Tech Bulletin

Electroplating and Electroless Plating: The Differences and Benefits of Each Process

Overview

In general, plating and finishing processes can be defined as any process used to protect, improve the appearance, insulate, or to increase the corrosion protection, conductivity, and/or solderability of the substrate material. These processes fall into 2 primary categories:

1. Electroplating
2. Electroless Plating

This Tech Bulletin provides an overview of how these processes work, discusses the differences and benefits of each one, with a focus on how each can best be used for various types of production applications.

Electroplating

Electroplating is a process by which metal ions migrate via a solution from a positive electrode (anode) to a negative one (cathode). An electrical current passing through the solution causes the workpiece at the cathode to be coated by the metal in the solution (Figure 1).

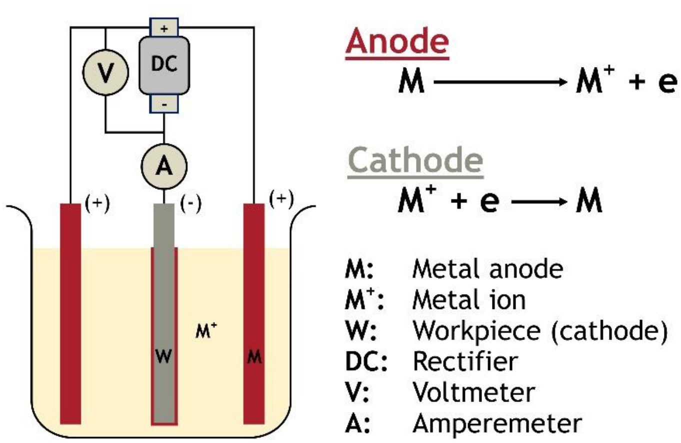

Figure 1 - Electroplating Process

Electroplating is a cost effective method to improve the properties of the base material. Plating protects the underlying material by either of 2 mechanisms:

1. **Sacrificial Protection**
   Zinc and Cadmium protect the base materials they cover by sacrificially corroding in preference to the substrate. This takes place because they are typically more reactive than the underlying substrate material.

2. **Mechanical Protection**
   Copper, Nickel, Chromium, Tin, and most other metals provide mechanical protection, as long as the coating remains intact. If there are any defects in the plating layer, the substrate will corrode before the plating does.

Standard electroplating practices typically involve the following production stages:

Figure 2 - Electroplating Process Steps

Each of these stages are common to all types of deposition. Cleaning is vitally important; without adequate cleaning and pre-treatment of the substrate, any subsequent deposits will be doomed to fail. Undercoats and final deposits are usually specified by customers to meet the respective specifications that are necessary to provide functionality to the finished component, and is very rarely discussed with the finisher at the design stage.

Electroplating processes are compatible with a wide range of finishes, including the following precious and non-precious metals:

Precious Metals

- Gold – Hard (Cobalt and Nickel hardened)
- Gold – Soft (wire bondable)
- Pure Palladium
- Palladium (wire bondable)
- Indium
- Silver
- Silver (wire bondable)
- Silver Tin

Non-Precious Metals

- Copper
- Nickel
- RoHS compliant Tin (whisker mitigating)
- Tin (matte and bright)
- Tin Lead
- Nickel Phosphorus (wire bondable)
- Tin Silver

Electroplating processes can be implemented using a variety of methodologies, including barrel plating, rack plating and continuous reel-to-reel plating. For parts that have already been singulated, barrel plating is typically the most viable process, with the alternative being a time-consuming process of rack mounting the parts to uniformly present them for plating. Rack mounting or masking each part is required in order to apply selective plating on a portion of pre-singulated loose parts.

Figure 3 - Reel-to-reel Plating Line

To overcome these process limitations of singulated parts and to achieve the highest possible throughput, continuous reel-to-reel plating is the best alternative. The reel-to-reel approach, as pioneered by Interplex, uniformly presents all reeled parts to the plating process, which enables much greater precision and consistency along with very high throughput and yields. In addition, the consistent presentation of the continuously reeled parts allows for a variety of partial plating options, such as selective plating, controlled depth plating, and stripe or spot plating. After the parts are plated in a single pass and rolled up on the finished reel, they are ready for automation-friendly use in subsequent assembly processes.

Electroless Plating

Electroless plating, as the name implies, involves the production of coatings from solutions of metal ions without the use of an external source of electrical energy. This definition can include each of the 3 following techniques:

1. **Immersion Plating**
   Immersion plating involves the deposition of a more noble metal in the electrochemical series onto the surface of a less noble metal. The best example of this is when steel (iron) is immersed in a solution of copper ions, and the copper is deposited onto the steel substrate. This technique has few applications due to the thin, non-adherent coatings that are typically produced.

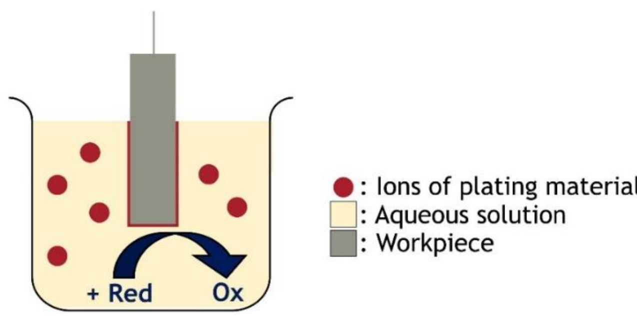

Figure 4 - Electroless Plating Process

2. **Homogenous Chemical Reduction**
   In homogenous chemical reduction, a chemical reagent provides electrons for the reduction of metal ions for deposition onto a substrate. Thicker coatings can be deposited by this method, but adhesion issues still exist. Another disadvantage of this process is that the metal ion solution and the chemical reducer must be kept separate, otherwise they will immediately react.

3. **Autocatalytic Deposition**
   Autocatalytic deposition utilizes chemical reducing agents to provide the electrons for plating, but the treatment solutions are formulated to deposit onto naturally catalytic surfaces, or ones which can be rendered catalytic. The deposit itself is catalytic, thus the reaction is self-perpetuating. As a result, the coating can be built up to a significant thickness and is highly adherent.

Differences Between Electroless and Electroplating Approaches

Both electroplating and electroless plating offer advantages for process engineers, depending on the specific requirements of the applications.

Electroplating Benefits

- Overall faster deposition
- Highest throughput
  (with reel-to-reel electroplating)

Electroless Plating Benefits

- Applicability for plating either metallic or non-metallic parts (e.g. ceramics)
- Ability to achieve greater uniformity

Generally, electroplating is more applicable for metallic parts that need to be produced cost effectively in very high volumes— for example, electrical interconnects, fasteners, and pins.

On the other hand, electroless plating is oftentimes more suited for parts requiring a high degree of uniformity, such as medical devices, and for plating non-metallic parts, such as ceramics.

Figure 5 - HDD Disk Clamp (Electroless Nickel Plating)

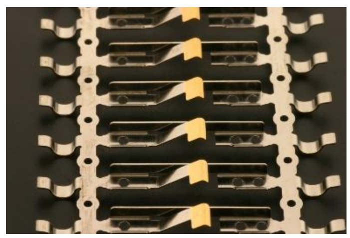

Figure 6 - Brush Plating (Selective Au)

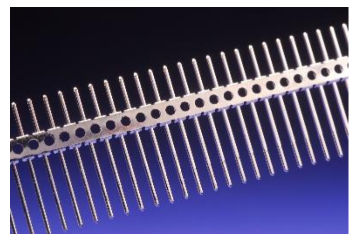

Figure 7 - Complete Coverage Plating (Bright Sn)

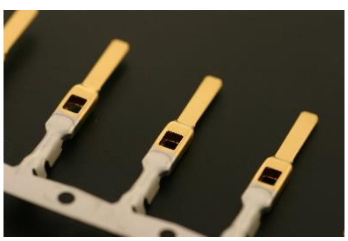

Figure 8 - Controlled Depth Plating (Ni Undercoat & Selective Au)

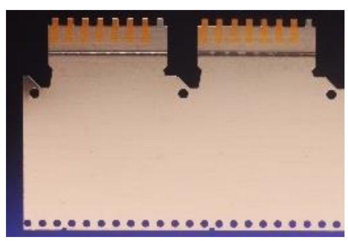

Figure 9 - Spot Plating (Selective Au Spots)

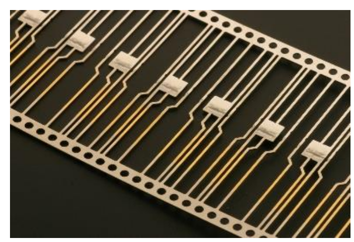

Figure 10 - Stripe Plating (Ni Undercoat & Selective Au & Sn)

Summary

With an extensive array of electroplating and electroless plating processes available, product and process engineers have a wide range of options to choose from for virtually any specific set of requirements. That said, it is important to begin evaluating the best plating alternative as early as possible and to follow disciplined Design for Manufacturing processes to assure the best fit for product specifications, quality, as well as production costs and throughput volumes.

In order to avoid sub-optimal choices of plating methods and/or last-minute re-designs to accommodate a change in plating approaches, it is vital for product engineers to work closely with plating service providers with deep process knowledge and who can bring a range of proven plating processes to the table. This way, engineers can make the right plating choice from the outset and be assured that their part designs will deliver high quality and high throughput, all while maintaining cost effectiveness for the target application.

For more information, visit our Plating Process and Capability website or drop us an email at communications@interplex.com.