

STRUCTURAL CHANGES IN FULLERIDES UNDER THE INFLUENCE OF ION BOMBARDMENT IN GLOW DISCHARGE PLASMA

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Introduction

The basics to control electrophysical properties of fullerides are variation of their electronic structure by noncarbonic atoms introduced in fulleride crystal. Due to the closed structure of fullerene molecule impurities embedded into interstitial space exchange charges with molecule. Despite weak hybridization of electron states there appear some peculiarities in their spectrum, which may have an essential influence on properties of the doped fullerene films [1]. Besides, additional changes into electronic and vibration spectrum of the doped fulleride films can be induced by their bombardment with high energy particles resulting in radiation damage of the fullerene shell and displacement of carbon atoms.

Obtaining of endofullerenes directly during the process of fullerene formation strongly limits the possibility of further control of their properties. Therefore, the purpose of this work was to study the possibilities of the influence of ion bombardment in glow discharge plasma on the fulleride structure and obtainment of endostructures similar to endofullerenes.

Experiment

Fullerite films were prepared in vacuum on stainless steel substrates heated up to 473 K by thermal evaporation ($T_{\text{evap}}=773$ K) of $C_{60}(84\%)+C_{70}(14\%)+C_{>70}(2\%)$ powder as well as evaporation of the same powder simultaneously with Cd. Obtained films of $\sim 1.2\div 1.6\mu\text{m}$ thickness were exposed to bombardment of Ar^+ ions in the glow discharge plasma. Structural studies of fullerite films were carried out by means of X-ray structure analysis according to the change of lattice parameter. Monochromatic $\text{CoK}\alpha$ radiation with the wavelength of $1.79020\text{ \AA}$ was used. Obtained results were analyzed involving the data of light stimulated combinational scattering studies of these films, their optical conductivity and photoluminescence spectrum.

Results and Discussion

As a result of X-ray structure analysis it was ascertained that after film deposition the lattice parameter of Cd doped fullerides was larger then lattice parameter of pure C_{60+70} and especially C_{60} films. With further bombardment of the undoped films by Ar^+ ions in the glow discharge it turned out that with the increase of bombarding ions dose the increase of lattice parameter due to embedding of inertial gas atoms into the fulleride crystal occurs at first. Decrease of lattice parameter with further increase of fluence we associated with partial breakup of molecular skeleton and introduction of C atoms into the interstitial space of the lattice, and also with the charge exchange processes between C and C_{60} . Besides, with the further bombardment the redistribution of embedded inertial gas in the fulleride lattice occurs. This embedded gas atoms can diffuse along the interstice even in metals.

Filling of the interstitial space as a result of ion irradiation of Cd doped C_{60+70} and C_{60+70} fullerite films was supported by the combinational light scattering studies. It was shown that such filling is possible both by bombarding Ar^+ ions and due to displacement of carbon atoms. These followed from analysis of appropriate spectrums. Results of studies of interband transitions in films, obtained from films optical conductivity measurements, also indicated the rebuilding of electronic structure due to embedding of atoms into interstitial space. Such conclusion was based on the fact, that atoms embedding considerably change the electronic structure first of all due to appearance of peculiarities in the range of energy gap that results in decrease of the free energy of the system and shift of the Fermi level [1].

In films doped by Cd atoms we also observed the increase of lattice parameter, which with the further bombardment by Ar ions was decreasing, apparently due to ordering processes during the redistribution of Cd throughout the interstices of

the fulleride lattice. It was noticed that embedding of cadmium did not introduce essential changes in optical conductivity of C_{60} films, as it happens, for example, when embedding copper [2]. We only observed slight redistribution of the appropriate pikes in spectrums of optical conductivity, and also appearance of peculiarities in the electronic spectrum, which could influence the origination of new vibration modes, registered in the Raman scattering spectrum.

Conclusions

Thus, the principal possibility to control implantation of both carbonic and noncarbonic atoms into fulleride lattice by ion irradiation of prepared fullerite films in the glow discharge plasma was shown. Embedding of impurity atoms into interstitial spaces of the crystalline structure of

fullerite films favours the rebuilding of electronic spectrums. These changes are induced by appearance of additional Coulomb interaction as a result of charge transfer between radiation defects and molecules, influencing vibration spectrums of fullerenes.

References

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