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Electronic properties of amorphous DLC films embedded with platinum nanoparticles

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In this report the results of electronic properties and structure study in amorphous diamond-like carbon films with platinum nanoparticles (a-C:H<Pt> films) are presented. The films were produced by ion-plasma magnetron sputtering of combined polycrystalline graphite-metal target. The sputtering process was produced in hydrogen and argon gas mixture. The films were deposited on quartz and silicon substrates. The content of platinum impurity in the carbon matrix was changed from 0 to 9 at. %. Concentrations of metal impurity in the films were alternated by change of platinum and graphite area relation in the combined target.

Platinum embedding in a-C:H films lead to increase in their conductivity. Impurity influence on the conductivity of a-C:H<Pt> films substantially depends on the films deposition temperature. It was found that conductivity of amorphous a-C:H<Pt> films deposited at a temperature of 200°C results in substantially by 13 orders of magnitude more than that of pure films. The most significant increase of a-C:H<Pt> films conductivity occurs at the Pt concentration lied in the range from 3 to 7 at.%. Transmission electron microscopy (TEM) showed the presence of isolated particles in the a-C:H<Pt> films. The diameter of particles weakly changed with a rise of a metal content, and it was ~5 nm.

One of the important peculiarity of a-C:H<Pt> films optical properties was the appearance of absorption peak in the visible range of the optical absorption spectra. The absorption peaks in spectra of the a-C:H<Pt> films situated in the range from 495 to 498 nm. The intensity of the peak rose with increase of platinum content in the films. It is supposed that the absorption peaks are the result from surface plasmon resonance on metal nanoparticles in the a-C:H<Pt> films. Sizes of particles were determined from resonance absorption spectra, and these results were in a good agreement with TEM results.

Modeling of the resonance absorption procedure with use of Mie theory for the isolated metal particles imbedded in the dielectric matrix provides good coincidence with our experiment.

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