Nanocomposites and nanomaterials

Electrical and mechanical properties of ion-plasma deposited carbon films

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The comparative investigation of mechanical and electrophysical properties of hydrogenated diamond-like carbon films (α-C:H) was realized. These films were deposited from directed ion beams of C_6H_{12}, C_7H_8 or C_2H_2 plasma, and by magnetron sputtering of high purity graphite target in an atmosphere of Ar, C_6H_{12} and their mixtures at different electric discharge power level applied to the substrate.

Density, atomic and electronic structures of α-C:H films were determined using quantitative Auger spectroscopy. The protective properties of α-C:H films were evaluated by analyzing the changes of high-frequency CV-characteristic of test capacitors. Photomasks wear resistance was evaluated from changing integral light transmittance of light and dark areas after abrasion treatment using fine quartz (SiO_2) with a grain size of 1, 5 and 10 μm.

It was found that the carbon films formed from vapors of primary compounds with sp^3-hybridization bounds have the highest deposition rate, resistivity and maximal density (wear resistance). Thereto the most technologically deposition method is the magnetron spraying of carbon target in $Ar + C_6H_{12}$ plasma. In addition, this method can also significantly reduce energy of particles and radiated power from Si-substrate (5 ÷ 10 W).

Electronic structure and properties of films obtained from primary compounds with different types of hybridization bounds differently depending on the particle energy used to form the film. For example, reducing the accelerating voltage from 2.5 to 0.3 kV for films deposited from C_6H_{12} leads to a sharp increase in the parts of graphite components (from 33% to 90%) and increasing the specific resistivity from 10^5 to 10^{11} Ohm·cm parallel to decreasing in the size of clusters and increasing of density films. In the case of carbon film deposition from C_7H_8 a similar decreasing energy of particle also leads to increasing specific resistivity from 10^5 to 10^8 Ohm·cm, but the content of the graphite components and cluster size are not changed. For films from C_2H_2 any reductions of particle energy don't change resistivity of these films.

1. Robertson J. (2002) Diamond-like amorphous carbon. Mater. Sci. Eng. R 27: 129-281.