Electrodeposition from Ionic Liquids by Using Pulse Current

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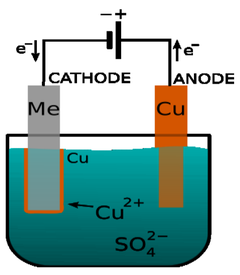
Abstract

Metal electroplating is of great significance in various industries such as electronics, sensors and optics, traditionally the process was performed in aqueous solution. However, they suffer a number of drawbacks such as poor deposit quality for some metals and environmental concerns [1]. The ionic liquid can overcome these limitations by aqueous solution [2]. In addition, the plating process can also be improved by applying pulse current instead of conventional direct current [3]. Therefore, it is worthy to investigate the combination effect of the utilization of both ionic liquid and pulse current in metal deposition.

Electrochemical Reactions

The metal plating process is performed in a electrochemical cell which is basically composed by power supply, cathode, anode and electrolyte. The chemical reaction splits into two half-cell reactions which take place on cathode and anode respectively. Cathode is the electrode where reduction process occurs and anode is the electrode where oxidation reaction occurs. Electrolyte conducts the movement of ions and forms a complete circuit with anode, cathode and power supply.

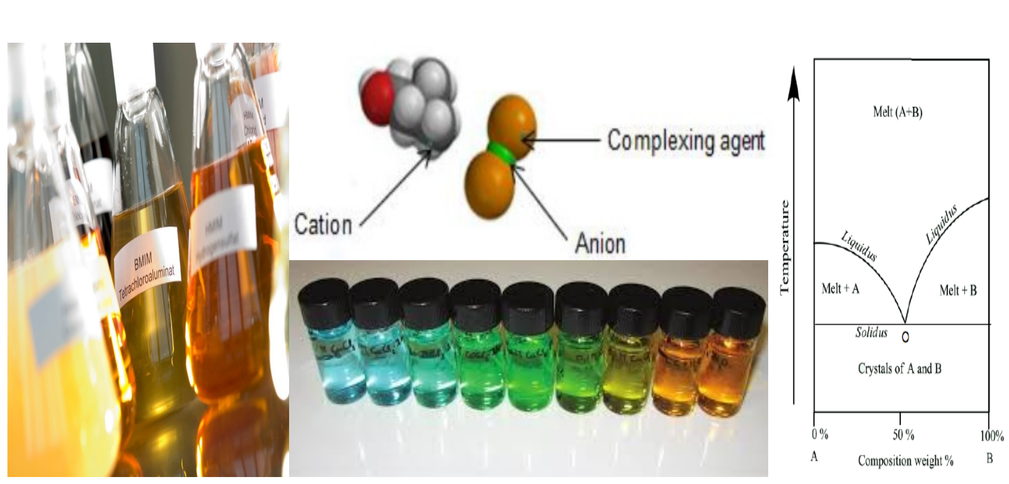
Cathode reaction: $X^{n+} + ne^- \rightarrow X^0$
Anode reaction: $Y^0 - ne^- \rightarrow Y^{n+}$
Overall reaction $X^{n+} + Y^0 \rightarrow X^0 + Y^{n+}$



In the half cell equations, X and Y are metal and they can be the same, X^{n+} and Y^{n+} are the metal ions, X^0 and $Y^0$are the metal atoms, e is the electron, n is the number of transferred electrons.

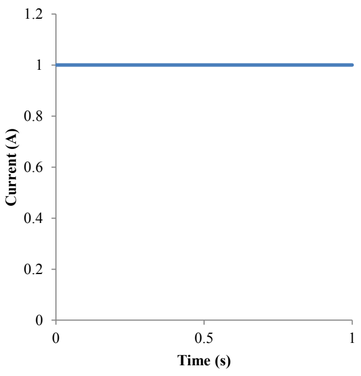
Ionic Liquid

Ionic liquid is a low temperature molten salt and in a liquid state at less than 100°C [4]. It is composed of cations which control the physical properties and anions which are responsible for their chemical characters [1]. One type of ionic liquid is called Deep Eutectics Solvents (DES) which is defined as the mixture of two chemical compound that has the lowest melting point. Deep eutectics indicates the melting point significantly decreases since the strength of interaction between two components is weakened [5]. In my plating copper ethaline melt DES is used as electrolyte to replace the conventional copper sulphate solution. This sort of DES is simple to prepare with low cost and doesn't interact with water [2]. Also it shows better electrochemical properties and is more environmental friendly than aqueous solution.

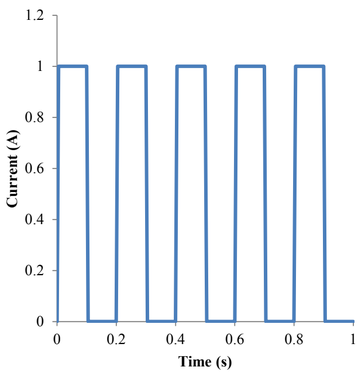


Pulse Current

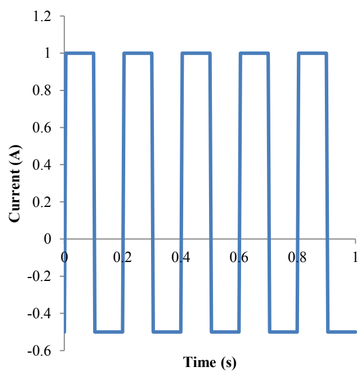
The metal plating process can either be applied by direct current (DC) or pulse current (PC). In DC plating a fixed unidirectional current is applied throughout the process. In PC plating the current changes in a periodically sequence between at least two different values [6]. The application of PC offers a number of advantages compared to DC : first the deposit is produced with a finer and smaller grain by improving the mass transport process [8]. Also there are a few engineering parameters can be tuned to optimize the deposit quality [9]. In addition, PC methods can reduce the usage of additives [7].



DC Current
Current 1: I A



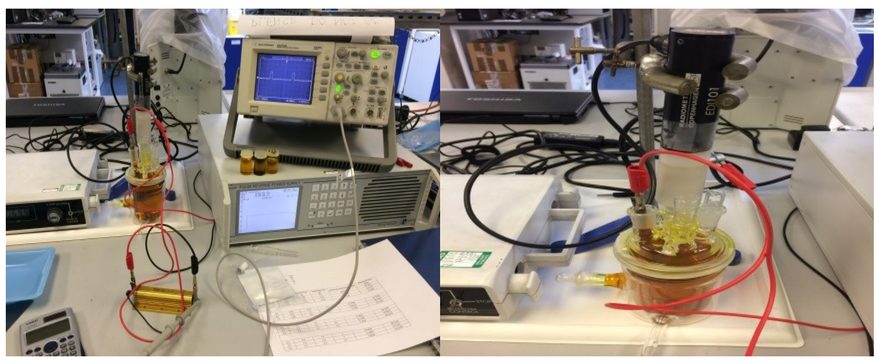
PC Current (Unipolar)
Current 1: I A
Current 2: 0 A



PC Current (Bipolar)
Current 1: I A
Current 2: -0.5 A

Objectives

My objective is to investigate how the magnitude of current, both current on-time and off-time affects the morphology of plated copper deposit and material distribution in DES by applying unipolar type of PC current. The current density and grain size will also be examined and compared to each other.



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