Applied Physics Research
www.ccsenet.org/journal.html
Vol. 1, No. 1
May 2009

The Effect of DC Plating Parameters on the Composition and Morphology of Silver-copper Alloy

C.Shanthi (Corresponding author)
Department of Physics
Sona College of Technology
Salem 636005, Tamilnadu, India
Tel: 91-427-409-9791 E-mail: shanthi_rec@yahoo.co.in

S.Barathan
Department of Physics
Annamalai University
Annamalai nagar-608002, Tamilnadu, India
Tel: 91-414-422-2751 E-mail: sbarathan_au@rediffmail.com

RajasrisenJaiswal
Department of Physics
Sona College of Technology
Salem-636005, Tamilnadu, India
Tel: 91-427-409-9823 E-mail: senoritta_in@yahoo.co.in

R.M. Arunachalam
Department of Mechanical Engineering,
Sona College of Technology
Salem-636005, Tamilnadu, India
Tel: 91-427-409-9716 E-mail: arun_rm@yahoo.com

The research is financed by All India Council for Technical Education (AICTE), New Delhi under the Research Promotion Scheme File No. 8023/BOR/RPS-145 /2006-07 and Sona College of Technology.

Abstract

This research attempts to optimize the parameters for DC plating of silver on silver alloy of two different compositions namely 50% and 75% silver alloy. In the Silver –copper alloy, the surface morphology and composition of the electro deposit are influenced by current density, silver concentration in the bath, applied current type and addition of additive. It has been found that concentration of silver in silver alloy has an effect in weight electrodeposited over cathode in DC plating. The surface morphology is studied by taking SEM micrograph for the two different compositions of silver alloy and grain size is measured using XRD analysis. Higher the purity of silver, finer is the grain size. It has been observed that with the increase of silver in the sample, the amount of silver deposited, hence the thickness of the deposit varies for the same current and voltage settings.

Keywords: DC plating, Silver alloy, Current density, Thickness

1. Introduction

Electroplated silver was developed primarily for use on hollowware, flatware and tableware. It has proven its usefulness in both decorative and functional applications in both Engineering, electrical and electronic applications. Its great success has been virtually a complete replacement of gold on metallic lead frames, the devices that support majority of silicon chips. Silver has been used as a bearing surface for many decades. Silver is plated almost exclusively with cyanide based solutions, despite the considerable research effort that has been expended on evaluating less toxic alternatives. It is possible to produce fully bright deposits that require no further buffing or polishing. This is achieved by including a brightening agent in the solution formula (Sarkar, 1971).Silver holds a distinguished position among the metals as it was the first metal covered by a patent for electroplating (Orr, 1982). Copper is the only metal with which silver forms a simple eutectic between two well defined terminal solid solutions. The salient feature of this system is that useful alloys are found over the full range of composition. The fact that the eutectic is between two terminal solid solutions, each having very similar properties, is largely responsible for this. The silver copper eutectic is the basis for the large family of silver –copper-zinc and silver copper zinc cadmium industrial brazing alloys. This alloy has the best combination of strength, hardness and electrical properties of any of the silver alloys. Numerous silver copper alloys in the range 99.8 percent silver down to 50 percent have been used for electric contacts, brazing and silver jewellery industry (McDonald, 1982).This research attempts to optimize the parameters for DC plating of silver over silver alloy for two different compositions namely 75% silver, 25%copper and 50%silver and 50%copper. DC plating is the process of depositing a coating having a desirable form by means of electrolysis. The main purpose is to alter the characteristics of a surface so as to provide improved appearance, ability to withstand corrosive agents, resistance to abrasion or other desired properties or a combination of them (Nasser Kanani, 2004).But with the advent of pulse plating, which is defined as metal deposition by pulsed electrolysis (interrupted direct current to electroplate parts) the above said properties are improved (Knodler, A., 1986).Pulse plating leads to smoother and fine grained deposits (Shanthi, et al.,2008) and almost completely free of pinholes. Pulse plating also reduces the variation of plating thickness from one part to the next. Plating speeds can be increased. Current efficiency is improved and raw material consumption is also low. Our present investigation is to optimize the parameters for DC plating of silver on silver alloy of two different compositions namely 50% and 75% silver alloy.

2. Experimental

2.1 Bath composition

Potassium cyanide, Silver Potassium cyanide and Commercial Brightener are the main composition of the bath with a silver content of 30gms/litre (Canning, W., 2005). The purity of the anode silver is 99.99% **.**Anode and cathode size ratio should be 2:1. Silver metal concentration is normally maintained by anode dissolution which needs small additions of metal salt occasionally. This is processed further by adding either silver cyanide or potassium silver cyanide. Silver is present as potassium silver cyanide, and its concentration must be maintained by making periodic additions of this double salt. Buffer salt is added to maintain the pH level.

2.2 Specimen Preparation

Samples from two different silver compositions namely 50% and 75% silver alloy are prepared by melting 50grams of pure silver and 50grams of copper and 75grams of pure silver and 25grams of copper at a temperature of 1100°C in a crucible using a charcoal furnace respectively. The molten silver ingot is poured in a rectangular casting plate of length 3cm and height 0.7cm and cooled at room temperature. This ingot is pressed and rolled in a press roller to get 0.17cm thickness sheet. Then it is cut into a size of 7cmX 2.5cm. Surface of the specimen was cleaned with acid pickling and polished in a vibrator polisher and finally hand brushed and cleaned with tap water.

2.3 Procedure of conducting the experiment

The anode which is annealed pure silver (99.99%) is connected to the positive terminal of the rectifier and the specimen cathode is connected to the negative terminal of the rectifier. A filter unit is used to remove the impurities in bath continuously. Deposition of silver is on the cathode silver alloy which undergoes a displacement of 8.75cm/second to avoid polarization in the solution. DC plating is studied for the peak current densities of 3.2103A/dm^2, 3.7453A/dm^2 and 4.5479A/dm^2 by giving a value to ON time and making the OFF time zero in the pulse rectifier. A DC voltage of 1.2volt and DC current of 1.2, 1.4 and 1.7 amp are set up and plating is done for 60 seconds with suitable bath composition. The cathode is weighed before and after electroplating and theoretical, experimental thickness, current efficiency are calculated and hardness measured using microhardness tester are recorded as shown in the Table 1.

3. Results and discussion

Samples from two different silver compositions namely 50% and 75% silver alloy have been made and electrodeposited. Figure 1 shows the SEM micrograph for DC plating of 75%silver and 25% copper alloy for a peak current density of 3.7453A/dm^2 and figure 2 shows the SEM micrograph for DC plating of 50% Silver and 50% Copper alloy for the same peak current density of 3.7453A/dm^2. In the Silver –copper alloy, the surface morphology and composition of the electro deposit are influenced by current density, silver concentration in the bath, applied current type and addition of additive (Mohan, et al.,2005).The increase of current density has increased the amount of weight electrodeposited and hence the thickness of the silver deposit. Experimentally it is determined that the current density for minimum time and maximum deposition as 3.7453A/dm^2 for 50% silver alloy and 4.5479A/dm^2 for 75% silver alloy for a specimen size of 0.7dm x 0.25dm beyond which darkening of the specimen is observed. Burning deposit is found in 50% silver alloy for a peak current density of 4.5479A/dm^2 and the hardness is found to be maximum. The current efficiency is found to be maximum for a current density of 3.7453A/dm^2 for 50% silver alloy and 75% silver alloy. It is found that concentration of silver in silver alloy has an effect in the weight electrodeposited over cathode in DC plating. Pure silver has low resistance, high current flow and so conductivity is more. It has been observed that with the increase of silver in the sample, the amount of silver deposited, hence the thickness of the deposit varies for the same current and voltage settings. Hence more amount of silver has been electrodeposited for 50% silver compared to 75% silver. But for 50% silver, at a current density of 4.5479amp/dm^2, the current efficiency decreases to a large extent due to the formation of burnt deposit on the specimen and the hardness also increased. The deposits are not smooth and it is coarse grained in DC plating. Plating thickness varies from one part to the next. Plating speed is less and current efficiency is also less. Raw material consumption is high (Shanthi, et al., 2007).

3.1 Grain size measurement using XRD

Figure 3 shows the XRD pattern for 75% Silver and 25% Copper and Figure 4 shows the XRD pattern for 50% Silver and 50% Copper. The grain size is calculated using Debye Scherer equation. It is observed that the grain size is finer for 75% Silver than that for 50% silver. The concentration of silver in silver alloy plays a vital role in determining the grain size. Higher the purity of silver, finer is the grain size.

4. Conclusion

Based on the conducted studies on DC plating of silver on silver alloy of two different compositions namely 75% silver, 25% copper and 50% silver, 50% copper, it has been found that the concentration of silver in the cathode plays a role in deciding the amount of silver deposited on the cathode. It has been observed that with the increase of silver in the sample, the amount of silver deposited, hence the thickness of the deposit varies for the same current and voltage settings. Higher the purity of silver, finer will be the grain size. Current density above 3.7453A/dm^2 for 50% silver alloy and 4.5479A/dm^2 for 75% silver alloy leads to darkening of the deposits. The 75% silver alloy can withstand more current density than 50% silver alloy. For 50% silver, at a current density of 4.5479amp/dm^2, the current efficiency decreases to a large extent due to the formation of burnt deposit on the specimen and the hardness also increased. It is suggested that the properties are improved if the concentration of silver in silver copper alloy is more.

References

Canning, W. (2005). *The Canning handbook surface finishing technology*. (23rd ed.). New Delhi: CBS publishers and distributors, (Chapter 19).

Knodler, A. (1986). Pulsed electrodeposition of precious metals. In Jean-Claude, Puippe, & Frank Leaman (Eds.), *Theory and practice of pulse plating*. Florida: American electroplaters and surface finishers society, pp.164–174.

Mcdonald, A.S., Price, B.R. & Sistare, G.H. (1982).Alloying behavior of silver and its principal binary alloys. In Allison Butts, & Charles D. Coxe (Eds.), *Silver economics, metallurgy and use*. Florida: Robert Krieger Publishing Company, pp.248-254.

Mohan, S., & Raj, V. (2005). The effect of additives on the pulsed electrodeposition of copper. *Transactions of Institute of metal finishing*, 83,194-198.

Nasser Kanani, (2004). *Electroplating-Basic Principles: Processes and practice.* Berlin, Germany: Elsevier Ltd, (Chapter 4).

Orr, M.A. (1982). Electroplating. In Allison Butts, Charles D. Coxe (Eds.), *Silver economics, metallurgy and use* (pp.180-189). Florida: Robert Krieger Publishing Company.

Sarkar, S. (1971). *Silver the Science and Technology*. Calcutta: Calcutta Book house, (Chapter 4).

Shanthi, C., Arunachalam, R.M., & Barathan S. (2007). *Study of Surface Morphology in DC plating of Silver for the Jewellery Industry*, paper presented at National Conference on Advances in Surface and Interface Analysis, Salem, India.

Shanthi, C., Barathan, S., RajasrisenJaiswal, Arunachalam, R.M., & Mohan, S. (2008).The effect of pulse parameters in electrodeposition of silver alloy. *Materials letters*, 62, 4519–4521.

Table 1. DC plating parameters for 75% and 50% silver alloy.

% of Silver	DC Current Ampere	Current density A/dm^2	Theoretical weight grams	Theoretical Thickness micrometer	Experimental Thickness micrometer	Weight Electrodeposited grams	Current Efficiency %	Hardness VPN
75%	1.2	3.2103	0.0805	2.1427	1.7302	0.065	80.75	80.3
	1.4	3.7453	0.0939	2.4995	2.1828	0.082	87.33	82.4
	1.7	4.5479	0.114	3.0355	2.5821	0.097	85.09	86.7
50%	1.2	3.2103	0.0805	2.2323	2.0243	0.073	90.68	88.3
	1.4	3.7453	0.0939	2.6039	2.5234	0.091	96.91	81.7
	1.7	4.5479	0.114	3.1612	2.5511	0.092	80.70	102

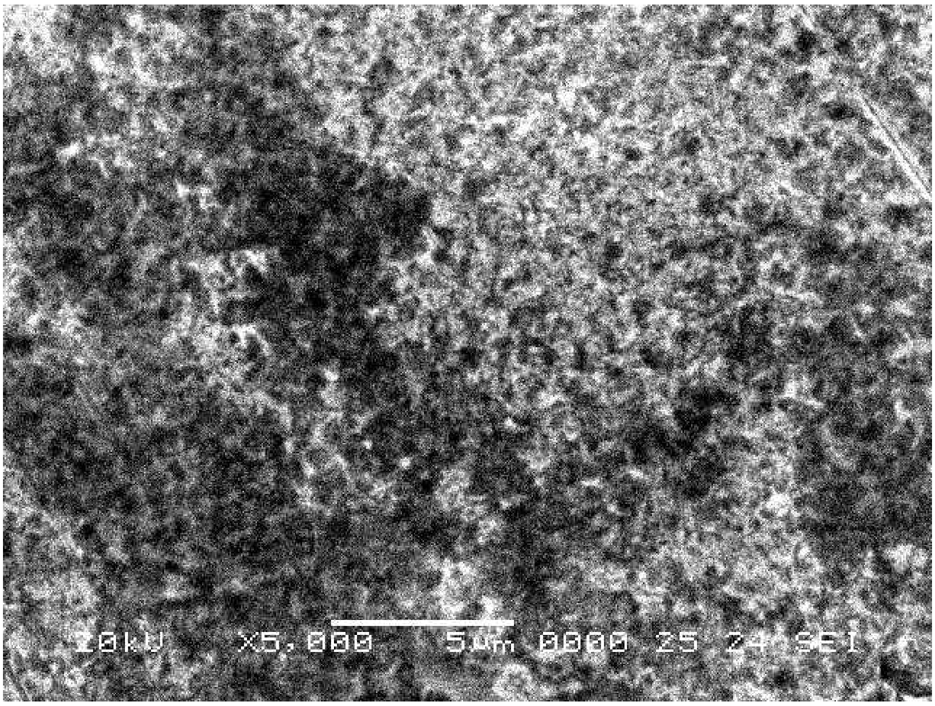

Figure 1. SEM micrograph for DC plating of 75%silver and 25% copper alloy for a peak current density of 3.7453A/dm^2

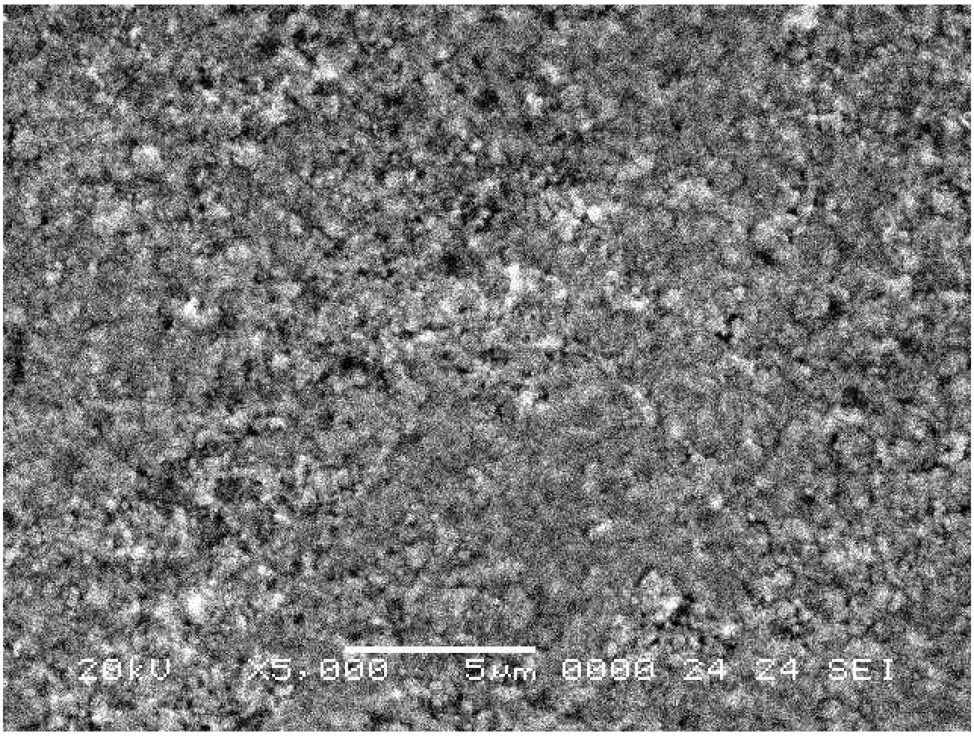

Figure 2. SEM micrograph for DC plating of 50% Silver and 50% Copper alloy for a peak current density of 3.7453A/dm^2

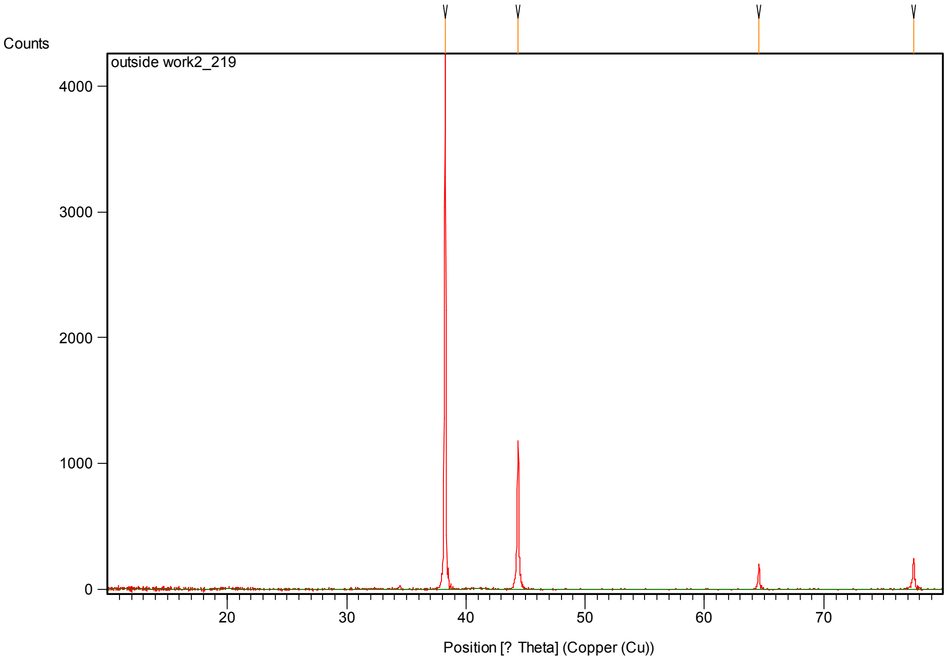

Figure 3. XRD pattern for 75% Silver and 25% Copper alloy for a peak current density of 3.7453A/dm^2

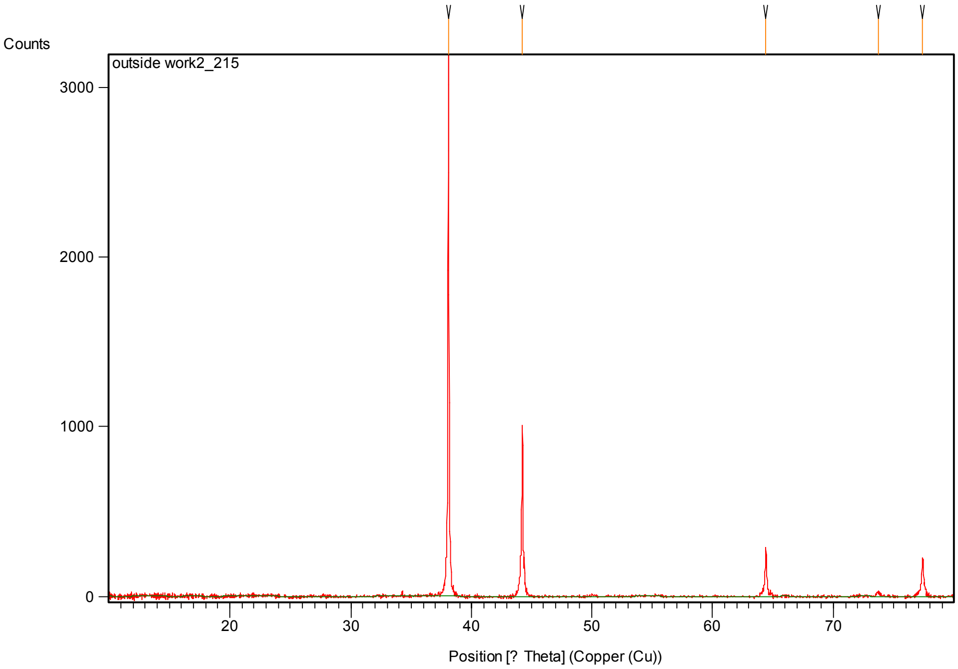

Figure 4. XRD pattern for 50% Silver and 50% Copper alloy for a peak current density of 3.7453A/dm^2