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CONDUCTION ELECTRON SPIN RESONANCE IN GRAPHITE INTERCALATION COMPOUNDS - MODEL SYSTEMS FOR TWO DIMENSIONAL PHYSICS

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ABSTRACT

A short review of our recent research work results in the field of conduction electron spin resonance (CESR) of two dimensional (2D) graphite intercalation compounds (GIC).

INTRODUCTION

GIC are 2D synthetic metals, which consist of an alternating sequence of n hexagonal graphite monolayers (n is the stage index of the compound) and a monolayer of foreign atoms or molecules (intercalate). The ability to vary the strength of interlayer interactions at the synthetic level suggests the possibility systematically investigating phenomena unique to 2D systems. The correct CESR lineshape, linewidth and position analysis might yield important information on physical properties and structure of these 2D compounds [1].

RESULTS AND CONCLUSIONS

1. CESR Lineshape Analysis. The experimental investigations and theoretical analysis of the effects of sample size, electromagnetic configuration, constant magnetic field orientation and modulation frequency, temperature and n on the lineshape and intensity of the CESR were performed in graphite and its acceptor intercalation compounds. The theoretical analysis of the line-shapes were carried out in limits of the 2D modification of the Dyson-Kaplan model and within this model the qualitative explanation of all observed peculiarities of the experimental curves were obtained. As for graphite, to achieve a quantitative agreement it is necessary in, addition, to take into consideration the dependence of the ratio of a mean value of the microwave amplitude at the nonequivalent faces on a sample size. By using this model, we proposed procedure to determine from CESR spectra parameters: the larger and smaller components of the conductivity and the spin carriers diffusion constant and the density of states at the Fermi energy. It was found that increasing of the CESR linewidth (decreasing of the spin -lattice relaxation time) in GIC during the lowering of its temperature (a "nonmetallic" behaviour) is due to decreasing of the conductivity relaxation time.

2. CESR and 2D melting in GIC $C_{5n}HNO_3$. In GIC $C_{5n}HNO_3$ (n=1, 2,..), 2D liquid-like layers of HNO_3 of lower T_c - 250 K are ordered and form a 2D crystal. We carried out a detailed CESR analysis of intercalate melting transition and dependence of its characteristics on HNO_3 sublattice dimension (on n). As a result, were have found: two-step (multistep, for n = 2) nature of the 2D intercalate

layers melting; "global" temperature hysteresis of the melting-crystallization process; larger T_c for a larger n in a series of samples with even (or odd) index; decrease of density and increase of mobility of spin carriers at intercalate melting and, simultaneously, step-wise decrease of planar and c -axis conductivity. Basing on obtained data we set up a model for a 2D melting in this GIC.

3. CESR and Physical Reasons of Intercalation. We carried out an in situ CESR study of intercalation of SbF_5 , HNO_3 , Br_2 and F_2 molecules into highly oriented pyrolytic graphite (HOPG) by the two-zone vapor transport method. The application of the new, developed by authors, procedure of this experiments allows to find and study: individual reaction steps, including unknown one; two essentially different intercalation mechanisms; constants of the 2D diffusion of the intercalate through the sample after insertion of it into HOPG; rate of the advance of the stage index change front occuring at the interface between initial and previous stages. The obtained data have been successfully applied to the elaboration of a theory of physical reasons of HOPG intercalation.

REFERENCES

1. A. M. Ziatdinov, N. M. Mishchenko and Yu. M. Nikolenko. Synthetic Metals. 1993. V. 59. N. 2. P. 253-258.