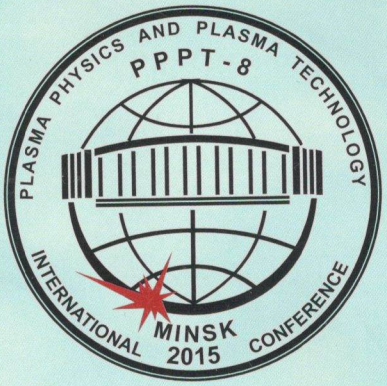

VIII International Conference

Plasma Physics and Plasma Technology

Contributed papers

Volume II

Minsk, Belarus,
September 14 – 18, 2015

Institue of Physics
National Academy of Sciences of Belarus

VOLUME II

4. NON-IDEAL AND DUSTY PLASMAS

OBTAINING OF PARTICLES AND MATERIALS WITH NANOSTRUCTURED SURFACES IN THE COMPLEX PLASMA

M.K. Dosbolayev[1], A.U. Utegenov[1], T.S. Ramazanov[1], M.T. Gabdullin[1], I.I. Filatova[2]

[1]Al-Farabi Kazakh National University, NNLOT, 71, Al-Farabi av., Almaty, 050040, Kazakhstan, E-mail: merlan@physics.kz
[2]B.I. Stepanov Institute of Physics, NAS of Belarus, 70 Nezavisimosti Ave., Minsk, Belarus, E-mail: i.filatova@dragon.bas-net.by

Introduction

The presence of dust particles in the plasma volume has found a positive approach in many technological applications. One of them is the use of dusty plasma in the production of high-tech composite materials such as small spherical particles with nanocoatings deposited in the plasma. For example, co-deposition of silicon particles in nanometer scale can lead to a significant improvement in stability of solar cells /1/.

Classical magnetron method and cluster beams in magnetron discharge are often used for the coating deposition on the surface of dust particles. The conditions in which a thin layer of metal deposited on dust particles surface by interaction with plasma has been described in /2-7/. In these experiments plasma of high frequency discharge was used to hold the dielectric particles that are formed a stable and ordered structures. Resulting in sputtering of the cathode at the magnetron discharge, the atoms of metal adhered to the particles and formed a thin film on a surface of dielectric particles.

In this paper, we report on the production of composite materials in the dusty plasma using the magnetron sputtering method. The main advantage of this method is the weak heat flux on the surface of the deposited material and a wide range of materials which can be used for the deposition.

Experimental setup

A schematic diagram of the experimental setup is shown in Figure 1. Hollow glass microspheres with known properties and chemical composition ($Si0_2$, CaO, O, Na_2O, Al) were used for nanolayer coating deposition in complex plasma.

The process of deposition is as follows: the electrodes are supplied by high-frequency voltage with a frequency of 13.56 MHz, thereby the plasma of high-frequency gas discharge is ignited in the interelectrode space. Then dust particles were injected into the plasma. The experimental parameters were as

follows: p= 0.15 Torr, P= 5 W – for RF discharge and U= 235 B, I= 0.22 A – for magnetron discharge.

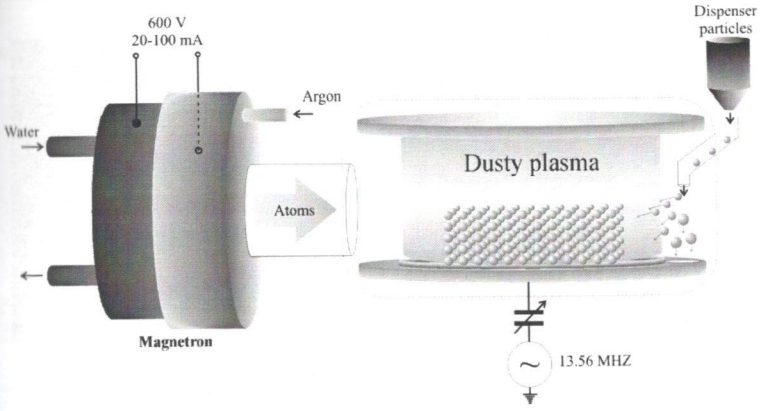

Fig. 1. The schematic diagram of experimental setup

As it is known that particles form in a plasma environment different dusty structures (cloud) due to the balance of the two forces (gravitational and electrostatic) /8-10/. Further, for the coating formation on the surface of dust particles the atomic beam produced by a magnetron is forwarded. Thus, we obtained in plasma created by the combination of high-frequency and magnetron discharges particles coated with the cathode material of the magnetron.

Experimental results

Surface properties of the obtained laboratory samples were tested by scanning electron microscope Quanta 3D 200i (SEM, USA FEI company). After synthesis, the dust particles levitated in RF plasma were withdrawn into a container by the trap located on the lower electrode. Then a conductive tape was loaded into the scanning microscope.

It was revealed from the SEM study (Figure 2) that the chemical composition of the synthesized material, except to the chemical elements corresponded to the original composition of the microparticles, consisted of atomic peaks corresponded to the sprayed material – copper (Figure 3). The thickness of the nanolayer on the particle surface was evaluated as 50 – 200 nm. The the nanolayer thickness formed on the particle depended on the exposure time, the more time, the thicker the coating.

Also, The figures shown that the nanocoating distributed uniformly over the surface of the investigated particles, indicating that the deposition of glass microparticles occurred in levitating conditions (Figure 3).

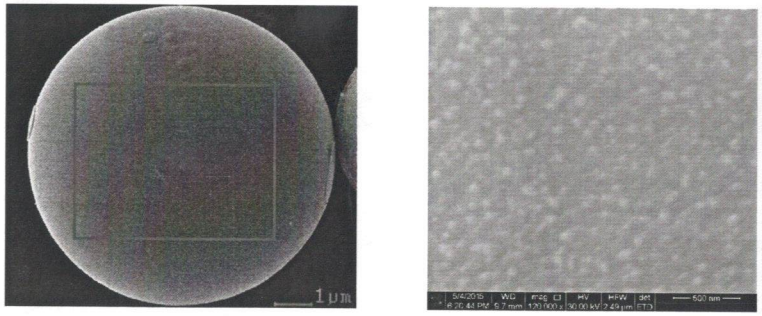

Fig. 2. SEM image of a copper coated hollow glass microsphere

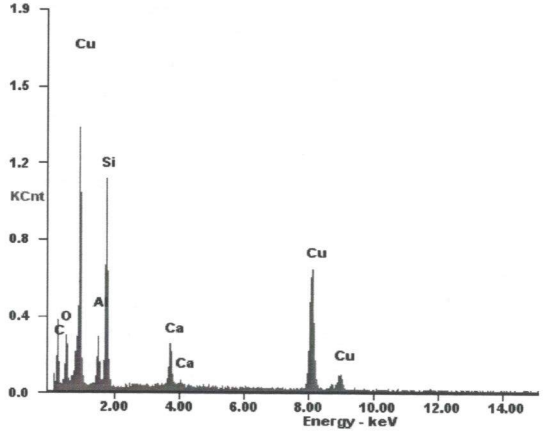

Fig. 3. The chemical composition of the synthesized material coated microparticle (a sample of particle coated with copper)

Thus, by the use of collected experimental setup the nanostructured materials were obtained, i.e. glass microparticles with copper nanolayer; the characteristics and properties of the composite materials were analyzed.

Acknowledgements. This work has been supported by International Program of Ministry of Education and Science of the Republic of Kazakhstan under the Grant program 0182/PCF-2015.

References

1. **Roca i Cabarrocas P., Gay P., Hadjadj A.** // J. Vac. Sci. Technol A14. – 1996. – P.655.
2. **Kersten H.**, et.al. // New Journal of Physics. – 2003. – Vol.5. – P. 93.
3. **H. Kersten, G. Thieme** et. al., Pure Appl. Chem., Vol. 77, No. 2, pp. 415-428, 2005.
4. **P.V. Kashtanov, B.M. Smirnov, R. Hippler**, Uspekhi Phys. Nauk, Volume 177, №5, pp. 473-510, 2007 (in Russian).
5. **P. Jensen**, Reviews of Modem Physics, Vol. 71, No. 5, pp. 1695-1735, 1999.
6. **A.N. Ryabkin, A.O. Serov** et all, Encyclopedia of low-temperature plasma, edited by Acad. V.E. Fortov, Vol. 1-2 (Dusty plasma), pp. 397-407, 1999 (in Russian).
7. **M.K. Dosbolayev, T.S. Ramazanov, T.T. Daniyarov** et. all, 6th International Conference on the Physics of Dusty Plasmas (ICPDP), Garmisch-Partenkirchen, Germany, 2011.
8. **Ramazanov T.S., Dzhumagulova K.N., Jumabekov A.N.,** and **Dosbolayev M.K.** // Phys. Plasmas. – 2008. – Vol. 15. – P.053704-053709.
9. **T.S. Ramazanov, T.T. Daniyarov, S.A. Maiorov, S.K. Kodanova, M.K. Dosbolayev** and **E.B. Zhankarashev** // Contrib. Plasma Phys. – 2011. – Vol.51. – Issue 6. – P. 505-508.
10. **M.K. Dosbolayev, T.S. Ramazanov, A.U. Utegenov, T.T. Daniyarov** // Contrib. Plasma Phys. – 2013. – Vol.53. – Issue 4-5. – P.426-431.