A novel bottom up fill mechanism for the metallization of advanced node copper interconnects

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Introduction

A new alkaline copper plating bath enabling a unique and innovative bottom up effect for sub 14 nm node damascene and dual damascene interconnect metallization is described. The formation of an ultra-stable polynuclear copper(I) layer during the early stage of the deposition process inhibits copper reduction, leading to a very strong suppressing effect. Bottom up growth is then achieved by means of selective breakdown of the suppressing layer from the bottom to the top of the features without any accelerator additive. This new bottom up approach is termed Sao Concept.

Sao Concept: Polynuclear Cu(I) Suppressing Layer

Most copper plating chemistries currently used for copper interconnects are acidic, involving special additives that provide bottom up fill of the narrow structures10. Many studies have been carried out to understand the bottom up effect in acidic bath2–4,6. Only a few approaches have been published to describe the bottom up effect in an alkaline copper plating bath8. In this new Sao formulation, we use an organic complexing agent (L) as a reactant to initiate polymerization of the intermediate Cu(I) complex formed during the early stage of the cathodic reduction, leading to the formation of an ultra-stable suppressing layer (Fig 1). This suppressing layer then strongly inhibits Cu(II) reduction on the entire surface including field, sidewalls and bottom of trenches.

Figure 1: Polynuclear Cu(I) suppressing layer formation

Overpotential comparison between Sao chemistry and conventional acidic bath

Characterization of the Suppressing Layer

Supressing layer stability over time

SEM micrograps of trenches at two different process charges with Sao chemistry

• No sidewall or bottom voids observed
• Strong bottom-up effect
• No deposition on the field
• No pinch off

Sao Concept: Bottom up Fill Mechanism

We described a disruptive bottom up mechanism involving an alkaline copper plating bath without the use of any additional additives, such as accelerator or suppressor. Void-free filling of narrow trenches was observed by SEM cross section. The associated bottom up mechanism was explained as the selective breakdown of the in situ formed suppressing layer from the bottom to the top of the trenches due to hydrogen accumulation and local pH increase. This new concept was successfully applied to advanced node metallization from N14 to N5.

Conclusion

Bibliography