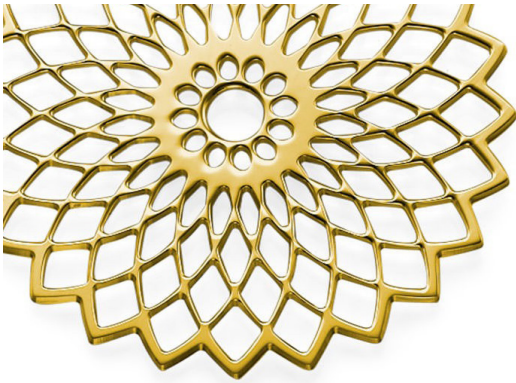


# GOLD PLATING

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All Industries that are engaged in electroplating activities use gold and its alloy electroplates of different varieties in their various electroplating applications. Though modern-day electroplating operations which involve gold are shortlisted and classified into eight categories thus;

Category A: Decorative 24K gold flash (0.000002 to 0.000004 of an inch that is two to four millionths), rack and barrel.

Category B: Decorative gold alloy (0.000002 to 0.000004 of an inch meaning two to four millionths), rack and barrel.

Category C: Decorative gold alloy, heavy (0.00002 to 0.00000005 of an inch; which reads twenty to over four hundred millionth of an inch), rack. These deposits may be either C-1 karat color or C-2 karat assay.

Category D: Industrial or electronic soft gold with high quality (0.00002 to 0.0002 of an inch meaning, twenty to two hundred millionths), rack, barrel, and selective.

Category E: Industrial or electronic hard, bright, heavy 99.5% gold (0.00002 to 0.0002 of an inch that is, twenty to two hundred millionths), rack, barrel, and selective.

Category F: Industrial or electronic gold alloy, heavy (0.00002 to over 0.00000005 of an inch reading twenty to over two hundred millionths of an inch), rack and selective.

Category G: Refining, repair and general, pure, and bright alloy (0.00005 to 0.00004 of an inch reading five to forty millionths), rack and selective brush.

Category H: Miscellaneous, including electroplating of gold and gold alloy, statuary and architectural, etc.

Gold and Gold alloy plating solution is a topic with great diversification, which comprises of a large subject matter, can still be sub-divided into five main headings such as the following;

Sub-head 1: Alkaline gold cyanide for gold and gold alloy plating: Category A to D and sometimes F to H.

Sub-head 2: Neutral gold cyanide for high-purity gold plating: Category D as well as G.

Sub-head 3: Acid gold cyanide for bright, hard gold as well as gold alloy plating; most often Category B, C, E to G.

Sub-head 4: Noncyanide, generally sulfite, for gold and gold alloy electrodepositing: usually Category A to D as well as F to H.

Sub-head 5: Miscellaneous.

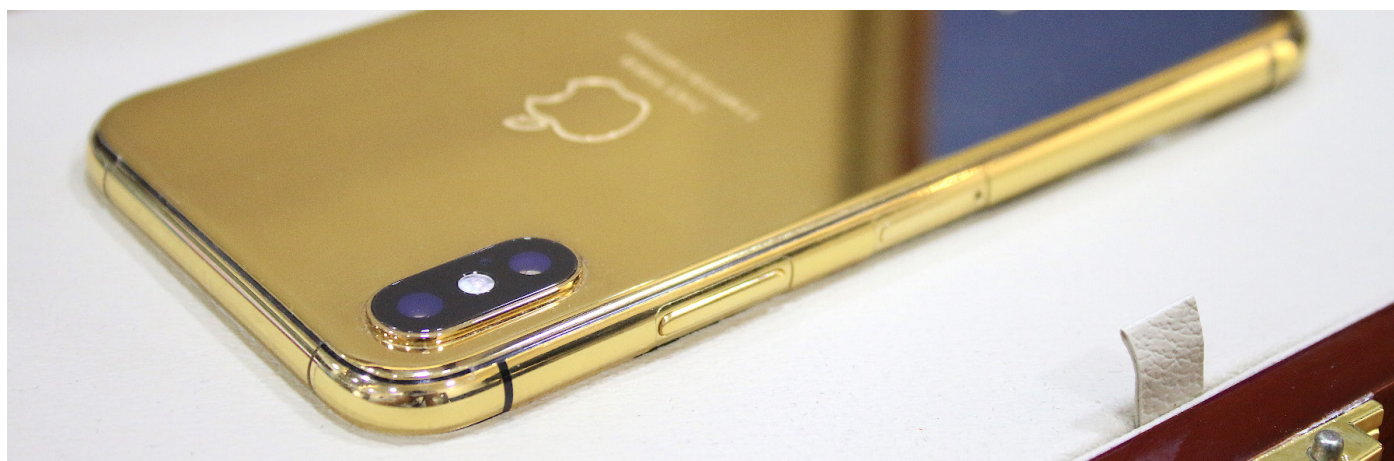
Formulations which fall within these five categories of gold electroplating solutions are hundreds in number.

Engineering /aesthetic considerations, as well as physical consideration, will differentiate the sub-heads and help in determining the most suitable out for the particular job in question, though economics will always be the independent variable on which other variables depends for selecting specific electroplating and formulating technique. In deciding on which of the barrel, rack, brush, continuous, or selective electrodeposition you should consider, the price of an ounce of gold per troy is an important aspect of economics that you should not neglect. Hence, it is necessary to optimize and equalize the following variables for any individual application. They include;

1. Cost price of the bath which comprises of the capacity of gold and its concentration.
2. The speed, bath as well as cost of producing the needed quantity of product.
3. Drag-out loss cost which depends on the concentration of gold used, form and structure of the parts; for the rack, barrel, continuous or selectively electroplated technique. This must comprise of the probable reformation of dragged-out gold by electrolysis or ion-transfer recovering.
4. Maintenance and control cost. Most high speed and high-efficiency baths need constant attention and analysis.
5. Longevity cost of the bath. Certain loss on a changeover is the consequence of periodic changes undergone to maintain the purity of high-speed and high-purity bath with good drag out recovery and this is essential.
6. Another aspect of cost is that used in keeping the bath which is otherwise known as the cost of money or interest cost.
7. The prime cost of acquisition of equipment.
8. The overhead cost of acquisition of the equipment not minding if it is in operation or not, meaning the interest rate of the machine hourly or daily.

Occasionally, manual rack or barrel technique might be cost-effective, though most of the time, a high-speed completely automated plant is acceptable.

Successful gold electroplating requires continuous monitoring and controlling of the ever-changing cost of gold which is now a commodity presently open to free and unrestricted trading activities.



## **Decorative Gold Electrodeposition**

(Category A to C and often, G)

Decorative plating is mostly but not always applied to items of adornment and of personal use such as jewelry, wrist watches, and watch attachments as well as other items not listed below. Gold or Gold alloy is about 0.00002 to 0.00005 inches thick, and the plating process lasts for about 5 to 30 seconds. The acceptable trading practice rules in the jewelry industry stipulate that this metal on metal deposit should be referred to as gold flash or gold wash because, for it to qualify to the standard known as gold electroplate, it must necessarily get to a minimum thickness of 0.000007inch.

Such metal on metal depositing are often applicable over bright nickel under plates, and they are usually bright as plated.

Brightening or grain-refining agent is not important in this case. Hundreds and different colors and hues are available, but the most commonly used sample of colors are those represented under Category A and B baths.

The whole of the coloring baths in table 1 must use 316 stainless steel anodes. 1:1 or 3:1 is the best anode to cathode area ratio. Uneven color and thickness of deposit with the end pieces constantly burning arises whenever very high ratios are used with the tank being the anode. Being unnecessarily agitated cannot ensure uniform color and should not be considered. The cathode bar should be tapped gently and slide to increase the deposition gold process and to make the colors richer, yet it will deplete gold quickly and unbalance the bath.

Gold and metals used for alloying should be added based on ampere-hour meter readings (A-hour) occasionally. Other baths excluding the white, green, as well as rose solution efficiently operates at approximately 6% cathode current with the addition of 5 g of gold and the proper quantity of alloy at every 11 amperes per hour. All aspect of the operating conditions should be kept under control as possibly as possible since any alteration of the conditions will automatically influence the efficiency of current on the cathode of both and gold alloy. The color of the deposits changes as there is a change in the number of metals deposited.

Other factors that are responsible for altering the color of the deposits are shortlisted below;

The surface finish of the basis metal changes the fake color of the deposit. It is predominant and conspicuous where one item has both textured area and brightness. They will apparently possess two different colors when plated in the same bath. The base metal's color changes the color of the gold deposit by addition of color to the gold till the deposit thickens to the desired state such that it can obscure the base if properly applied after 2.5 millionths of an inch have been applied. The gold can be allowed by proprietary additives to obscure the base with as little as 1.5 millionth of an inch for richer color.

Two low current density happens to favor gold deposits making the alloy to become richer. While, too high current densities at first may favor the alloy paling out the color only to cause a pink, orange, and red tones if further increased.

#### **4. Free Cyanide Content**

In the free cyanide content solutions containing copper are very sensitive to changes. High cyanide causes an increase in the yellow color by withholding the copper, while low cyanide significantly increases the pink and red shades.

#### **5. Temperature effects**

Temperature has effects similar to that of current density in the sense that high temperature favor the alloy color and temperature that is over 160-degree f are not advisable unless in rose golds, due to the rapid disintegration of cyanide and the darkening of its color. Low Temperatures favors yellow color on the other hand.

#### **6. The pH of gold and its alloy**

Adjustment of the pH value of gold and its alloy is seldom necessary as Rose, red gold, and pink are the only ones favored by higher values

### **Barrel Plating**

(Category A and B)

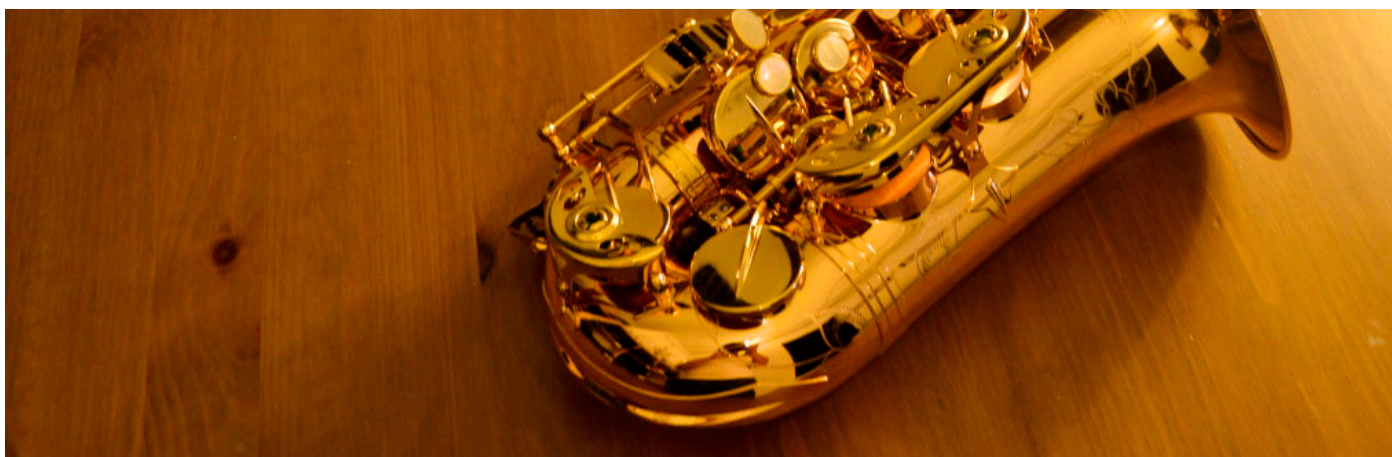
Gold as  $\text{Kau}(\text{CN}_2)$ , 0.4g/l.

Free cyanide as  $\text{NaCN}$ , 30 g/l.

Disodium phosphate, 23 g/l.  
Temperature, 100 to 120oF.  
Anodes, stainless steel (1.1or better)

Jewelry barrel electroplating requires about 6 volts, 0.000002-inch decorative finishing which you need to deposit within 3 to 4 minutes. For plating to last up to 8 minutes, you have to pack the small parts of the barrel densely. Once you are through the possibility of getting an even coverage will be guaranteed.

This formulation above can be changed to achieve varieties of colors. Addition of 1.5-3 g/l of nickel will lead to the achievement of Champagne or light Hamilton colors. Production of lighter and more uniform color is by reducing the temperature.



## Antique Golds

(Category A and B)

Those engaged in plating during the 19th century aimed at producing a finishing whose apparent outlook was to look like it had been mercury gilt over silver or copper (vermeil) and buried or weathered by the elements for a century or so. Every master plater developed an antique finish which was their trademark outcome. To achieve this effect, the basic modern method is shortlisted below.

1. "Burn on" a smutty dark finishing.
2. The highlights on a deeply recessed particle or the flat surface of a filigreed particle can be relieved by hand rubbing method using pumice and sodium bicarbonate, wheel relieving method using a cotton buff, Tampico brush, a brass or nickel-silver wheel. All other techniques are obtainable
3. Depositing of flash gold or gold alloy on the imperfectly erased highlights.

The more you alter a sample solution, the more the operation officer violates the right plating techniques as well as good neatness, the better and more distinctive the finishing.

A costly finishing needs double-racking, while a beautiful finishing, is Russian antique. This production might be possible by relieving the green-gold antique displayed in table II and flashing it over using 24K or English gold. The 1940s' and 1950s' antique baths which did not need double-racking or stringing are not obtainable in this modern practice due to the high cost of gold.

## Heavy Decorative Gold

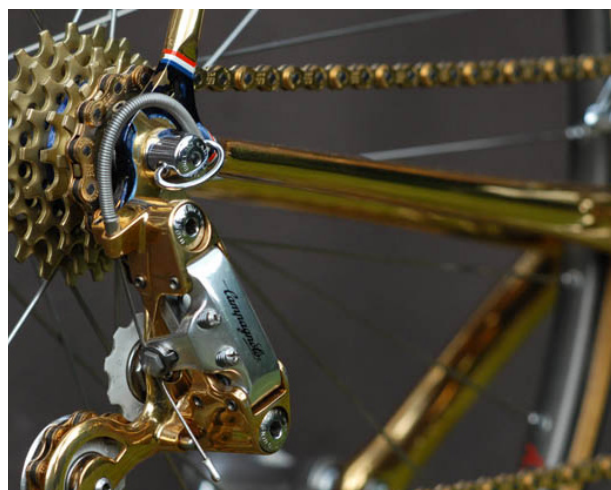
(Classes C-1 and C2)

Differentiating the actual karat assay of a gold alloy electrodeposit and the plates with apparent karat color is vital. Decorative karat electrodepositing looks like a much lower karat than it really will assay. A 14K color may assay 20 to 21K.

## Electronic or Industrial Gold Plating

Electrodepositing of metal on metal using gold is done for several electrical, electronic reasons in the past. But presently, most of the plating is done to three classes of components which includes: semiconductors, contacts or connectors as well as printed or etched circuits.

The following pH range: alkaline cyanide pH>10; neutral cyanide, pH 6 to 9; acid cyanide, pH 3.5 to 5 (below pH 3.5 the gold cyanide is unstable and precipitates). Noncyanide (especially sulfite), pH 9 to 10 can be used to categorize gold plating solutions that are suitable for use by an electronic plater.



In the United States, [subhead 2 or 3, i.e. (category F)] which is low-karat gold alloys are not yet popular applications. The electrical properties of the gold are affected by the alloying metals adversely. As small as 1% of iron will raise the electrical resistance of the gold to above 1,000%, and the same quantity of other metals possess little, but yet not acceptable, impact on the ability of the gold deposit to conduct electricity. Die bonding of semiconductor chips, good welding to the gold surface might be inhibited or prevented completely by the introduction of even amount of a much less than 1% even alloy. Since good engineering and new design required little gold, Duplex gold coatings of low-karat gold base over plated with the high-karat gold surface, though of use in some electrical aspects have lost their economic important.

## Electronic Gold Plating Solutions

The electronic gold plating process is a means of plating a thin gold layer on another gold surface. It is used mainly in jewelry and semiconductor industry. It uses electricity to provide a corrosion resistant electronic surface.

It was formerly prepared using poisonous cyanide compounds that are understandably restricted. New inventions have tried to make the solution using a publically obtainable chemical that is not as toxic to handle as the former, though the end product is still as poisonous as the traditionally manufactured solution.

Hence, when undertaking experiments on electronic gold-plating, one should do so with great experience and skills. The following steps are to be adhered to:

1. Concentrating the dilute nitric acid up to 50% or above by preparing aqua regia which is gotten by mixing hydrochloric and nitric acid at a molar ratio of 1/3. This is done by either making sodium nitrate to react or tetraoxosulphate vi acid with distillation following after to produce acid with a concentration of 90% and above. This makes nitric acid highly corrosive as well as fuming nitrogen toxic dioxide gas, or by using a concentrated dilute nitric acid from 30% to 50% concentration to achieve the azeotropic concentration of 68% which is favorable for the gold plating solution.
2. Making gold (iii) chloride is by dissolving gold in aqua regia which is a mixture of nitric acid and hydrochloric acid to a molar ration 1/3. Purity of gold does not matter since gold will be purified to 24K on the process. This mixture produces toxic fumes. For gold to dissolve at room temperature 20munites must elapse. The end point gives a solution of dissolve gold, copper compounds and solid crystals of silver salts. Filtration to separate solid from liquid and precipitation of gold out of the solution in its elemental form by the introduction of sodium meta-bisulfite solution is done with toxic sulfur dioxide gas evolved. You can perform this process in the fume hood or outside only. The absence of any visible reaction during the introduction of the sodium meta-bisulfite means that gold is precipitated. Finally, separate the solid gold and re-dissolve in aqua regia for complete dissolution and appearance of reddish color while acid is evaporated to obtain red crystals of gold (iii) chloride at 120oC.
3. Making gold plating solution. A solution of strong alkaline of potassium ferrocyanide and gold chloride is produced and matched with electrical current to electroplate gold on another metal surface. Due to the possession of poisonous cyanide ions, mixture with acid is prohibited since it will release hydrogen cyanide gas.

## **Alkaline Cyanide Baths**

(Sub-heads 1, Category D)

Worthy of mention is the fact that for matte deposits, the more, the temperature the better the discharge and the faster the rate of plating: though temperatures above 150 degrees F produces an instantaneous disintegration of the free cyanide, as well as a building of cyanide, disintegrated impurities.

The alkaline cyanide baths are reactive to impure organic particles which are either introduced by drag-in or by the absence of total cleanliness, and the ones which cyanide breakdown caused. For a deposit with a pleasant outlook and which is structurally sound to be maintained, it is a most that the solution is carbon treated and filtered periodically. The quality of the carbon used should be pure enough so that it will not add more impurities thereby causing more harm than good. Regular carbon packed filtration is a standard and recognized but inefficient batch treatment technique for removal of impurities. Where the solution is already polluted before treatment, it is vital that the used carbon and the filter cartridge be preserved for refining to recapture any gold lost in the course of the treatment.

1. Carbon treating of solutions takes the following procedures;
2. Heating of solution from 150 to 160 degree Fahrenheit.
3. Transferring of the hot solution into an auxiliary tank.
4. Addition of 1/8 to ¼ oz carbon each gallon of the solution.
5. Mixing that will last within an interval of 20 to 30 minutes only.

Using method of decantation to filter the solution back to the initial tank. The frequency of Carbon treatment has not got a general procedure. It will depend on total cleanliness, the work being processed and the housekeeping activity; though, there may be variations once in two weeks or two months. The hot cyanide bath requires much more carbon treatment than the room temperature bright bath.

## Neutral Cyanide Solutions

(Sub-head 2, Category D)

This type of solution which industries engaged in producing semiconductors use. Great care must be observed to ensure that the solution is not contaminated in any way since such impurity even if it is just a little part per million of not desired inorganic materials will deposit to die bond or fail in compression.

Table VII is a list of typical nonproprietary solutions.

Pulse plating may be advantageous with the high-speed formulation. The 10% duty cycle is the most effective. Proprietary baths introduce grain refiners which reduces porosity and raises the maximum current density allowable, reduce the size of the grain as well as improve the outlook of the deposit.

## Acid Cyanide Plating Solutions

(Sub-head 3, Category E)

The illustration of the process and effect is shown below;

Under BARREL PLATING MATTE BATH 1, Gold as potassium gold cyanide (g/l) is 8, while Citric acid (g/l) is 60. Cobalt as Cobalt metal (g/l) or nickel as Nickel metal (g/l) is nil. PH is between 3.8 to 5.0 while, Temperature in degree Fahrenheit is between 120 to 140. The Anode is platinum clad or stainless steel. Agitation is desirable, and the current density is 1.5 A/ft<sup>2</sup>. Under rack or barrel plating, matte bath 2 and in high-speed continuous plating bright bath 2.

Gold as potassium gold cyanide (g/l) is 8 and 8-16, Citric acid (g/l) is 60 and 90, Cobalt as Cobalt metal (g/l) or Nickel as nickel metal (g/l) is 0.2 to 0.5 and 0.75 respectively.

PH values for both baths above are in the range of 3.5-4.5 and 3.8-4.3 respectively.

Their Temperatures in degree Fahrenheit are in the ranges 70-90 and 70-120 respectively. Both Anodes is platinum clad; agitation is desirable and violent respectively, Current densities are 5-20 and 100-400 A/ft<sup>2</sup>, Current efficiency in (%) is 30-40 for both baths, Time to plate 0.0001 inches of each is 10 minutes at 10 A/ft<sup>2</sup> and 15 seconds at 400 A/ft<sup>2</sup>. Finally, replenishment is at 1 oz gold / 12 A-hr and 1 oz gold / 12 A-hr.

You should note that pulse plating may be applied with high-speed bath, though the usage is not popular.

## Optima Anodes and Catalytic Electro-Coatings

For electrochemical, electroplating as well as electrolytic metal recovery applications, optima anodes electrode products are the most preferable of all because it is designed for unique operating parameters. It is equally manufactured using precious top quality metal coatings whose performance in automotive, electroplating, treatment of wastes, cathodic protection as well as all electrochemical applications is excellent.

For the optimal result to conventional designs, use anode proven superior. Get possession of the environmental friendly types of anodes which assures long-lasting performance, high chemical resistance with little operating cost.