

SELF-ORGANIZATION OF NANOPARTICLES OF COPPER, SILVER AND GOLD IN PULSED PLASMA IN LIQUID.

Sulaimankulova S.K., Akkoziev I.A., Mametova A.S., Akkaziev B.K.

Institute of Chemistry and Chemistry Technologies under the National Academy of Science of the Kyrgyz Republic, 167 Chui avenue, Bishkek, 720060, Kyrgyz Republic

INTRODUCTION

In pulsed plasma produced in different media were obtained nanoparticles based on copper, silver and gold. Studied the phase composition, dispersity and structure of these products.

EXPERIMENTAL AND RESULTS

One of the high-energy impacts on a solid body with the aim of nanostructuring by pulsed plasma produced in liquids (PPL).

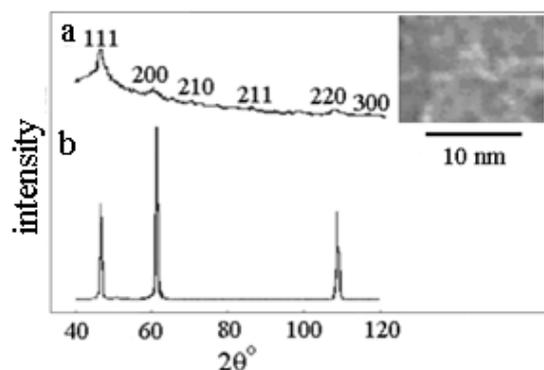
Energy of single pulse is enough to disperse any heat-resistant conductive material to form nanostructures [1].

Self-organization of copper in a pulsed plasma

Nanostructuring of copper, silver and gold was carried out at a voltage in an electrical circuit - 220 V and a current-6A, a single pulse energy of - 0.05 J.

Figure 1 shows the diffraction pattern of the product dispersion of copper in styrene compared to the massive copper. Decrease in the intensities of the peaks and their broadening indicates the formation of highly dispersed phase. XRD analysis showed that the dispersion of the bulk copper led to the formation of metallic copper nanoparticles with an fcc structure (space group -Fm3m, Z-4).

Figure 1. Diffractogram of the product of nanostructuring of copper in styrene (a) in comparison with the diffraction pattern of a massive copper (b).



The crystal lattice of copper nanoparticles ($a = 3,6215 \text{ \AA}$) somewhat extended in comparison with the crystal lattice of a massive copper ($a = 3,6147 \text{ \AA}$). The average size of copper nanoparticles calculated by Scherrer formula (22-25 \AA). In the upper right corner of Figure 1, shown a TEM image of nanoparticles of copper from a pulsed plasma. The size of copper nanoparticles from the data of electron microscopy 21-35 \AA .

To justify the self-organizing processes of nanoparticles in pulsed plasma we have carried out nanostructuring of metallic copper in a different environment – water, using the energy of pulsed plasma (0.05 J). Analysis of the diffraction pattern of the product of nanostructuring of copper in water are detected through three phases: copper oxide, copper oxide and metallic copper. Copper oxide CuO has a monoclinic structure (symmetry C2 / c) with lattice parameters: $a = 4,599$, $b = 3,409$, with $a = 5,119 \text{ \AA}$. Oxide Cu₂O and metallic copper have a cubic structure (Fm3m symmetry) and lattice parameters: $a = 4.2636$ and $a = 3,6149 \text{ \AA}$, respectively.

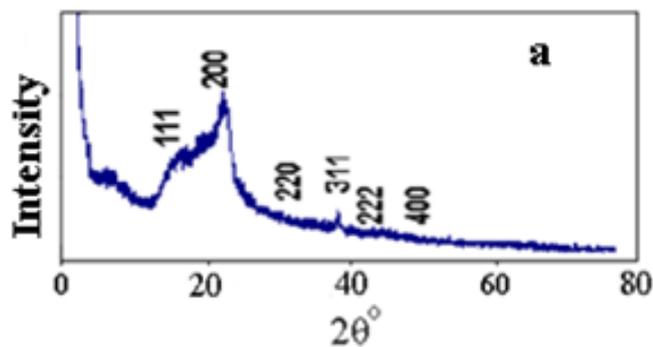
The average particle size of nanostructured metallic copper by Scherrer formula $\sim 344, 5 \text{ \AA}$. It is seen that the copper particles obtained in water more than ten times larger than the copper nanoparticles, obtained by dispersing copper in styrene, but the lattice parameter of the nanostructured copper produced in the water less than that of copper nanoparticles from styrene and coincides with the lattice parameter of a massive copper [2].

Self-organization of silver in a pulsed plasma

Authors of [3] obtained silver nanoparticles on the surface of polystyrene microspheres without prior surface activation

X-ray diffraction analysis (DRON-3M, Cu K _{α} , nickel filter) showed that the surface of polystyrene beads are silver nanoparticles with well-formed crystalline structure, which confirmed the presence of peaks 111, 200, 220, 311, corresponding to a cubic structure of metallic silver.

Figure 2. Diffraction pattern of silver nanoparticles from a pulsed plasma (a) Diffraction pattern of sample material of silver-polystyrene [3] (b).



Silver nanoparticles on the surface of polystyrene microspheres obtained by chemical reduction, are well-formed cubic crystal structure (fcc lattice) and largest number of particles has a size of 300 ± 50 Å.

Silver nanoparticles formed in the PPL (single pulse energy of 0.05 J) in hexane, crystallized in the fcc lattice (O_h^5 -Fm3m, Z-4). The lattice parameter of silver nanoparticles $a = 4,0817$ Å and coincides with that for bulk silver - 4,0812 Å. Diffraction pattern of silver nanoparticles by PPL in hexane is shown in Figure 2. The size of silver nanoparticles by PPL, calculated by Scherrer formula - 22-25 Å. By dispersing silver in PPL formed more than 10 times smaller nanoparticles of metallic silver than silver nanoparticles on surface of polystyrene microspheres. We attribute this to the synergy effects of physical and chemical characteristics of single impulse PPL. The authors [4] used the surface energy of polystyrene microspheres and we using huge energy of PPL.

Self-organization of gold in a pulsed plasma

In a study [4] proposed to synthesize gold nanoparticles restoration $H AuCl_4$, using the surface energy of halloysite nanotubes, deposits of China. Gold nanoparticles as long 300-1000 Å and 50-200 Å in diameter grow on the surface of the halloysite nanotubes (Hunan) with length of 200-2000 Å and a diameter of 20-70 Å. Using halloysite nanotubes of the province of Jiangsu were obtained gold nanotube length 0,35-1,5 μm in length and 0,05-0,25 μm in diameter, much larger than when using halloysite nanotubes from the field Hunan.

The morphology and size of gold nanoparticles depend on the length and diameter of halloysite nanotubes.

Figure 3. Difraktogramm of gold nanoparticles from a pulsed plasma

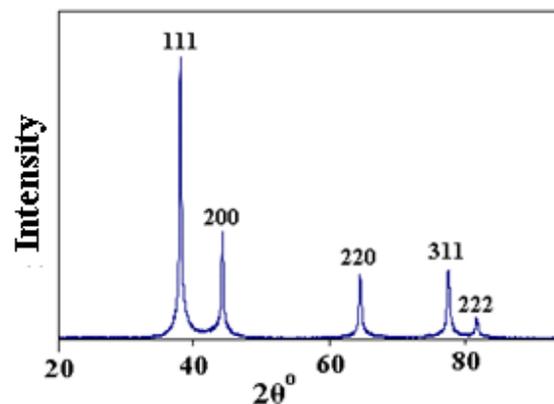


Figure 3 shows the diffraction pattern of the product dispersion of gold by PPL in hexane. Analysis of the diffraction pattern showed that obtained nanoparticles of metallic gold, which crystallize in the fcc lattice of copper with parameter $a = 4,0779$ Å, with an average size of 25Å.

CONCLUSION

Once again we see that the conditions for the formation of nanoparticles (synergetic effects of process conditions nanostructuring) affect the size of the nanostructures. Gold nanoparticles, we obtained in the medium of hexane smaller than gold nanoparticles grown on halloysite nanotubes Hunan 2-10 times.

Based on these results, we concluded: synergetic effects of the conditions of synthesis, the nature of the substrate, the nature of the nanostructured elements determine the phase composition, dispersity of products of dispersion by PPL.

Extreme energy PPL applied to the electrodes by dispersing the metal can be formed most smaller nanoparticles.

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