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PRECIOUS METAL ELECTROPLATING, SOLUTION FILTRATION & METAL RECOVERY

Precious Metals

The current list of precious metals used for electrodeposition include Silver (Ag), Palladium, (Pd), Gold (Au), Rhodium (Rh), and Platinum (Pt). Ruthenium (Ru) is an electroplated platinum group precious metal but has limited use today. Iridium (Ir) is rarely used, and Osmium (Os) electroplating is possible but non-existent as a commercial offering.

Precious metal electroplating is used for both decorative and industrial applications. Typical industries include jewelry, musical instruments, awards, electronics, electrical, military, aerospace, medical, etc. These noble metals are used because of their exceptional cosmetic and/or physical properties, and are referred to as precious because of their high material cost. For example, the approximate market prices for these metals on April, 13, 2012 are the following: Silver = $32.00/Troy oz., Palladium = $650.00/ Troy oz., Gold = $1,650.00/Troy oz., Rhodium = $1,450.00/ Troy oz. and Platinum = $1,600.00/Troy oz. One Troy oz. is equal to 31.10348 grams by weight. With the exception of Silver, electroplaters use insoluble anodes, usually Pt clad Titanium, Niobium, or Tantalum, in their processes, and, therefore, purchase metals in a compound form to charge and replenish the solution. Often, proprietary additives are blended into these compounds to provide specific characteristics to the deposit. For example, an Acid Gold Plating Electrolyte might require a hardening agent such as Cobalt or Nickel to increase hardness values (Knoop). This can be added to the Gold compound (AuKCN) to provide a complete “salt”. Another example is Silver Plating (CN) where an Antimony additive can be used to harden the deposits to survive post plate mechanical polishing & buffing. The actual cost of the precious metal to the electroplater can be 2% - 5% per troy oz. above the metal market price for processing and technical service costs by the provider. Since a typical Gold Electroplating Bath formulation contains up to one troy oz./gallon of ionic metal, a 100 gallon plating tank could have $160,000.00 - $190,000.00 in metal invested in the solution. Or, expressed in another way, each “drop” of solution could be worth up to 2-1/2 cents.

Characteristics of Precious Metal Plating

Parts for precious metal plating are processed by wire, rack, barrel,vibratory basket, or some form of reel-to-reel technique, usually with selective placement of the deposit from depth control or masking. Primarily because of the cost of the solution, plating bath volume tend to be as small as possible. This reduces the investment cost but causes more potential for problems from inorganic and organic contaminants. Since most applications for precious metals are critical or premium, this can be very problematic if proper filtration and purification systems are not in place.

Most substrates for precious metal plating are non-ferrous, typically copper,or a copper alloy. A common practice is to plate a barrier layer of Nickel, at 0.0002” minimum thickness, over the substrate prior to the application of the precious metal deposit to prevent migration of the base material to the surface.. Often, a Copper “flash” or “strike” (20X10-6) is used prior to the Nickel Plate. Silver Plating requires a “strike” coating prior to plating to avoid non-adherent immersion Silver deposits on the surfaces of less noble metals. A Pure Gold Strike prior to Gold Plate is used to ensure activation of the Nickel Plate and/or protect the Gold Plate Bath from inorganic contamination.

Thickness and functional properties of precious metal electroplated depositsare normally governed by established military and industrial specifications. Except for Silver, the thickness requirements for precious metals are usually 100 microinches (0.0001”) or less. While a physical micro-section and microscopic measurement can be employed to determine thickness, non-destructive X-ray Fluorescence and Beta Backscatter instruments are much more efficient methods. For best accuracy, non-destructive testing requires reference standards that match the density of the actual plated deposit. As an example, Pure Gold has a density of theoretical 19.3 grams/cubic centimeter. However, a typical hard Gold deposit, with a very small amount of Cobalt (< 0.2%), might have a deposit that has 16.0 grams/ cubic centimeter of Gold. In fact, even pure (“soft”) Gold electrolytes (Type III) will not meet the density of theoretical pure Gold. Control of deposit thickness requires the use of an Ampere Hour Meter (Faraday’s Law) connected to the DC power source (Rectifier), and diligent monitoring by non-destructive testing. It is important to have a very “clean” power source of less than 1.0% maximum AC Ripple at any voltage for optimum plating results. The objective should be to consistently meet the minimum thickness requirement with the most uniform deposition from the very lowest to the very highest current density area on the piece part. If you know the efficiency of your plating bath, ampere hours can predict the amount of metal by weight to theoretically meet the thickness requirement, if the deposit had perfectly uniform distribution. However, because of the inherent nature of electroplating (“lightning rod”), it is not unusual that the actual total deposit by weight could increase the theoretical weight by 20% to meet the minimum thickness requirement. For example, if the minimum thickness requirement is .0001” Hard Gold (Type I), and the surface area to be plated is one sq. ft., a typical electrolyte will deposit about 4.0 grams of Gold. However, if you add the actual average thickness, and

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an allowance for solution drag-out and other losses, the actual material cost would be closer to 5.0 grams of Gold. Therefore, at today's cost of Gold to the electroplater, the actual Gold material cost for a plated single square inch of surface area with a minimum of 100 microinches could be up to $2.00 in material cost.

Hardness, as a physical property of an electroplated precious metal, is an important functional characteristic. Hardness is determined by an indenter probe that impacts the surface with a specified load (weight). The following typical Knoop hardness values apply: Silver = 80, Soft Gold = 90, Hard Gold = 200, Palladium = 400, and Rhodium 800. For reference, electroplated Nickel (Semi-bright Watts) has a Knoop hardness of about 300.

Other factors must also be considered. For example, hard Gold deposits for use in the electronics industry for contact wear applications require "lubricity" as well as hardness. Lubricity is inherently acquired as a co-deposition polymer when using acid Gold electrolytes.

(Pictures of SERFILCO Admiral EOL, Labmaster Filtration Systems), and Space Saver J)

Filtration and Agitation of Precious Metal Plating Solutions

Size of System – Depending on potential for contamination, considering plating surface area per solution volume, speed of operation, hours of operation, masking material, nature of process and chemistry, etc., a solution turnover range per hour within 4 – 8 (open) should be applied. Filtration systems are usually rated at "open", meaning no restriction from filter media. Ideally, the turnover rate should be estimated with the specific intended, clean filter media in place. This can reduce actual operational flow rates at start-up by up to 20%. Change-out of media is normally on the basis of pressure delta and/or flow rate. It would not be unusual to have pressure double and solution flow reduced to half of start–up at media change-out. A vertical depth cartridge filtration system is generally preferred over a horizontal disc or a bag system for precious metal electroplating. The most common filter media for particulate removal are string wound Polypropylene (w/o sizing agent) with Polypropylene core, and FDA approved extruded, melt blow cartridges, both with nominal density of 1 – 10 micron, made of all Polypropylene. One (1) micron is approximately 40 microinches (0.0000394") in size. For reference, a standard 2.5" X 10" string wound filter cartridge has the equivalent of approximately 3.5 sq. ft. of loading capacity. As a general guide, the equivalent of two to three 10" cartridges should be used for each 50 gallons of solution. For example, a 100 gallon Acid Gold Electrolyte with three 20" – 3 micron nominal filter cartridges could be ideal for most applications.

Another consideration in determining the size of the filtration system is method of discharge return. Ideally, some form of sparger manifold should be used for uniform distribution of the filtered solution, which will also create circulating solution agitation. For the full advantage of solution agitation, a separate system with a dedicated pump and an eductor nozzle manifold assembly should be considered. Agitation systems are very dependent on operating pressure. While 10 PSI is generally considered the absolute minimum to utilize the venturi effect of the eductor nozzle; in practice,15 PSI minimum provides the full velocity for optimum utilization. An equivalent range of 20X – 40X is generally considered optimum turnover/hour for precious metals based on a 5X pump rate factor.

The optimum turnover/hour rate is reached as a consequence of strategically placing eductor nozzles in the tank based on the tank configuration, anode/cathode positions, and type of work to be plated, together with an appropriately sized pump to supply sufficient flow and pressure to the agitation system. It is essential that all of these parameters are taken into account when configuring an agitation system to optimize throwing power, hydrogen removal and ionic replenishment. Eductor agitation systems have been used successfully in all precious metal solutions for many years. With cyanide solutions such as a Silver Electrolyte, agitation can be vastly improved as air agitation should definitely not be used due to accelerated carbonate build up in the bath. So, eductor agitation is the only sensible alternative to cathode rod movement, although some find optimum results from adding an eductor system to existing mechanical agitation..

It is worth noting that with precious metal material costs being very high; all measures that can be taken to eliminate rejects and increase efficiency must be considered. So, along with filtration and agitation of the "strike" and plating tanks – cleaners, activators and even rinse tanks are increasingly filtered and agitated to ensure that parts are in the best state possible for plating, and to ensure that contaminants are not being dragged into the plating tank.

(Pictures of Serductors, and Filter Cartridges –Purefybe 10", 20" & Polyspun, Carbon)

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Design – Whenever possible, the use of an in-tank filtration system, meaning the pump and filter chamber are installed within the plating tank, is usually the optimum installation because this allows for better containment of solution in the event of leakage. The pump is of a vertical design and the system itself is as compact as possible. Unfortunately, space constraints often eliminates this possibility, so variants of this theme are usually employed. For example, a vertical pump is often placed in the plating tank, and the chamber, connected by pipe or hose, is mounted outside of the tank. While some plating tanks are designed with an outboard vertical pump and the suction inlet fixed to the tank by a bulkhead type fitting, the wisdom of this design is certainly questionable because of the potential for leakage below the solution level. So, in the end, an out-of-tank filtration system could be the only practical method of providing vital filtration of the solution.

Type & Material of Construction - As a standard reference, most Gold, Rhodium, and Platinum electroplating solutions are acidic. Silver (Cyanide) and Palladium (Ammoniacal) are usually alkaline. Operating temperatures are in a range of ambient to 120 Degrees F. Plastic filtration systems are generally used and should be constructed of Polypropylene or CPVC, with pumps of Polypropylene, CPVC, PTFE, or ECTF

Because of environmental reasons, as well as the value of the electrolyte, a double containment (tank within a tank) tank design is recommended. Construction of welded Polypropylene is the material of choice. A secondary containment tray, capable of holding the full volume of solution under the plating tank, is also advised. Whenever possible, an in-tank pump and filter system is best. If an out-of-tank filtration system is used, seal-less magnetic pumps are the best choice with placement within the secondary containment tray. Every attempt should be made to "bullet proof" each plating station from accidental loss of solution.

A suction strainer is always helpful to prevent small parts or solids from entering the pump and causing damage to the impeller. Siphon breakers on a pump suction and return lines should be installed as an additional measure of safety to prevent loss of solution.

(Pictures of EO Pumps, Series A, X, M

Carbon Treatment – Like non-precious metal plating solutions, organic contamination from chemical breakdown, drag-in, or accident will reduce plating efficiency and the cosmetic and/or performance characteristics of the deposit. Controlled, periodic carbon filtration is preferred verses batch carbon treatment. For small volume tanks, special carbon cartridges are available for full or partial replacement of particulate filter cartridges in the standard filtration system. For example, in a three cartridge filter system, one cartridge could be replaced by a carbon cartridge for one day during the work week. In a larger volume bath, if space permits, a separate post-filter carbon chamber with an adjustable stream control can be used for periodic treatment with a carbon cartridge or granular carbon. In any case, the purest, chloride free, activated carbon should be used for precious metals plating, and all filter cartridges and granular carbon should be saved and sent to a reputable reclaim source for recovery. At today's market price for Gold, each recoverable gram could be worth about $50.00. *To reduce organic contamination of the plating solution it is common to filter and carbon treat the rinse tank immediately before the plating tank.*

Precious Metal Recovery

Every type of precious metal plating system should incorporate post-plate drag-out water rinses, and perhaps additional methods of capturing fugitive metal. Remember, the Gold plating solution reference that each drop can contain up to 2-1/2 cents of metal. After adjusting the drip dwell time over the plating tank to a point of diminishing returns, the next station should be a recirculating drag-out water rinse. Water should be deionized or distilled, and a filtration system with a carbon cartridge should be turning at least two tank volumes per hour. Additions of water to the plating bath for evaporation replacement can be made from this tank. An ion-exchange resin system can replace the filter if drag-out concentration can justify.

Depending on concentration of drag-out metal, multiple drag-out stations and other methods of recovery can be employed. Ion-exchange with selective resins can capture up to 50 troy oz of Gold per cubic foot of resin. Electrowinning cells (electrolytic recovery) can also be used to recover metal if warranted, however, every attempt should be made to reduce the drag-out at the source before considering these options.

Pictures of SERFILCO Ion-Exchange System

Replenishment by Ampere – Time Controllers

The most accurate and efficient method of making additions to a precious metal plating bath is from the use of an automatic pump system with an ampere hour controller.

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These systems are connected to the shunt on the rectifier. Integrated packages are readily available to automatically add pre-dissolved solids or liquid additives pumped from a "day tank".

(Picture of SERFILCO 1200 Integrated Ampere=Time Controller)

Summary

While precious metal plating does not take place using the solution volumes normally associated with other plating sectors using Nickel, Copper, Zinc, etc. – in terms of cost per volume of solution, the value of precious metal chemistry is very significant. and represents a high level of investment. In many cases, especially when dealing with critical electronic components such as connectors, coatings in this sector present very special properties uniquely provided by precious metals (electrical conductivity, solderability, wearability, corrosion protection, etc.). It is therefore of highest importance that solutions are maintained at their optimum within narrow operating parameters at all times, and the physical operating system be "bullet proofed" to prevent solution losses.

SERFILCO LTD. has been the benchmark provider of pumps, filtration systems, filter media, agitation systems and related equipment and supplies to the metal finishing industry for over 50 years. Our products are of the highest quality available in the industry, and our technical expertise is unmatched for equipment , process, and application knowledge. We welcome the opportunity to be of service regarding your requirements.