An Investigation of Copper Deposition from Dilute HF Solutions Containing Multiple Metal Ions

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Copper deposition at silicon wafer surfaces was investigated by performing electrochemical measurements and surface characterizations in dilute HF (DHF) solutions containing different concentrations of iron (Fe^{3+}), nickel (Ni^{2+}) and calcium (Ca^{2+}) ions. The open-circuit potentials (OCP) and ac impedance spectra were obtained in the presences of 2-, 3- and 4-metal combinations. The metallically contaminated wafer surfaces were subsequently examined by SEM and XPS techniques to study their morphologies and chemical compositions that are related to copper deposition occurred at the wafer surfaces.

It was found that the values of OCP increased by adding Fe^{3+}, Ni^{2+} and Ca^{2+} into DHF solutions, both individually and with various metal combinations. The impedance values significantly reduced in the presences of multiple metal ions, indicating the acceleration of copper deposition. The p-type silicon was more heavily contaminated than n-type silicon, while copper deposition took place more favorably by adding more concentrated and more combinations of metal ions. Copper coagulation was also observed with the increase of time; in particular, large amount of copper coagulation became apparent when the multiple metal ions were present in solutions with 2-, 3-, and 4-metal combinations, leading to severe metallic contaminations.

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