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OBTAINING COPPER NANOPARTICLES IN GLOW DISCHARGE AT RESONANT OSCILLATIONS OF BUFFER GAS *)

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Nanoparticles exhibit unique properties and find applications in various fields of science and technology [1]. Copper nanoparticles are studied as promising functional materials for conductive inks [2], used in conductive materials [3]. The effectiveness of copper nanoparticles as additives to lubricating fluids has been demonstrated [4]. Cu-to-Cu direct bonding is one of the most promising methods to replace conventional solder [5] in three-dimensional (3D) integrated circuits. The most challenging problem for direct Cu-to-Cu interconnection is to reduce the melting temperature, one possible way to solve the problem is Cu nanominiaturization, which is done by reducing the size of Cu material elements and directly reducing the melting temperature [6, 7].

Nanoparticles were obtained in a tube (length L = 32 cm, inner diameter d = 2.6 cm) made of heat-resistant borosilicate glass with two plane-parallel copper cooled electrodes. The tube was filled with argon. Oscillations of the buffer gas were excited at the resonance frequency of the system by an electrodynamic radiator connected to the tube through a confuser. A constant voltage was applied to the electrodes and the discharge was ignited. The acoustic characteristics of the discharge tube were monitored using a microphone. The experiment was carried out at pressures from 20 to 320 Torr and currents from 20 to 125 mA.

The morphology of the particles was investigated by scanning electron microscopy. The particle sizes vary from 24 to 1070 nm. The shape of particles close to octahedral is clearly observed. The particles are formed according to the “bottom-up” principle [8], when during the creation of such particles individual atoms are recruited and arranged in an ordered structure, i.e. the enlargement of initial elements to nano- and micrometer-sized particles is achieved. Due to surface plasma-chemical reactions, particles in plasma can be intensively heated up to the crystallization temperature [9], exceeding the temperature of the buffer gas, and acquire a crystalline structure.

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