Band structure of all-boron 2D metallic crystal as a prospective electromagnetic shielding material

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Due to the large neutron-capture cross-section of boron 10B isotope nucleus, the solid-state boron compounds and composites are good candidates for use as protection from neutron exposure. At the same time, materials with the high bulk concentration of B-atoms, e.g., nanotubular boron nitride BN, usually are non-metals and, therefore, not suitable for electromagnetic shielding purposes. However, the possibility of formation of all-boron layered structures (multi-layered planar sheets and multi-walled nanotubes) consisting of layers with metallic conductivity has been suggested. Intra-layer metallic conduction of layered boron opens an essentially new prospect for designing of materials which can combine the effective protection against neutron irradiation with the effective electromagnetic shielding. The evaluation of the efficiency of electromagnetic shielding provided by 2D boron crystals requires deep insight into their electronic structure. In this paper, a quasi-classical type theoretical method, developed in and successfully applied in calculations of the electronic structure of various BN modifications, is used to obtain electronic energy bands of an isolated B-sheet and map the corresponding Fermi-surface. These results may provide a proper theoretical basis for characterizing the properties of metallic layered nanosystems of elemental boron and assessing their potential for electromagnetic shielding.

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Direct chemical vapour deposition of semitransparent pyrolytic carbon film

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Here we propose and demonstrate simple single step methane-based chemical vapour deposition (CVD) process in order to produce highly uniform, transparent, conducting pyrolytic carbon film. Methane is conventionally used in the CVD of nanocarbon materials. Its low reactivity at low temperature (500 °C-1000 °C) makes methane well-suited for various hot wall CVD experiments. Generally methane based CVD processes usually utilise catalysts, however at 1100 °C, the methane molecules start to decompose to CH2 and CH3 molecules more aggressively and eventually form C2- and C6-species, which lead to formation of graphitic nanocrystals. Since reactivity of different hydrocarbon species is related to the process temperature we used dynamic process temperature from 700 °C to 1100 °C in order to enhance the graphitic nanocrystal development. Moreover the employed hot wall CVD setup operates in static atmosphere i.e. there was no gas flow during the process. This prevented the replacement of CH2 and CH3 molecules with CH4. Samples were characterized by atomic force microscopy, Raman spectroscopy, optical transmission spectroscopy and conductivity measurements. The obtained results showed that pyrolytic carbon films manufactured using methane- and acetylene-based CVD technique have nearly the same properties. At the same time the manufactured films overperform those, synthesised using photoresist pyrolysis technique in terms of resistance/transmittance ratio. In conclusion, we have demonstrated synthesis of a high quality transparent pyrolytic carbon electrode. This proposed low cost technique does not need any pre- or post- processing of the sample and can be applied with the standard CVD setup.

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