

PhD Seminar

“Pulse Electrodeposited Copper from Lean Electrolytes”

Sudipta Roy

Abstract

Introduction

The standard method to manipulate and control deposit properties during electroplating is through the use of chemical additives. Many of these additives are coming under increased scrutiny due to their impact on the environment. For example, the Printed Circuit Board (PCB) Industry typically requires plated copper to have low electrical resistance coupled with good mechanical properties. Such specific properties are imparted by using bespoke electrodeposition processes where acid concentration and metal ions are prescribed through experience, typically 2.0 M H₂SO₄, and 0.6 M CuSO₄. In addition, small amounts of additives are used to tailor deposit properties. However, new government regulations and green chemistry principles requires the minimisation of both metal ions as well as additives.

Green Electrodeposition is a marriage of Green Chemical Principles and Electrodeposition. Green Chemical Principles urges one to focus on the reduction of waste, employ atom economy, increase energy efficiency and use benign solvents, etc. These guidelines are useful for the development of any process, including electrodeposition processes. We adopted some of these ideas for the manufacture of micro-scale copper features. In such a case, the both metal ions as well as additive content has been lowered compared to a standard process and coupled with pulse deposition in electrolytes.

Although there has been some research of the synergy between pulse deposition and additive action [1-2], few have interrogated if pulse currents or additive actions dominate the microstructural evolution of a plated material. Indeed, these two aspects will become more important for lean electrolytes, where fewer anions from the supporting electrolyte (SO₄²⁻ for the case of copper deposition) adsorb on the electrode surface. From a practical point of view, the amount of additive needed in lean electrolytes needs to be ascertained, and its use needs to be justified as a method of optimization of the plated material. Indeed, pulsing current could play a major role in deposit modification when additive levels are low.

Scope of the Presentation

This work examines the effect of lowering additives, metal ions and supporting electrolyte on deposited copper. The electrolyte used contained only 0.1 M CuSO₄ and varying amounts of additives provided by a standard supplier for PCB manufacturing. Films have been deposited from electrolytes containing different concentrations of additives ranging from 17% to 200% of the levels recommended by the supplier using pulse and direct currents. Copper films of 25 µm thickness have been plated on stainless steel substrates following the recommendations provided by IPC-TM-650 (IPC-TM stands for The Institute for Interconnecting and Packaging Electronic Circuits Testing Methods) standard [3].

Both direct and pulse currents have been used for deposition. Direct currents were fixed at 40% of the maximum plating rate (or limiting current) and pulse current parameters used a pulse on time of 100 ms and a duty cycle of 25%. The grain size and deposit microstructure were examined using electron backscatter diffraction (EBSD) and scanning electron microscopy (SEM), respectively. These parameters were chosen because defect free foils could be produced reproducibly using these conditions.

Our results showed that current pulsing produced finer grains in the absence of additives; and as additive levels were increased the effect of current pulsing on deposit properties was less pronounced. The results indicate that foils produced by pulsing currents produced deposits with fewer inclusions or defects at grain boundaries. This could be due to the desorption of additives during the off-time. These results show that current pulsing may become more important when leaner electrolytes are used.

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References

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