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Comparison study of structural and optical properties of boron-doped and undoped graphene oxide films

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HIGHLIGHTS

▶ B-doped GOs are fabricated by annealing the films, which were obtained from the suspensions with GO and H₃BO₃.

▶ Raman spectra revealed more graphitization of the B-doped GO, due to B-doping effect.

▶ PL intensity of GO was decreased by B doping, presumably due to the B-induced graphitization.

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ABSTRACT

We prepared boron (B)-doped graphene oxides (GOs) by means of annealing the films, which were obtained from the suspensions of GO and H_3BO_3 in N,N-Dimethylformamide solvent. The interplanar spacing of as-synthesized GO in X-ray diffraction spectra has been reduced by the thermal annealing at 1100 °C. First-order Raman spectra revealed that the intensity ratio of the *D* and *G* bands of B-doped GO was significantly lower than those of as-synthesized and annealed GOs, suggesting more graphitization of the B-doped GO due to doping effect. The C1s X-ray photoelectron spectroscopy (XPS) of B-doped GO films not only indicated that considerable amount of functional groups has been removed but also exhibited the peak of C—B band at around 283.7 eV. Additionally, the B1s XPS spectrum of B-doped GOs could be deconvoluted into several peaks centered at 187.2, 188.9, 190.3, 192.0 and 193.7 eV, being attributed to the presence of B atom in B₄C, B-sub-C, BC₂O, BCO₂ and B₂O₃, respectively. Comparison of the photoluminescence spectra of B-doped GO with that of 1100 °C-annealed GO indicated that the overall intensity was decreased, presumably due to the B-induced graphitization. An additional band at around 600–700 nm from B-doped GO is attributed to the generated boron carbide phases.

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1. Introduction

Boron (B) doping is known to effectively modify the intrinsic properties of carbon materials. The B atom differs only by one in its number of valence electrons compared to C atoms and thus incorporation into C honeycomb lattice will be easily achieved, without changing the crystal lattice significantly with the electronic band structure remaining essentially unaltered. It is therefore expected that the p-type doping can be accomplished by the incorporation of B atoms into the nanotube walls or graphene sheets and thus by replacing the C atoms.

The B can act as an electron acceptor and induce a redistribution of the π -electrons between the layer planes, ultimately lowering

the Fermi level [1]. Accordingly, the B-doping will tune and improve the electronic and transport properties, enabling the fabrication of a field effect transistor on a single graphene nanoribbon [2–5]. In particular, the B doping reduces the resistivity, resulting in superconductivity of carbon allotropes, such as diamond [6] and multi-walled carbon nanotubes (MWNTs) [7].

On the other hand, the B doping into carbon allotropes as the impurity doping makes a shallow impurity level in contrast to the substitutional nitrogen impurity [8]. The B doping turns graphene into an electron deficient system, enhancing the lithium ion storage capacity [9]. B-doped graphene is a promising candidate for potential applications such as solar cells [10], fuel cells [11]. It is clear that the ban gap of B-doped graphene can be controlled by controlling amount of B atoms [12]. Thus, B-doped graphene can be used in transistor devices. The B-doped carbon and graphite exhibited improved anode performance, in regard to the energy storage capacity and Coulombic efficiency [13].



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