C3-O-051901

NON-SPHERICAL PLASMONIC COPPER NANOPARTICLES IN A TRANSPARENT $MGAL_2O_4$ CERAMIC MATRIX

A.SH. VAGAPOV [1], A.N.KIRYAKOV [1], A.F. ZATSEPIN [1], B.L. OKSENGENDLER [1,2,3], N.V. GAVRILOV [4]

[1]*Ural Federal University, Yekaterinburg, Russia*
[2]*Institute of Materials Science NPO "Physics-Sun" AS RUz, Tashkent, Uzbekistan*
[3]*Institute of Ion-Plasma and Laser Technologies AS RUz, Tashkent, Uzbekistan*
[4]*Institute of Electrophysics UB RAS, Yekaterinburg, Russia*

Plasmonic nanostructures attract high attention due to their promising ability to enhance the physicochemical effects of various devices and sensors [1]. At the micro level LSPR effect can be controlled by setting the required form to plasmonic nanoparticles. Promising plasmonic nanostructures for photonic and optoelectronic devices are copper core-shell nanoparticles. In a solid possible controllable growth of plasmonic nanoparticles in spinel matrix was induced by the method of ion implantation of glasses and radiation-resistant monocrystals of $MgAl_2O_4$ [2]. The aim of this work is to study the optical characteristics of plasmonic nanoparticles formed during spinel ion implantation.

We chose transparent nanocrystalline $MgAl_2O_4$ ceramics as a radiation-resistant material for ion-implantation. Plasmonic copper nanoparticles synthesized by pulsed ion implantation with the synthesis parameters: ion type is Cu^{2+}; working atmosphere is Ar; implantation dose is 1×10^{17} cm^{-2}; accelerating voltage of ions is 30 kV; pulse time is 0.4 ms; discharge current is 60 A. The bombardment was perpendicular to the sample surface.

We analyzed the dependence of the polarization plane of transmitted radiation on the sample rotation angle. Irradiation of plasmon particles with polarized light resolves the SPR band to two maxima (fig. 1a). Two-mode structure of SPR band and its dependence on sample rotation angle and the polarizer position show that the particles have an ellipsoidal shape, and these modes are characteristic for the major and minor axes of the ellipsoid [1]. The two-mode structure of the LSPR band in the polarized optical absorption spectra indicates that the particles in the sample are oriented not chaotically, but co-directionally. Figure 1b shows the approximate orientation of the particles. Additionally, we calculated optical characteristics of plasmonic nanoparticles with the finite element method the, as well as the calculation of the electric field strength near an ensemble of codirectional plasmonic nanoparticles

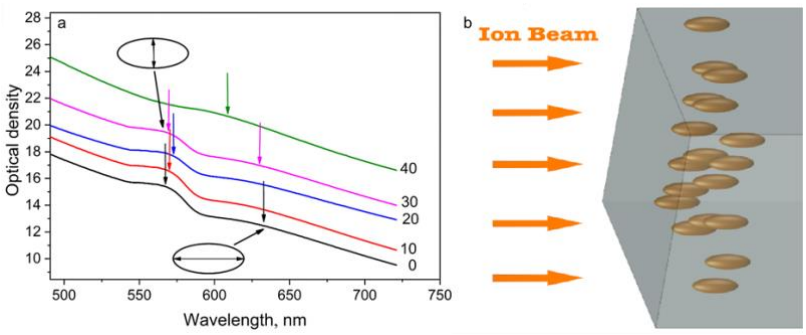

Fig.1. Optical absorption spectra in polarized light (a), approximate orientation of particles formed during implantation (b)

The sensitivity of plasmons to polarized light causes the appearance of microstresses as a result of the coincidence of the polarization planes with the direction of the major and minor axes of the ellipsoid. A conceptual model has been developed for the formation of nonspherical nanostructures as a result of highly nonequilibrium impacts.

REFERENCES

[1] P. Khan, G. Brennan, J. Lillis, S.A Tofail, N. Liu, C. Silien, "Characterisation and manipulation of polarisation response in plasmonic and magneto-plasmonic nanostructures and metamaterials," Symmetry (Basel)., vol.12, no. 8, pp. 1365, 2020

[2] A.F. Zatsepin, A.N.Kiryakov, D.A. Zatsepin, N.V Gavrilov, B.L. Oksengendler, "Ion-beam synthesis of copper nanoparticles in transparent ceramics of aluminum-magnesium spinel." Vacuum., vol. 175, pp. 109243, 2020