Electrolessly Deposited Films in Electronics and ULSI

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Our department started comprehensive investigations of electroless plating forty years ago. We widely introduced the developed technologies into aerospace techniques, microelectronics, piezo- and computing engineering and instrument making. The present paper describes the results of the investigation of Sn and Pd ions adsorption and desorption, influence of different factors on sensitization, activation and electroless metallization, some properties of deposited films and shows wide application of electroless plating in the industry (1-6).

For the development of an optimum technology we have improved the whole cycle of the devices production: preliminary treatment of various substrates (the sensitization and activation), composition of solutions and electroless plating parameters, conditions of heat treatment after deposition, conditions of photolithography, selective etching processes, etc.

The influence of different factors, such as concentration of Sn and Pd ions, temperature, pH, additives, surface roughness, time of treatment, etc. on the sensitization, activation and electroless deposition have been investigated.

The mechanism of sensitization and activation, involving the concept of equilibrium shift towards the formation of complex palladium anions and the predominance of the number of palladium ions over tin ions on the surfaces, has been established. It is shown that the part of Pd ions, not reduced at sensitization-activation, can be partially reduced at subsequent interaction with hypophosphite in the solution of electroless deposition.

The results obtained by electron microscopic studies showed local nickel deposition on the dielectric in the shape of small plate-like islands. During of activation, the small islands are merged. It was shown that sensitization promotes complete surface coverage and reduction of the particles size.

We have developed the conditions for obtaining electrolessly deposited films with the desired properties, with the adhesion strength exceeding the cohesion strength even of quartz, with the specified conductivity, mechanical, magnetic and optical properties.

A technology for production of piezoceramic devices by electroless deposition of electrode layers made of Ni-P or Cu for hydroacoustic equipment of submarines, delay lines of color TV sets, capacitors, etc. was developed. As a result of usage of the developed technology, the time for production of piezoceramic devices was reduced by a factor of 80 as compared to high-temperature fusing of the silver-containing paste, and Ag was adequately substituted with non-noble metals.

The proposed methods of metallization of different materials are widely used in the enterprises of the CIS for production of quartz resonators and filters (several tens of mln. have been already produced), monolithic piezoquartz filters, photomasks, piezoceramic devices for hydroacoustics and delay lines of colour TV sets (several hundreds of mln. were produced), ohmic contacts on Si, Ge, AsGa, casings of integrated circuits and semiconducting devices, ceramic microplates, precise microwire and film resistors, etc.

Application of the proposed technologies gives a large economic effect. With this method:

-the coatings made of gold and silver are adequately replaced by non-noble metal alloys and the technology is significantly simplified;
-the time of the technological cycle of metallization is reduced by a factor 10 and labor intensity decreases sharply;
-the maintenance, quality and operational characteristics of photomasks increase;
-the reliability of quartz resonators is increased 1.8 times and dynamic resistance is decreased by 30%.

We have developed the patentable, technological and schemotechnical bases for solving one of the main problems in contemporary microelectronics - i.e. making photomasks and a plasma-resistant mask for Si device fabrication processes with submicron-sized elements by means of a highly productive group conventional single photolithography or modified resistless technology. The developed technology solves the problems of contact photolithography and has a number of advantages over the technologies having existed so far.

The proposed nanotechnology for the first time allows one to produce adjacent elements (of submicron size) of different thickness made of various materials (particularly of Si) by single conventional photolithography. The abovementioned and other advantages significantly increase the possibilities of the device design and its functional purposes, and simplify the removal of undesirable gases and heat dissipation.

A novel true additive method of formation of multiple conducting layers, contact filling materials, dielectric layers and pads on Si, GaAs or other substrates was developed for ULSI by combination of selective electroless deposition with the proposed thin layer LIGA, sacrificial layer and chemical mechanical polishing techniques.

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