

Project Title: *Slurry formulation for ruthenium chemical mechanical planarization*

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Summary

Fumed silica based slurry containing NaOCl as oxidizer with and without benzotriazole on Ru and Cu CMP removal rate was investigated in this work. The XRD spectra of Ru were sharp and crystalline, indicating the shift of diffraction peak from (101) to (002) as the pH is increased. In presence of BTA, the highest RR of Ru was found to be ~150 nm/min at neutral pH, but the selectivity ratio of Ru to Cu was found to be 1:1 at pH 9. The oxidized layer over the metal surface of copper and ruthenium plays an important role during CMP operation. The positive sign of enthalpy (ΔH_{act}) reflects the endothermic nature of the dissolution process of copper and ruthenium. A negative value of ΔS_{act} indicates that the dissolution process is controlled by activation complex.

Ru and Cu CMP was carried out using the slurry composed of 1 wt% titania, 0.5 wt% NaOCl with and without 5 mM BTA. The desirable selectivity of 1:1 for Ru and Cu RR was obtained at pH 9 when the slurry formulation was 1 wt% titania, 0.5 wt% NaOCl and 5 mM BTA. Potentiodynamic polarization studies show that the corrosion current density follows similar trend as that of RR as a function of pH. Similarly, EIS studies with and without BTA for Ru show a decreasing trend for R_{ct} and R_{film} until pH 7 and increases gradually in the alkaline region indicating the formation of different oxide layers which matches well with the CMP results. The decrease in the C_{film} values with the addition of BTA in both Cu and Ru indicates the adsorption of the BTA on metal surface which alters the dissolution rate. Proposed slurry is robust and does not affect the selectivity with a slight change in the process conditions.

Project Outcome

1. K. Yadav, **R. Manivannan**, S. N. Victoria, Chemical mechanical planarization of ruthenium using sodium hypochlorite based titania slurry, *ECS J. Solid State Sci. Technol.*, **6** (12) (2017) P879-P885.
2. Kavita Yadav, Jitendra C. Bisen, S. Noyel Victoria, **R. Manivannan**, Sodium hypochlorite as an oxidizing agent in silica based ruthenium chemical mechanical planarization slurry, *Microelectron. Eng.* 180 (2017)96-100.

