ION BEAM ASSISTED DEPOSITION OF LAYERS ON METALS

A.A.Kamarou[1], A.F.Komarov[1], V.V.Pil'ko[1], V.A.Emel'yanov[2], P.Zukowski[3], Cz.Karwat[3], M.Kozak[3], K.Kiszczak[4]

[1] *Institute of Applied Physics Problems, 7 Kurchatava St., 220064, Minsk, Belarus*
(Phone/Fax: ++375 17 2774833; E-mail: kff@rfe.bsu.unibel.by)
[2] *NPO "Integral", Minsk, Belarus*
[3] *Technical University of Lublin, 38A Nadbystrzycka St., 20-618, Lublin, Poland*
[4] *Institute of Physics, M.Curie-Sklodowska University, 1 M.Curie-Sklodowskiej Sq., 20-031, Lublin, Poland*

New original approach was proposed by the authors in order to realize *in situ* nitrogen implantation and Au deposition on copper samples by the same ion beam. The developed simulation software enabled us to describe ion beam assisted deposition process as well as to calculate radial and depth distribution of deposited/introduced particles. The simulations yield definite conclusions on influence of ion beam energy, fluence and particular geometry of a sputter. Experimental results (RBS) are also presented that made possible to obtain depth distribution of Au and nitrogen atoms in copper.
The observed variation in thickness of the deposited layers, their uniformity and an efficiency of the layer-substrate intermixing is discussed and interpreted on the basis of both simulation results and experimental data.

Introduction

Ion beam assisted deposition (IBAD) technique is well known worldwide and is used frequently to modify mechanical, electrical, optical, tribological and other physical and chemical properties of surfaces. The main feature of IBAD as compared with common ion implantation is *in situ* deposition of additional component from magnetron system, plasma or residual atmosphere in an implantation chamber.

For example, formation of titanium nitride coatings on surface of iron details greatly improves their corrosion- and wear-resistance, and, therefore, significantly increases their lifetime [1-2]. Implantation of nitrogen with simultaneous carbon deposition from residual gases (carbohydrates, used in diffusion pumps) results in a better performance of copper switches with a view for wear-out time [3].

Therefore, IBAD can be considered as a very attractive tool in a field of machine-building and electrical engineering industry as well as microelectronics and its applications. However, it cannot help noticing that wide application of IBAD technology (say, for improving performance metallic surfaces) implies necessity to use rather expensive and power-consuming systems, such as magnetrons or plasma sources.

Experimental

We proposed new original procedure for IBAD modification of metal surfaces (particular, copper with a view for electrical engineering applications): realization of *in situ* nitrogen implantation and Au deposition on copper samples by the same ion beam (see Fig. 1). The central part of the ion beam affects only sample surface, while peripheral one causes sputtering of the special construction made in whole or covered with necessary metallic layer. Some part of being sputtered particles reaches sample surface, i.e. during irradiation stage we deal with simultaneous implantation, sputtering and deposition processes.

Simulations

The problem of modeling Au deposition assisted by molecular nitrogen implantation into copper has been broken into three relatively independent parts:

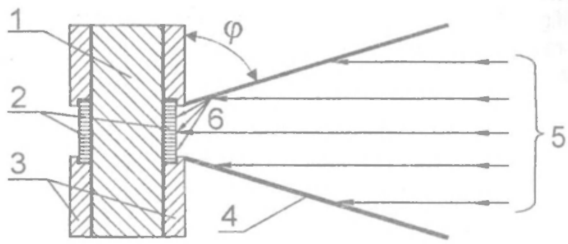

Fig. 1. Scheme illustrating our construction used for the ion beam assisted deposition process. The construction is axially symmetrical. 1 - frame, 2 - samples, 3 - samples holders, 4 - cone-shaped sputter, 5 - primary ion beam, 6 - sputtered particles.

- Simulation of a spatial distribution of the sputtered particles as a function of both azimuthal and polar angles (due to oblique incidence of the ion beam onto sputter).
- Calculation of radial distribution of sputtered particles that reach sample surface per unit of time.
- Simulation of IBAD process with account for target sputtering, impurity diffusion and new phase formation (deposition rate is calculated during first two steps).

The first task was solved due to application of SATVAL code [4,5] (last version). This software enabled us to obtain sputtered particles distribution versus two spatial angles so as in our case we dealt with indirect ion beam incidence onto sputter.

The second step was performed on the basis of code developed by one of us (A.A.K.).

And, finally, the last part of the work was carried out due to BEAM2HD software (A.F.K.). This program allows simulation of two-beam high-dose ion implantation with *in situ* deposition process, when one cannot neglect such processes as target swelling and sputtering, impurity diffusion and new phases formation, like as for conventional ion doses.

The simulations based on the developed software complex yield definite conclusions on radial and depth distribution of deposited/introduced particles as samples with Au deposition. Experimental investigations (RBS) revealed rather significant concentration of Au in near-surface layer of the samples (up to 7 at.%; and up to 15 at.% of nitrogen), which is sufficient to modify mechanical and electrical properties of Cu surfaces used in many applications in a field of electrical engineering. We also developed a program complex to simulate numerous physical processes, involved. These are high-dose ion implantation; repeated sputtering and deposition, new phase formation, etc. Theoretical predictions are in agreement with obtained experimental results. Further, in order to obtain larger dopant concentration in deeper layers it will be necessary to use screening/shielding of a sample but not a sputter surface to lower sputtering of particles deposited onto sample surface.

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