Electroless Deposition of Ni Alloys in Nanotechnology and Electronics

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The effects of different factors: concentration of Sn and Pd ions, temperature, pH, additives, surface roughness, time of treatment on sensitization, activation and electroless deposition were investigated. The adsorption and desorption of tin and palladium ions have been investigated using the method of radioactive isotopes, XPS and photometry.

The proposed methods of metallization are widely used in electronics and instrument – making. As a result, Au, Ag and Pd were adequately replaced with the alloys of non-precious metals, usage of toxic substances was eliminated and the technology was significantly simplified. A new resistless technology is proposed.

It is shown that existence of the adsorbed tin ions provides both a greater number of palladium ions on the glass and a greater strength of bonding of palladium to the surface. The experimental results show that application of the sensitization becomes less essential in case of electroless metal plating of non-metallic materials with greater surface roughness. With the increase in the substrate roughness, the surface concentration of the adsorbed Sn and Pd ions increases. The optimal conditions for preliminary treatment of non-metallic material surfaces depend on their state and nature. The conditions of activation such as pH of palladium chloride, solution concentration, temperature, and surface roughness determine whether the sensitization is necessary or not. The sensitization reduces the induction period of the nickel deposition reaction, promotes complete coverage of the surface and improves the coating quality.

There was established the mechanism of sensitization and activation, involving the concept of an equilibrium shift towards formation of complex palladium anions and predominance of the number of palladium ions over tin ions on the surfaces.

It was established that a part of the palladium ions, not reduced by sensitization-activation:

$$Sn(II)+Pd(II)=Sn(IV)+Pd \quad (1)$$

can be partially reduced at subsequent interaction with hypophosphite in the solution of electroless deposition according to the reaction:

$$PdCl_4^{2-}+H_2PO_2^-+H_2O=Pd+H_2PO_3^-+2H^++4Cl^- \quad (2)$$

There were developed the competitive methods which allow us to substitute palladium chloride with inexpensive non-precious substances for activation both of non-metallic powder-like particles and bulk dielectrics prior to electroless metallization.

A new method of production of precise piezoelectric quartz resonators and filters, and monolithic piezoquartz filters with electrodes made of electroless nickel-phosphorous alloys for spacecraft, hydroacoustics and communication devices was developed.

As a result of the investigation, the optimal conditions of metallization were established and technological process of electroless nickel plating of piezoelectrical quartz elements with a smooth surface, including a polished surface, was developed.

Basic advantages and innovations of the developed technologies in the field of electroless nickel plating of piezoquartz, lithium niobate and glass as compared to silver and gold plating are: 1. Frequency stability of piezoquartz devices increases1.8 times. 2. The absolute value of dynamic resistance of piezoquartz resonators decreases by 30 % and resistance scattering of decreases by about 40-50 % as compared to the resonators with silver-plated piezoelements. 3. The quality and long-term stability of piezoquartz devices improve.

A technology of production of piezoceramic devices by electroless deposition of electrode layers made of Ni-P or Cu for hydroacoustic equipment of submarines and ships, delay lines of color TV sets, etc. was developed. As a result of usage of the developed technology, the time for production of the devices was reduced by a factor of **100** as compared to high-temperature fusing of silver-containing paste, and Ag was adequately substituted with non-precious metals.

The developed method of local chemical etching of piezoquarts, glass, etc. in combination with photolithography allows us to produce thin, high-quality piezoelements by a highly productive method. This technology is promising for obtaining thin piezoelectric layers (and thin glass).

The developed electroless methods allow one to produce the films with specified electrical, mechanical, magnetic, optical and chemical properties.

Application of the proposed technologies gives a large economic effect. With this method: the coatings made of gold and silver were adequately replaced by non-precious alloys in the process of metallization; the technology was significantly simplified as well; labour intensity of the process decreases sharply; the production volume per square meter of the production increases 8 times as compared to metallization by fusing the silver paste; the reliability, quality and operational characteristics of photomasks produced by deposition of the semitransparent masking elements improved significantly; the accuracy of fitting the precise microwire resistors increased 10 times.

The proposed nanotechnology for the first time allows one to produce nano-sized adjacent elements of different thickness made of various materials (particularly of Si) by single conventional optical UV photolithography. These advantages significantly extend functional capabilities of the devices and simplify removal of undesirable gases and heat dissipation.