EFFECT OF MAGNETIC Co–CoO PARTICLES ON THE CARRIER TRANSPORT IN SINGLE LAYER GRAPHENE

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Fabrication and studying of magnetic and magnetoresistive graphene-based hybrid structures is a highly relevant problem, because it opens new perspectives for their use in magnetic tunneling transitions, spin valves and filters, magnetoresistive memory devices, and other spintronic elements [1][2][3]. These kinds of structures can be successfully fabricated by depositing particles or layers of various ferromagnetic materials (e.g., *Co* and *Ni*) onto graphene [2][4]. We note that specific features characteristic of deposition of metallic particles on graphene constitute one of the issues related to its prospective use in electronic devices, and these must be investigated in order to overcome the difficulty of making low-resistance ohmic contacts to the graphene surface.

The aim of this work is to investigate the interrelation between the electric and magnetic properties of composite structures consisting of a ferromagnetic metal and graphene that are fabricated by electrochemical deposition of cobalt nanoparticles onto monolayer CVD graphene, since this will enable us to identify the effects that covered with *CoO* shells have on carrier transport in zero and nonzero external magnetic fields.

Graphene was synthesized on copper foil by CVD-method using a PlanarTech G2 unit. Cobalt nanoparticles were deposited onto graphene from a solution containing 1.25 $g/L\ CoSO_4{\cdot}6H_2O$ and 0.064 $g/L\ NaCl$ using a PI-50-1.1 potentiostat coupled to a PR-8 programming unit. Depositions were performed in the pulse reverse mode, a controlled- current technique, at a cathodic current density of 2.5 mA/cm^2 (pulse duration, 5 *s*) and anodic current density of 1.25 mA/cm^2 (pulse duration, 2 *s*); the total deposition time was 30 *s*.

Temperature and magnetic field dependences of electrical resistivity $R(T,B)$ were measured by the four-point probe method in the temperature range of 2 to 300 *K* and in a transversal magnetic field with magnetic flux density *B* up to 8 *T* using a noncryogenic measuring system (Cryogenics Ltd) on the basis of a closed-cycle refrigerator.

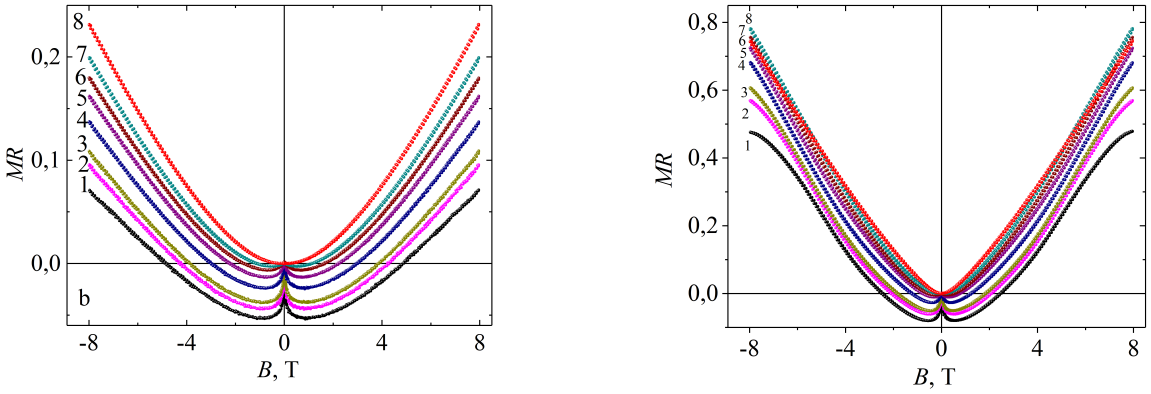

Fig. 1. Relative magnetoresistance MR(B)=$\frac{[R(B)-R(0)]}{R(0)}$ on magnetic flux density *B* for Gr/SiO_2 and $Co-Gr/SiO_2$ sample at different temperatures covering the range of 2–300*K*: (1) - 2, (2) - 7, (3) - 10, (4) - 25, (5) - 50, (6) - 75, (7) - 125, and (8) - 275 *K*.

Electrochemical deposition onto CVD graphene in the pulse-reverse mode from an electrolyte containing $CoSO_4 \cdot 6H_2O$ produced with size (up to 500 *nm*) on the graphene surface consisting of polydisperse agglomerates with prolate shapes.

The deposition of *Co–CoO* particles was shown the increase of resistance of graphene samples due to a lower electron concentration in dielectric *CoO*. For the Gr/SiO_2 and $Co-Gr/SiO_2$ samples, we revealed the existence of a competition between the NMR and PMR contributions to the observed magnetoresistance effect and at the low-temperature carrier transport in the NMR region was due to quantum localization correction to the Drude conductivity, while the enhancement in PMR after depositing *Co–CoO* particles onto graphene may be attributed to the Lorentz mechanism operating within *Co* cores.

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