The Application of Pulsed Current to Sn-Pb Alloy Deposition onto a Rotating Disc Electrode

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Sn-Pb alloys are electrodeposited on copper or copper-based alloys for soldering of electronic components. Deposits of pure tin are not used for soldering due to their high melting point and also their tendency to form "whiskers" during storage that can be disastrous to electronic equipment [1]. Sn-Pb alloy deposits with about 40 wt% Pb are considered to be completely free of whisker growth [2]. However, such high lead content is becoming increasingly unacceptable for environmental and health reasons. Thus, an important goal is to reduce lead content while preventing whisker formation.

The favorable effects of the use of pulsed current during plating on the microstructure of the resulting deposits have been reported for numerous systems. Recent work in our laboratory demonstrated that the application of current pulses with frequencies as high as 200 kHz can improve the quality (smoothness, hardness, etc.) of copper deposits without the addition of any brightener in the plating bath [3]. Accordingly, the objective of this study is to investigate the use of pulsed current and pulse reverse current at both low and high frequencies in Sn-Pb alloy electro- deposition. Particular attention is focused on alloy composition, deposit morphology and microstructure. In addition, the effect of organic additives on deposit composition and morphology and the feasibility of reducing the reliance on these additives are explored.

Experiments have been conducted to deposit Sn-Pb alloys onto copper rotating disc electrodes from fluoroborate baths (containing $Sn(BF_4)_2$, $Pb(BF_4)_2$, HBF_4). A platinum sheet was used as the counter electrode. Figure 1 shows the effect of pulse frequency over the range from 20 Hz to 200 KHz during the pulse reverse plating from a bath containing 40g/L Sn, 10g/L Pb and 15 g/L HBF_4 at a rotational speed of 500 rpm, duty cycle of 80%, cathodic pulse current density of 6.25 A dm^{-2} and anodic pulse current density of 5.0 A dm^{-2}. The bath also contained the organic additives (peptone and gelatin). Under identical conditions, DC plating at the same average current density of 4 A dm^{-2} produces an alloy deposit containing about 16 wt% Pb. Figure 1 shows that frequency has a dramatic effect on alloy composition. Below about 200 Hz, the resulting deposits contain low lead levels in the range from 3 to 5 wt%. However, as the frequency is further increased, the lead content rises sharply, reaching close to 30 wt% when 20 kHz pulses are applied. A further increase in frequency to 200 kHz does not alter the alloy composition under these conditions. This effect of frequency is presumably due to the kinetics of lead reduction being faster than that of tin reduction.

The effect of cathodic pulse current density on alloy composition during pulse reverse plating at 20 Hz is shown in Figure 2. By increasing the current density from 2.5 A dm^{-2} to 20 A dm^{-2}, the lead content rises from 2.1% to 12.9%. This trend is consistent with the effect of increasing the applied current density during DC plating.

Other results to be presented will include the influences of other operating parameters (e.g., pulse duty cycle, anodic pulse current density, etc.) on alloy composition during pulse plating and pulse reverse plating. The effect of some of these variables on deposit morphology will also be discussed.

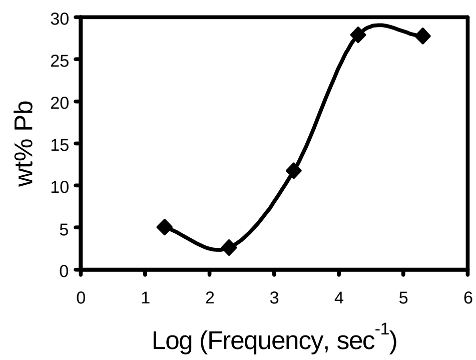

Figure 1. Effect of pulse frequency on alloy deposition composition. (Bath content: Sn:Pb(wt) = 4:1, duty cycle = 80%, cathodic current density = 6.25A dm^{-2}, anodic current density = 5A dm^{-2})

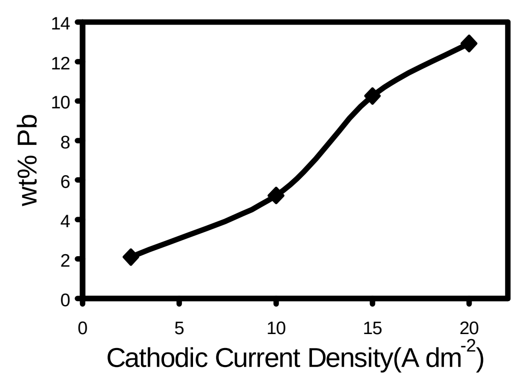

Figure 2. Effect of pulse cathodic current density on alloy deposit composition. (Bath content: Sn:Pb= 4:1, duty cycle = 80%, pulse frequency = 20 Hz, anodic pulse current density = 5A dm^{-2})

References:

1. J.W. Price, *Tin and Tin-Alloy Plating* Electrochemical Publications Limited, Scotland. (1983), p.112.
2. M.I. Smirnov et al., *Russian Journal of Electrochemistry*, 31, no.5 (1995) 498-500.
3. P. Kristof and M. Pritzker, *Plating and Surface Finishing*, 85, no. 11 (1998) 237-240.