

Electrochemical Formation of Brazing Alloys on Metal Substrates

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Brazing is a trustworthy method for joining different materials at temperatures above 450°C. Cusil™ is a eutectic alloy having a composition of 72 % silver and 28 % copper, and it is produced in forms of thin folios for use in brazing applications. The purpose of this study is to electrochemically form the Ag-Cu alloy of eutectic composition on metal substrates of different geometry and thickness. Therefore, brazing of small and complicated surfaces could be possible with less material and labor when compared to usage of foils.

Standard reduction potentials of silver (0.799 V) and copper (0.337 V) are far apart from each other, which makes the codeposition process difficult. To bring the electrode potentials closer, complex ion formation was realized in the electrolyte. A cyanide plating bath showing an irregular codeposition behavior was used for this purpose. The sources were KAg(CN)₂ and CuCN for silver and copper respectively. KCN was used as the complexing agent. The effect of KCN addition on the electrode potentials of Cu and Ag relative to hydrogen reference at 30°C are shown in Figure 1. Complete dissolution of CuCN in water was achieved at around 13 g/L KCN concentration and the difference between cell potentials increases afterwards.

Different plating parameters, and their effects on the composition of the deposits were studied. These parameters were KAg(CN)₂, CuCN and KCN concentrations, current density, temperature and agitation. Copper metal was used as the substrate, and plating was applied onto the surface after a silver strike process in order to obtain a smooth surface, good adhesion, and to prevent immersion deposition. Silver alone was deposited at relatively low voltages and high amounts of KCN. Higher voltages and lower amounts of KCN were required for copper deposition. Copper could not be deposited together with silver at high KCN concentrations (i.e. 26 g/L) or at low voltages (i.e. 1.5 V) at room temperature. A black, non-adherent deposit formed on the silver strike layer at such conditions. At 2.1 V potential, 8 mA/cm² current density and 13 g/L KCN concentration; maximum 43 % Ag was obtained in the deposit at room temperature. SEM image of this deposit is shown in Figure 2. The CN⁻ to Cu mole ratio was 3 and the Cu(CN)₃²⁻ was the electroactive species at these conditions [1]. The decrease in current density at constant KCN concentration and temperature, slightly increased the Ag content with formation of a black, non-adherent deposit. The increase in temperature on the other hand, decreased the Ag in the deposit while the current density and KCN concentration were kept constant at 8 mA/cm² and 13 g/L respectively. This was probably due to the larger increase in the cathode current efficiency of copper [2] than Ag with increase in temperature.

By increasing the temperature, decreasing the current density and KCN concentration, it became possible to

lower the applied voltage down to 1.2 V. Since the current efficiency of copper increases with increasing temperature, it was possible to initiate Cu deposition together with Ag at low voltages and the desired composition of 72 % Ag and 28 % Cu could be obtained. EDS data obtained from the deposit is given in Figure 3.

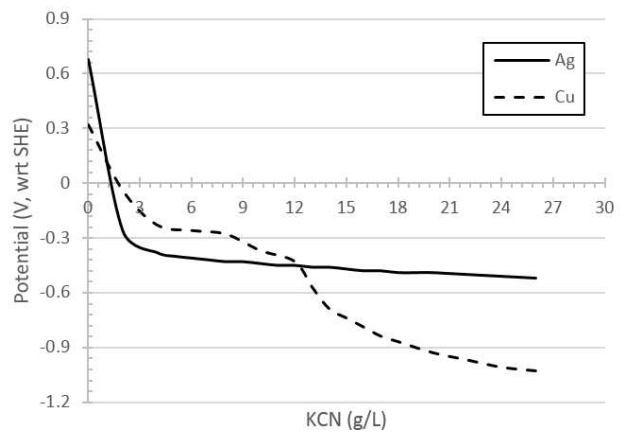


Figure 1: Electrode potentials of Cu and Ag relative to hydrogen reference as a function of KCN concentration.

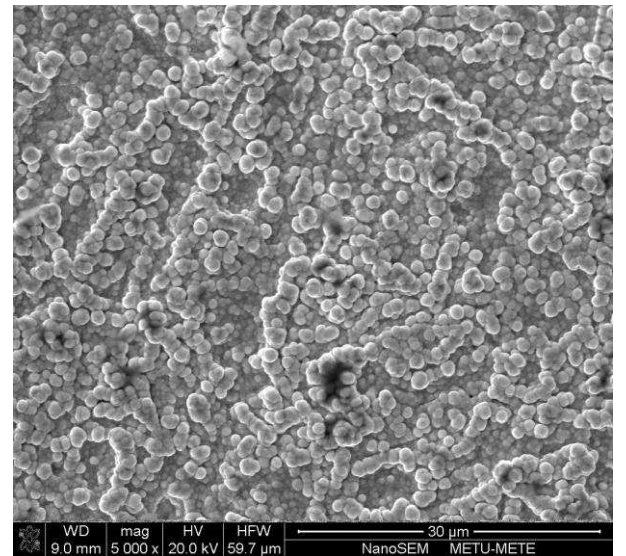


Figure 2: SEM image of the electrochemically formed alloy containing 43 % Ag and 57 % Cu.

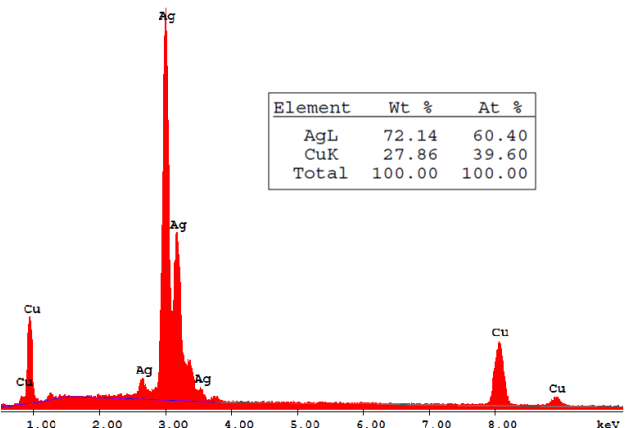


Figure 3: EDS spectrum of the electrodeposited Ag-Cu alloy of eutectic composition.

References
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[2] Brenner, A. Electrodeposition of alloys, Volume I. NY and London: Academic Press. pp. 140-141, (1963).