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DEVELOPMENT OF CREATIVE COLORING TECHNIQUE IN ELECTROPLATING

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ABSTRACT

This paper deal with the research on electroplating in jewelry and art product manufacturing. It is focused on the development of method to make a creative plating, by which a non uniform and decorative plating can be performed.

This research is inspired by phenomena that gold and silver (and other jewelry material) are not a kind of color, they are actually a kind of material, hence we have to be able to make any color for them. Using electroplating, people could make several color, but most of them are uniform color. Concerning to those situation, a reseacrh is done to achieve more attractive color.

Keywords*: jewelry, creative plating, attractive color.*

1. INTRODUCTION

1.1. Colors in Jewelry

Color is an important aspect to make people interested in an object. It can be used as aesthetic attribute, symbol, signal, etc. As a symbol to express one's feeling, people need product with attractive color. The more color can be provided, the more people get alternative to buy a product. Fig.1 shows resulted color in recent plating method.

Figure 1. Colors in electroplating [2]

Jewelry is mostly related to gold and silver. Most electroplating are related with a process to cover jewelry with gold, silver, rhodium or another type of precious metal. Electroplating mostly done to cover an object with uniform color. To perform multiple color, pen plating technique, whis is actually uniform color is usually used as it is showed in Fig.2.

Figure 2. Pen-plating [6]

1.2. Creative Color and Pattern in Jewelry

From the previous mentioned discussion a research in multi and creative coloring method is proposed to get attractive color and pattern using electroplating.

Figure 3. Sample of creative pattern. [3]

This paper deal with a preliminary research to achieve a method to make creative pattern with single process of electroplating.

2. THEORETICAL BACKGROUND

2.1. Electroplating Basic

Electroplating is an electrodeposition process for producing a dense, uniform, and adherent coating, usually of metal or alloys, upon a surface by the act of electric current.[1] The coating produced is usually for decorative and or protective purposes, or enhancing specific properties of the surface. The surface can be conductors, such as metal, or nonconductors, such as plastics. Electroplating products are widely used for many industries, such as automobile, electronics, jewelry, etc.
The main component of electroplating process is the electrolytic cell. In this cell, electrict current is passed through a medium containing electrolyte, from the anode (positive electrode), to the cathode (negative electrode). In industrial production, pretreatment and posttreatment steps are usually needed [4].

The workpiece to be plated is the cathode (negative terminal). The anode, however, can be one of the two types: sacrificial anode (dissolvable anode) and permanent anode (inert anode).[6] The sacrificial anodes are made of the metal that is to be deposited. The permanent anodes can only complete the electrical circuit, but cannot provide a source of fresh metal to replace what has been removed from the solution by deposition at the cathode. Platinum and carbon are usually used as inert anodes.[5]
Electrolyte is the electrical conductor in which current is carried by ions rather than by free electrons (as in a metal). It completes an electric circuit between two electrodes. Upon application of electric current, the positive ions in the electrolyte will move toward the cathode and the negatively charged ions toward the anode. This migration of ions through the electrolyte constitutes the electric current in that part of the circuit. The migration of electrons into the anode through the wiring and an electric generator [8] as shown in Fig.3.

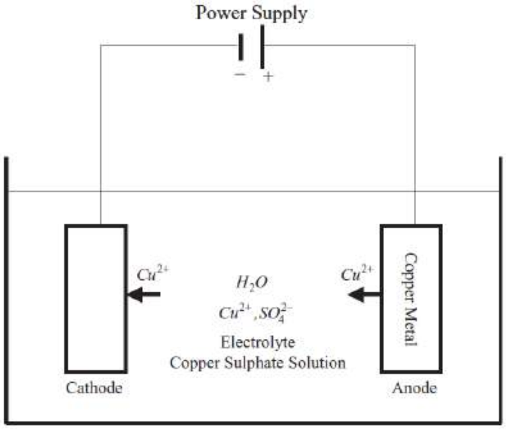

Figure 3. Principle of electroplating [8]

2.2. Anode and Cathode Reaction

Electroplating is the application of a metal coating to a metallic or other conducting surface by an electrochemical process. The article to be plated (the work) is made the cathode (negative electrode) of an electrolysis cell through which a direct electric current is passesd. The article is immersed in an aqueous solution (the bath) containing the required metal in an oxidised form, either as an aquated cation or as a complex ion. The anode is usually a bar of the metal being plated. During electrolysis metal is deposited on to the work and metal from the bar dissolves:

at cathode M^{n+} (aq) + ne - → M(s)
at anode M(s) → M^{n+}(aq) + ne-

Faraday's laws of electrolysis govern the amount of metal deposited.

2.3. Faraday's Laws Of Electrolysis

Farady's laws are quantitative relationships based on the electrochemical researches published by Michael Faraday in 1834.

The first law of Faraday is that the mass of a substance produced by electrolysis is directly proportional to the quantity of electricity passed through the cell.

$$M = kQ = kIt \qquad (1)$$

Q = quantity of electricity or charge in coulombs (C),
I = current in amps (A),
t = time (seconds);
k = the electrochemical equivalent [mg/A·s]

The quantity of a substance produced by 1 ampere second (1 coulomb), 1 ampere hour (ah) = 3600 coulombs is used as the practical unit in electroplating technology.

The second law states that the masses of different substances deposited or dissolved as a result of the passage of the same quantity of electricity through the electrolyte are proportional to the chemical equivalents A of the substances.

Faraday's laws can be summarized by:

$$M = [Q/F][M/z] \qquad (2)$$

where: **m** is the mass of the substance deposited at an electrode in grams; **Q** is the total electric charge passed; **F** = 96485 C mol−1 is the Faraday constant; **M** is the molar mass of the substance; **z** is the valency number of ions of the substance (electrons transferred per ion).

2.4. Industrial Application

Electrolysis is used in almost all industries such as electronics, automotive, jewellery and others. Electrolysis is commercially highly important as a stage in the separation of elements from naturally occurring source. Industrial electrolysis can be divided as follows:

- Processes in which there is no deposition of the metal on the cathode.
- Processes with deposition of the metal on the cathode.

Processes with no deposition of metal on the cathode can be seen for example in production of pure hydrogen by decomposition of water, production of chlorine and sodium hydroxide by the electrolysis of sodium chloride, production of hypochlorite or sodium chlorate (used as a strong bleaching or oxidizing agents), oxidation of sulfuric acid to the corresponding peroxy compounds, which decomposition leads to a hydrogen peroxide, various processes of reduction and oxidation.

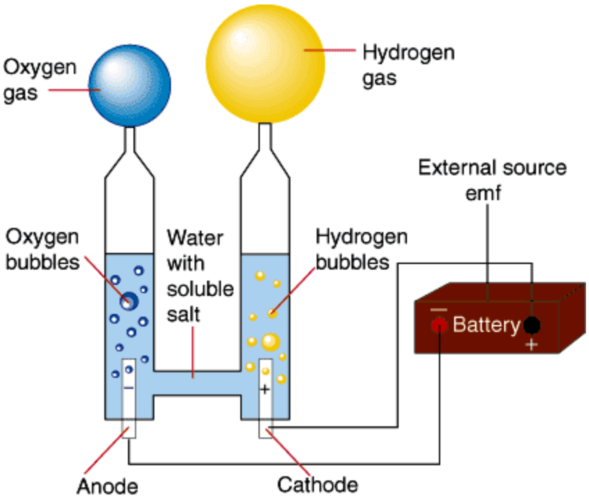

Figure 4. Setup for the electrolysis of water [5]

Cathode (-) $2H_2O + 2e^- \longrightarrow H_2\uparrow + 2OH$
Anode (+) $H_2O \longrightarrow 2H^+ + ½O_2\uparrow + 2e.$

$$2H_2 + O_2 \rightarrow 2H_2O$$

Processes with deposition of the metal on the cathode can be found in the electrolytic refinery of copper as it shown schematically in Fig.5. In this process the impure of copper is connected to anode (+) and the pure copper is connected as cathode (-).

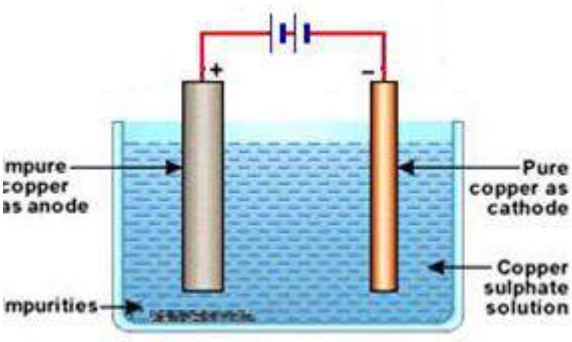

Figure 5. Purification of copper.

3. RESEARCH METHOD

Research in this preliminary stage is firstly conducted with common plating processes which is done in industry to make sure that correct procedure can be guaranteed so that plating quality can be accepted acording to industrial quality.
After plating procedure is understood, research is done by manipulating the plating parameters to achieve industrial requirements. Parameters that is manipulated in this research are:

- Voltage
- Temperature
- Plating time
- Electrolyt stirring method

The voltage, temperature, and plating time is used to control the plating thickness that is measured by weight difference before and after plating process. It also be used to find the optimum parameter setting for each condition.
Concerning to the condition of small scale plating industry in Jogjakarta, it is common for each industry that parameters will may not the same as it is recommended. In some cases for example thereis no exact value for temperature (sometimes room temperature).

Figure 6. Magnetic stirrer

After optimal parameters values are known, the important thing in this research is to find a strirring method. A magnetic stirrer that is commonly be used will face problem when electrolyt viscosity is changed. When the liquid viscosity become greater, magnetic stirrer will may not work properly or it will change the viscosity because it will have direct contact with the electrolytic liquid.

Figure 7. Aeration

4. RESULT AND DISCUSSION

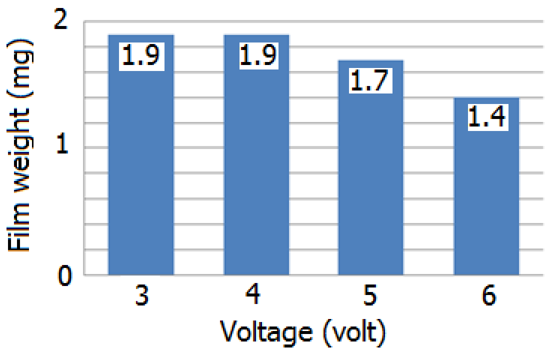

Figure 8. Voltage vs Gold film weight (28^oC, 120 sec).

Fig8. Shows that in the room temperature, the optimum voltage which result the best film for gold is 3 to 4 volt. This is meet with industrial application in gold plating.

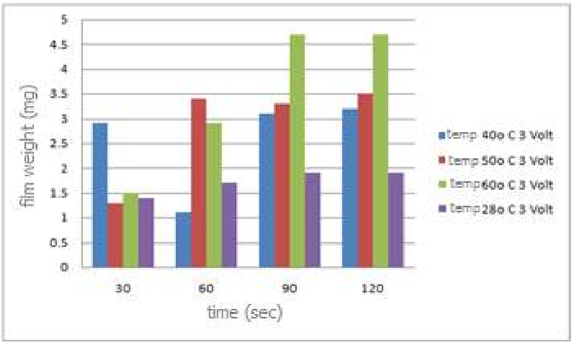

Figure 9. Time vs Gold film weight (60^oC, 3 volt).

Fig 9. Shows that in the optimum time which the result film for gold is best is 60 sec. This is meet with industrial application in gold plating.

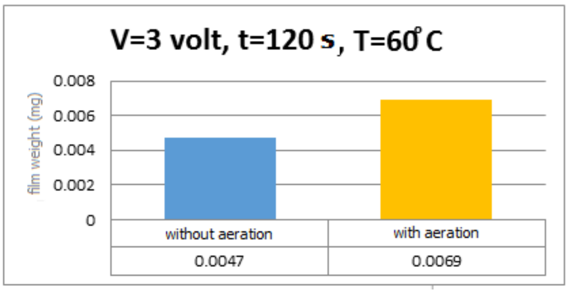

Figure 10. The effect of aeration.

Fig 10. Shows that aeration affect good for plating. It can replace magnetic stirrer with easier operation, cheaper and simpler.


Figure 11. Plating result with stirring (PGC solution without claryx)

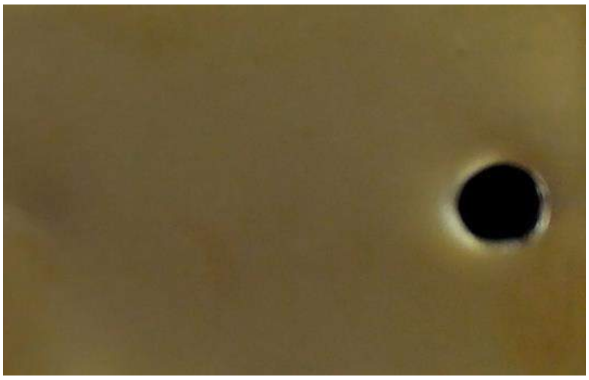
Figure 12.. More homogenous plating result, with aeration (PGC solution without claryx)

From Fig.11 and fig.12 can be seen that aeration can also improve plating result in gold. It can eliminate the usage of claryx in solution of PGC in water to improve plating result.

5. CONCLUSION

From the earlier mentioned discussion, it can be concluded that plating process for gold plating is optimum at 3 volt

It can also be found that stirring method using aeration can be used with better mixing performance, lower cost and simpler. This is also make sure that next coming research on plating to produce creative color can be realized since there is no contact that may affect electrolyte liquid viscosity.

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