolve, but the chips inside do dissolve. This way, the entire amount of metal that is bought is used up in the plating process. As the chips in the basket become smaller, they settle down toward the bottom, and we just keep adding more chips to the top of the load in the basket. In some plating operations, such as nickel plating, it is very important to keep the baskets full. If the baskets in the nickel plating solution are not kept full, the basket itself can start to dissolve into the plating solution. The solution then becomes contaminated and the baskets must be replaced, at high cost.

In solutions containing acids, the baskets are usually made out of titanium, while cyanide-based solutions can use either titanium or steel baskets. Anode baskets are usually shaped in the form of wire mesh boxes, or coiled-up wire.

> Filtration: Plating solutions are filtered through paper or other "media" … This principle is the same one you might use at home to make coffee.

Agitation System

Some plating processes require a lot of agitation. Agitation, sometimes called "mixing," is used to stabilize the temperature of the plating solution across the depth of the tank, and to speed up the plating process. Agitation is movement of the solution across the surface of the part to be plated. This can be done several ways. The most common agitation system uses low-pressure, contaminant-free blower air to make air bubbles, which rise to the surface of the plating solution. As they rise, they push the solution, forcing some movement.

Another agitation system uses recirculation of plating solution through pipes or eductor systems. Mechanical agitation is performed by moving the part, instead of the solution. The part may be moved by a motor pushing the cathode rod back and forth, for example.

Agitation is important to certain plating systems, because it results in a better-looking plated coating (brighter, more uniform, better coverage). When the agitation system is not working properly, the appearance—and sometimes the usefulness—of the plated coating is usually not as good as when it is working properly.

Filtration

Some plating processes are very sensitive to the presence of dirt, dust or any other solid particles. Such processes are equipped with filtration equipment to remove such particles. There is a wide variety of filtration equipment that can be used, but all such systems use the same principle. This principle is the same one you might use at home to make coffee. A paper filter holds back the coffee grounds while the hot water goes through the paper, picking up coffee flavoring from the grounds. Plating solutions are filtered through paper or other “media,” such as sand, or cartridges made from various fibers. The particles are held back by the media, while the solution and anything dissolved in the solution goes through.

To be effective, filters must recirculate the plating solution around the plating tank, at a flow rate that is high enough to capture solid particles before they can get incorporated into the plated coating (which would make the plated surface rough, like sandpaper). The recirculation rate depends on the size and condition of the pump, and the condition of the filtration media. As the filter gets used, the media clogs up with particles, and eventually the pressure across the media is too high for the pump to push the plating solution through the media at the desired flow rate. Each filter is rated for a maximum operating pressure that allows the filter to do its job. As the filter operating pressure reaches this maximum pressure, the media must either be cleaned or replaced. Replacing the filtration media at the correct interval and making certain the filtration pump works at peak efficiency are very important to quality plating.

Parts to Be Plated

The part or parts we intend to coat with plated metal(s) are referred to as the cathode in the plating tank. The cathode is connected to the negative terminal of the rectifier. In rack plating, this is accomplished through the hook of the rack, as the rack hangs on the cathode bus bar of the tank. In barrel plating, the parts are connected to the cathode saddle, through the dangler of the plating barrel.

How Plating Occurs

Let’s combine everything we have learned so far to demonstrate how plating happens.

At the anode, the rectifier moves electrons from the anodes through the anode bus/cables, through the guts of the rectifier, through the cathode cables/bus of the plating tank, and finally to the parts we want to plate. The electrons that are delivered to the parts we want to plate perform a chemical conversion, converting dissolved metal to solid metal. This is a complicated process, which we will simplify as follows:

1. When a metal is a solid metal, it has a certain number of electrons spinning around each atom of metal.
2. If the anode is a soluble anode, when the rectifier moves some of these electrons from the anode, the solid metal converts to dissolved metal (called ions) and the anode proceeds to dissolve into the plating solution. In this way, the metal that is plated-out of the solution is replaced by metal that dissolves from the anode.
3. When the rectifier delivers the electrons produced at the anode to our part, they are able to “jump” back onto the dissolved metal ions in the plating solution, converting them from ions back to solid metal. Because this “jumping” happens on the surface of our part, our part gets coated with this converted metal. Because electricity concentrates at points and sharp edges, more jumping occurs at these areas of a part, and we therefore get a higher thickness on such areas, so the plating may not be uniform.

What Happens Before Plating

Before a part is plated, it must be properly prepared for plating. Poor preparation can lead to bare spots of poorly appearing plating. Preparation of parts for plating typically requires removal of all surface impurities. This includes oils, greases, fingerprints, and corrosion products, called oxides. The number of steps used to remove these surface impurities depends on the kind of metal to be plated. The most commonly plated metal is steel. A typical preparation process for steel includes the following steps:

1. **Soak clean** to remove most of the oils/greases on parts to be plated. Soak cleaning is done by simply soaking the part, with or without agitation, in hot water containing detergents and numerous other ingredients designed to float off oil, grease and dirt.
2. **Electroclean** to remove remaining traces of oils and greases and to remove some oxides. Electrocleaning is similar to soak cleaning, in that the same basic solution is used for cleaning. But in electrocleaning, a DC current is applied, which causes water to decompose into gas bubbles that “scrub” the surface clean. If the parts that are cleaned are connected to the negative terminal of the tank bus, then hydrogen gas bubbles are doing the scrubbing. This is often called cathodic cleaning, direct electrocleaning or direct cleaning, meaning the charge on the parts is directly the same as it is during the plating cycle. If the parts that are cleaned are connected to the positive terminal of the tank bus, then oxygen gas bubbles are doing the scrubbing. This is often called anodic, reverse electrocleaning or reverse cleaning, meaning the charge on the parts is the opposite of the charge on the parts during the plating cycle.
3. **Rinse**
4. **Acid dip** to remove all traces of oxides (rust) and to remove traces of cleaner left on the surface of the part to be plated.
5. **Rinse**

Each of the above steps is performed in a separate tank. The tanks are typically lined up in sequence, and the entire sequence is called a plating “line.”

What Happens After Plating

After a part is plated, it is rinsed to remove residual plating solution, and it may then undergo additional processing steps. These may include additional plated layers, or chemical processing, thereby creating additional coatings. For example, nickel-plated parts are often plated with chromium on top of the nickel for appearance and tarnish resistance. Zinc-plated parts are often immersed in chemical solutions that convert part of the zinc plate to a corrosion-resistant film, called a chromate conversion coating.

I hope I have been able to answer some of your questions on electroplating, and wish you good luck on your science project. P&SF