Synthesis of Cu/CuO nanostructures obtained by electrochemical deposition

Inesh Kenzhina[1,2], A. Kozlovskiy[1,2], M. Zdorovets[1,2], K. Kadyrzhanov[1]

[1] *L.N. Gumilyov Eurasian National University, Astana, Kazakhstan*
[2] *The Institute of Nuclear Physics of Republic of Kazakhstan, Astana, Kazakhstan*

E-mail: *kenzhina@physics.kz*

Unique physical-chemical properties of nanostructured materials are explained by the crystal structure, geometry and conductive properties that can be controlled by changing the synthesis conditions of nanostructures. In turn, the process of electrochemical deposition makes it possible to control the formation of nanostructures and their physical-chemical properties with high accuracy. Electrochemical synthesis in tracks of the template was carried out in potentiostatic mode at a voltage of 0.5 to 1.5 V. The electrolyte temperature was 25, 35, 50 °C. The composition of the electrolyte solution: $CuSO_4 \cdot 5H_2O$ (238g/l), H_2SO_4 (21g/l). The yield of copper by current from the sulfuric acid solutions of electrolytes is 100%. The growth of nanostructures was monitored by the chronoamperometry method with the "Agilent 34410A" multimeter. Since the template PET matrices are dielectric, a layer of gold with a thickness of no more than 10 nm, which is further a working electrode (cathode) during electrochemical deposition, was deposited to create a conductive layer by magnetron sputtering in a vacuum. By controlling the deposition time, the difference in the applied potentials, the electrolyte temperature, we can change the geometric parameters of synthesized nanostructures. All possible reactions associated with the synthesis process are listed below.

$CuSO_4 \rightarrow Cu^{+2} + SO_4^{-2}$

$Cu^{+2} + 2e \rightarrow Cu(s) \downarrow$

Copper sulfate dissociates into Cu^{+2} and SO_4^{-2} ions in the first stage of electrolysis. Then Cu^{+2} ions are reduced near the cathode to Cu(s), and a layer is formed behind the wall layer of the nanostructures in pores, repeating the template geometry. Because of the change in concentration of H+ ions during the synthesis, the pH of the solution can vary, which leads to uneven filling of the pores. To control pH of the solution, sulfuric acid H_2SO_4 was used, acting as a buffer to maintain the pH.

Optimal conditions for obtaining Cu/CuO nanostructures in the form of nanowires and nanotubes synthesized in pores of polymer templates have been established as a result of the research. Morphology, crystal structure, element and phase composition of nanostructures were studied using the methods of scanning electron microscopy, energy dispersive and X-ray phase analysis. Dependences of the change in structural and conductive properties of synthesized nanostructures from the synthesis conditions are established. Optimal conditions for the synthesis of Cu/CuO nanostructures of various geometries (nanowires and nanotubes) that have potential applications in microelectronics are determined.