Plasma Technology for Surface Preparation of Silver to Improve Electroplating Efficiency

Author: Pornchanok Wanpra Advisor: Dr. Ratthaphon Amphon
Gemology, Department of Geological Science, Faculty of Science, CMU

Introduction

Silver is one of the important precious metals in the jewelry industry. In silver jewelry production, electroplating with other metals, such as gold, rhodium, platinum, is commonly applied to protect the jewelry from scratches and tarnishing caused by sulfur in the air reacts with silver and forms silver sulfide (Ag_2S). Before the electroplating process, the silver surface must be prepared to remove contamination, such as oxide layers, dust, and organic matter. This ensures a smooth surface without pinholes or scratches after being electroplated. Usually, manufacturers use hazardous chemicals, such as sulfuric acid (H_2SO_4) to get rid of the contamination. However, plasma technology can safely clean and prepare the surfaces and has potential to replace the chemical process.

Objective

1. To study and develop process of silver surface preparation for electroplating efficiency by using plasma technology
2. To find alternative way to prepare silver surface to decrease chemical usage.

Materials & Methods

18 of a centimeter square-shape sterling silver plates polished on one-side ranging from 0.919-1.157 g were used for this study (Figure 1). The samples were devided into three groups. Group A and B were experimented with low-temperature vacuum Inductively Coupled Plasma (ICP) system at a power of 100 W, experiment for 20 and 5 minutes. The cleaness of the surface measure by contact angle measurement. Chemical composition was examined using X-ray Fluorescence Spectrometer.



Figure 1 Sterling silver samples that used in this study

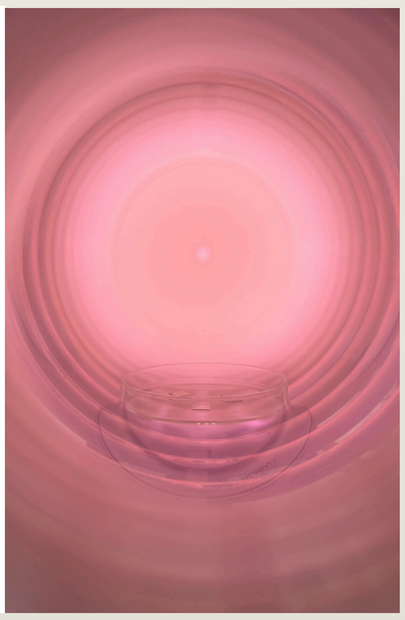


Figure 2 Plasma chamber

Conclusion

Plasma technology has potential to replace traditional chemical surface preparation before electroplating with the best result at five-minute of plasma-prepared. It effectively cleaned the surface causing damage at minimal rate, increased surface hydrophilicity and provided tarnish resistance comparable to the conventional chemical preparation method.

Acknowledgement

The author would like to express my sincere gratitude to my advisor for valuable guidance, encouragement, and continuous support throughout this study and cooperative education mentors and all staff members at Science and Technology Park, Chiang Mai University, for their kind assistance, support, and valuable suggestions during my cooperative education period. In addition, would like to gratefully acknowledge the financial support provided by the 50th Anniversary Fund of the Department of Geological Science, Chiang Mai University, which made this study possible.

References

- Amirfazli, A. (2001). Drop size dependence of contact angles and line tension [Doctoral dissertation, University of Toronto]. TSpace Repository.
- Kunthida Chanthaban. (2023). Tarnish resistance of silver reinforced with carbon material to artificial sweat and hydrogen sulfide [Master's thesis, Chulalongkorn University]. Chula Digital Collections.
- Wu, Q., Gubanov, K., Zhou, H., Marozau, I., Passaretti, A., González-Frutos, J., Degrigny, C., Bertrand, L., Meidani, N., & Valls-Fina, A. (2025). Natural and artificial aging methods for silver mock-ups in recent conservation and heritage studies: A short review. Chemistry-Methods, 5(1), Article e202400055.

Results

Silver Surface Preparation Using Plasma Technology

The results showed that using plasma technology can clean the surface of silver, proven by contact angle measurement. The average angle of samples from group A decreased from 88.56 degrees to 34.20 degrees (61%) and group B decreased from 93.11 degrees to 33.51 degrees (64%). The difference between these two is the damage the plasma caused to the surface due to the period of time that used for treatment. Group A show significant damage to the surface that can be observe via un-aid eyes.

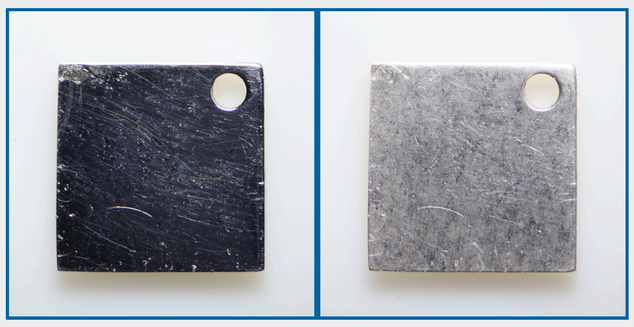


Figure 3 Silver plate after plasma treatment for 20 minutes

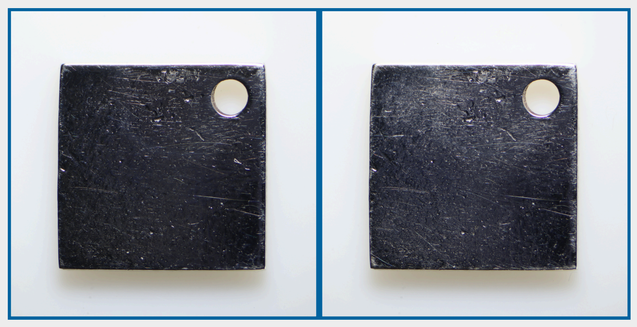


Figure 4 Silver plate after plasma treatment for 5 minutes

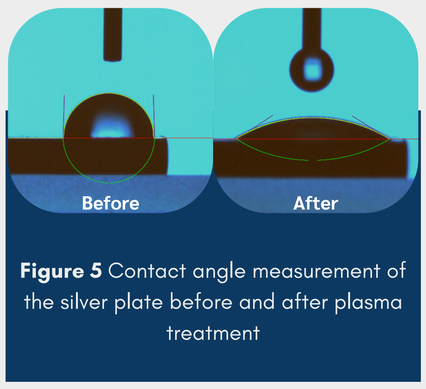


Figure 5 Contact angle measurement of the silver plate before and after plasma treatment

Electroplating and Chemical Composition

After plasma treatment, silver plates are electroplated with platinum to compare between the samples that prepared with plasma and the samples that prepared with chemical. Platinum content from group A increased from 0.02% to 0.20%, group B increase from 0.02% to 0.17% and the chemical-prepared increase from 0.02% to 0.18%. Showed that plasma-prepared samples have comparable efficiency as chemical-prepare.

Tarnish Resistance Performance Test

The test was designed to determine whether plasma surface treatment could improve resistance to tarnishing. Tarnishing was accelerated by exposing the samples to hydrogen sulfide (H_2S) generated from crushed boiled egg in a plastic box at approximately 38°C. Color changes were then measured every 2 minutes for 20 minutes using the CIE L*a*b* color system. In the first experiment with unplated silver, untreated sample began to tarnish after about 8 minutes, while the plasma-prepared sample showed visible change at about 12 minutes and also showed a slower decrease in brightness (dL*) (Figure 6), indicating that plasma treatment helped delay tarnishing. In the second experiment with platinum-plated silver, the plasma-prepared and platinum-plated sample was compared with the chemical-prepared and platinum-plated sample. Both samples began to show changes at around 8 minutes, and their brightness and color-change rates were very similar (Figure 7). This indicates that plasma surface preparation before electroplating provided tarnish resistance comparable to conventional chemical cleaning.

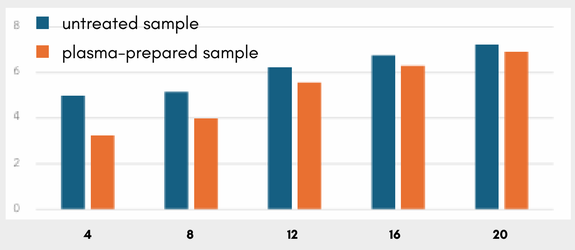


Figure 6 Rate of change in brightness (dL*) of unplated silver samples

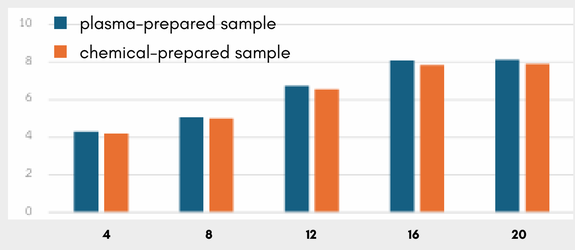


Figure 7 Rate of change in brightness (dL*) of platinum-plated silver samples