Electroless Metallization of Dielectrics, Semiconductors and Powder-Like Particles

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A new competitive nanotechnology is presented and the mechanism of sensitization and activation is described. The developed technologies of electrolless metallization of various materials are widely used in piezoengineering, for mass production of ICs and semiconducting devices, ceramic microplates, precise microwire and film resistors and other devices [1-5]. The results of the investigation of Sn and Pd ions adsorption and desorption were obtained using the methods of radioactive isotopes and XPS [1-6].

The proposed methods allow to obtain nanometer-scale layers (having the properties very different from those of bulk materials) with unusual electrical, optical, magnetic and mechanical properties.

It is clearly observed that with the increase in substrate roughness the surface concentrations of Pd and Sn increase.

The part of palladium ions, not reduced by sensitization-activation:

$$Sn (II)+Pd (II)=Sn (IV)+Pd, \qquad (1)$$

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

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

The ductility of the electrolessly deposited Ni-P coating was studied by bending using a new ductility tester designed by T. Khoperia. The operation principle of the developed tester is based on the detection of cracks appearing in the coating due to the bending. The bending angle can be converted mathematically to the percent of elongation.

Besides the wedge-shaped support, the ductility tester has easily changeable supports of different diameters allowing to change the testing conditions.

The developed ductility tester has the following advantages as compared with the existing ones:

1) It makes possible to observe the crack development during bending with the help of the microscope, to observe (to photograph) the shape of cracks and the cracks density, their geometry, to measure the crack length and width, and to detect the moment of formation of a continuous crack grid (merging of cracks).
2) It also allows us the in-situ observation of cracks initiation, their growth and the speed of cracks propagation at different (but constant) speeds specimen deformation (bending).
3) The developed ductility tester enables us to determine in-situ the ductility at different temperatures.

The abovementioned advantages of the ductility tester (by bending) can help to overcome the several crack problems and particularly some problems of micro-mechanics and flip-chip technology. This ductility tester can establish the optimal conditions for obtaining the metallic coatings and varnish-and-paint films with desired ductility and internal stresses. The maximum ductility of the 30-micron-thick NiP coating is reached at the annealing temperature of 600ºC for 1 hour.

The developed methods of fabricating the thin void-free and pore-free electroless coatings on micro- and nanosized particles (carbides, borides, nitrides, oxides, zeolites, etc.) allow to obtain nanostructured composite materials and coatings with the specified catalytic activity. The method allows us to vary the electrical resistance and melting points of the coatings in the wide range. The incorporation of metallized powder-like particles into metals, alloys, ceramics or plastics can significantly increase their strength, microhardness, tribological properties, wear resistance, temperature and radiation stability, and provide dry lubrication. This point is very important for powder metallurgy; for increasing the toughness of metals (having high or low electrical resistance and melting points), ceramics and other dielectrics; ecology (in the case of obtaining high-quality adsorbents); civil nuclear techniques (at obtaining getters for ultra-high vacuum); electric-vacuum devices; composites fabrication; power electronics; microelectronics; photonics; machine building; etc.

The great importance of deposition of void-free and pore-free films on powder-like particles by the proposed electroless method is emphasized also by the fact that the theoretical strength of metals and alloys exceeds the strength obtained in practice 100 or even 1000 times.

The powder of alluminium oxide (Al_2O_3) with the grain diameter of 1 μm was metallized with the Ni-P alloy from the acid solution by a chemical method. From the metallized powder, a cathode for hydrogen release was made. The specific surface area S_{spec} of this metallized powder was measured with the help of the curves, showing the change in the electrode potential depending on the amount of fed current (charge curves). The specific surface area S_{spec} of the metallized powder was equal to 30 m^2/g. Then the number of particles (N) in a gram of the powder was determined by the following equations:

$$S_{spec}= \pi D^2 \cdot N=\pi \, 1^2 \cdot N=30 m^2/g= 30 \cdot 10^{12} \mu m^2/g$$

Hence, $N=9.5\cdot 10^{12}$

The metallized micro- and nanosized powder-like particles having the specified catalytic activity and very large specific surface area can be also successfully used for capturing toxic gases and cleaning the environment. The abovementioned predetermined properties of metallized micro- and nanosized particles provide great possibilities of their application in a biomedical field, in medical practice, etc.

The proposed method of metallization of powder-like particles can be applied for safe transportation and destruction of gunpowder without explosion.

References

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