MECHANICAL PROPERTIES OF METAL COATINGS OBTAINED BY VACUUM EVAPORATION AND SPUTTERING

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The most frequently investigated mechanical properties of thin films are their adhesion to substrate, the mechanical stresses in them and their tensile properties.[1]

In this work the mechanical properties - adhesion and microhardness - of vacuum deposited metal films were studied in relation to the method of preparation, either by the electron beam evaporation or by ion sputtering. The metals with different capabilities for the exidation (Cu, Ni, Au and dental gold) were used for the deposition. They were deposited on substrates of different hardness in relation to the hardness of the applied starting material.

RESULTS AND DISCUSSION

The results obtained for the adhesion of copper thin films deposited by vacuum evaporation and by sputtering onto borosilicate glass, are shown in Fig.1. The films obtained by

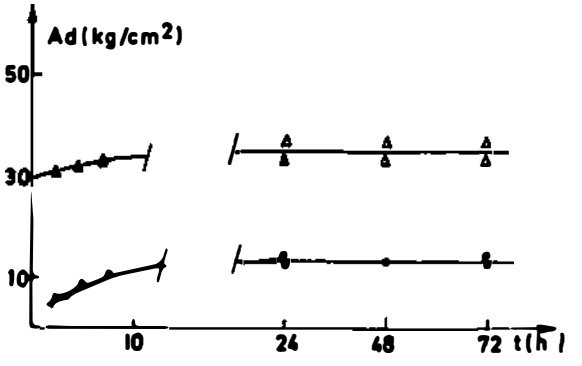

Fig.1. Adhesion of thin films v.s. aging time.

sputtering have adhesion values about 2-3 times higher than those obtained by vacuum evaporation. The aging effect of copper thin films is especially visible in freshly deposited films. For thinner films (1200 Å), due to the enhanced oxidation and highly expressed small grain size structure, the increase of the adhesion with the time is especially pronounced in the first two days after the deposition.

The experimental values of the copper microhardness measurements on glass and aluminium, as a function of the ratio of the film thickness to the indentation depth are shown in Fig.2.

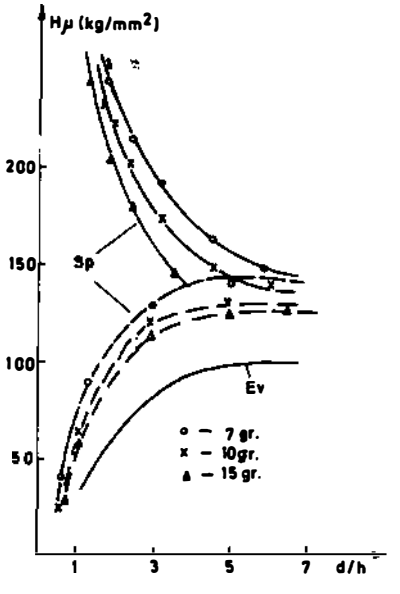

Fig.2. Microhardness of evaporated and sputtered thin films.

For the used substrate the obtained curves may be separated in two characteristic parts. The first part of the curve which makes an angle with the abscissa (x) axis, represents the area in which the value of the microhardness is changed with the thickness of the deposited layer. The horizontal part of the curve represents the values of the real microhardness. In this region the experimental value of the microhardness of the evaporated metal corresponds to the value of the bulk sample.

Thin films deposited by sputtering show higher microhardness values than those prepared by vacuum evaporation. The shape of the experimental curves for used substrates and loads is similar to that obtained for evaporated films, but the values of microhardness for the same thickness are for several percents higher.

Similar effects have been also observed on the other used thin films (Au, the gold alloy and Ni).

On the basis of the experimental results the following conclusions can be drawn.

The reason for the higher adhesion values of thin films obtained by sputtering is the higher energy of the particles during deposition on the substrate. The high energy of impinging particles causes the desorption of the impurities from the surface, atom penetration and partial incorporation of the sputtered atom (a few atomic layers) in the substrate. Besides the rate of oxidation is also important parameter for adhesion measurements.

The reason for higher values of microhardness of thin films deposited by sputtering is, probably, the higher density of films and coatings and defect concentration in it. Namely, due to higher energy of sputtered atoms, it probably causes the formation of better oriented crystals in the initial phase of the growth of the film. However, the atoms deposited in later phase of the growth, bombard the already formed layer and increase the concentration of defects in it.

REFERENCES

1. R.Hoffman, Phys.Thin Films 3(1966) 211.
2. T.Nenadović, N.Bibić, N.Kraljević and M.Adamov, Thin Solid Films 34(1976) 211.