OPTIMIZATION OF NOVEL SILVER ALLOY ELECTROLESS DEPOSITION SOLUTION FOR ULSI APPLICATIONS

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In the last decade metal and alloys electroless deposition methods are of great practical and theoretical interest due to rapid decreasing of features size in microelectronics, MEMS and etc. Electroless deposition technology, as relatively simple, high selective and not expensive, is very useful for ultra-large scale integration (ULSI) interconnect metallization. Silver metallization looks promising because of lowest specific bulk resistivity (ρ=1.59 $\mu\Omega$·cm). As it was shown in preliminary studies [1-2], the drawbacks of using Ag in ULSI metallization (e.g. high resistivity in thin films, corrosion in atmosphere and high diffusion in SiO_2), may be avoided by using a binary layer of silver tungsten (Ag-W) instead of pure Ag. Moreover, barrier-less silver metallization will offer higher effective conductivity than copper metallization especially at greatly decreasing of critical dimensions.

In this paper we present the results of plating solution and deposition parameters optimization for improving of Ag-W thin film properties. Primary criteria of optimization, which minimum value has to be achieved, is the specific resistivity of thin (less than 100 nm) film. Input vector of optimization parameters including component concentration, pH and process temperature was formed.

A novel benzoic acid based solution for silver-tungsten electroless deposition was developed. The basic solution contains benzoic acid as complex agent, silver nitrate as source of Ag^+ ions, Na_2WO_4 as source of tungsten ions and hydrazine hydrate as reducing agent. The influence of additives like surfactants and brightener was studied as well. This electrolyte seems more perspective to reach thin film low resistivity comparing to previous developed ammonium-acetic bath [3] (Fig.1).The Ag-W films were deposited at the room temperature on the $Co/Ti/SiO_2/Si$ substrate where seed layers were deposited by ion beam sputtering method with the thickness about 200 Å (100 Å of Ti and 100 Å of Co).

The Ag-W films composition, structure, electrical properties and reaction kinetic were studied. The resistivity of deposited layers was measured by an in-line four point Probe with a dual configuration procedure (Lucas/Signatone^{TM}). The study of the films composition was carried out by X-ray fluorescence spectroscopy (XRF) and secondary-ion mass spectroscopy (SIMS) analysis. Optical microscopy, secondary electron microscopy (SEM) and atomic force microscopy (AFM) methods data were used to characterize the topography of deposited Ag-W films. The thickness of the films was determined using an Alpha-step 500.

The optimal concentration of basic component of solution which allowed to deposit 100 nm thick Ag-W films with the resistivity about $5\ 10^{-6}$ Ohm cm was achieved. Deposited films look smooth, bright, have a good coverage and adhesion to the substrate. Strong dependence of resistivity on solution composition was found. The resistivity of the Ag-W layers is decreased with increasing of the film thickness achieving to the silver bulk resistivity (order of $2\ 10^{-6}$ Ohm cm).

The research of the deposition rate was carried out. Deposition rate dependencies vs. component concentrations and solution pH are obtained.

It is shown that silver-tungsten alloy does not corrode at 240°C in air. Moreover, the resistivity of the annealed films decreases with increasing of temperature (Fig. 2). It may be due to grain size growing and organic part removing from the film.

The perspective of use Ag-W layers for advanced ULSI metallization is increased by these encouraging results.

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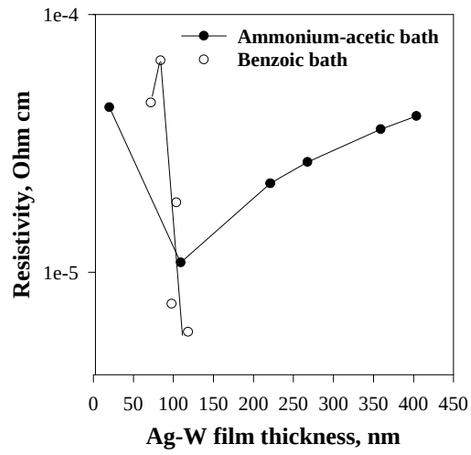

Fig.1. Comparing of electrical properties of Ag-W film deposited from different solutions

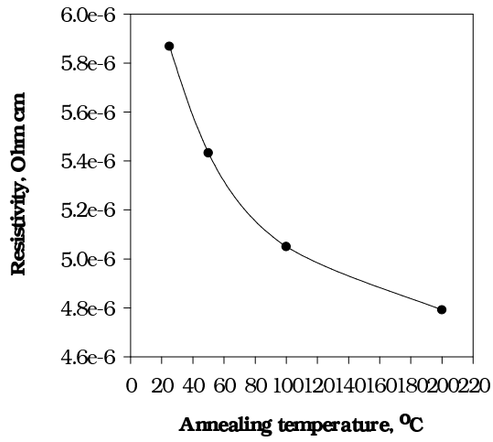

Fig.2. Dependence of the Ag-W film resistivity vs. annealing temperature in air

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