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Research Article

Hydrothermally development of boron-integrated graphene nanoparticles for p-n junction diode applications

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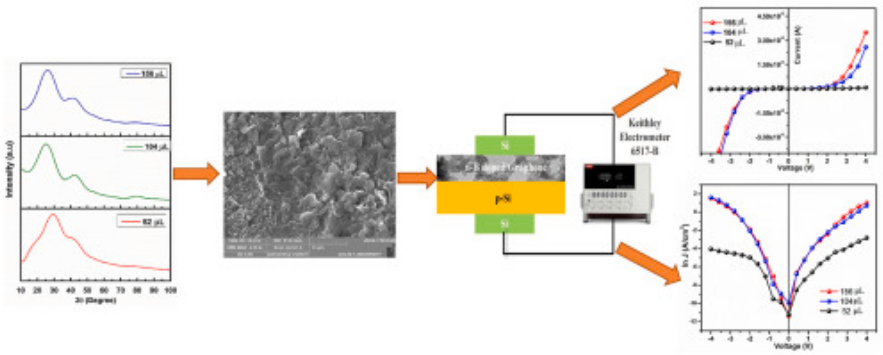
Highlights

- Boron doped graphene nanoparticles were synthesized by the hydrothermal route for various concentrations of Boron tribromide.
- XRD pattern exhibited a hexagonal crystal structure with sharp crystalline peak at (002) orientation.
- A sheet-like surface morphology was observed through SEM image.
- TEM images confirm the particle size was reduced upon increasing boron tribromide.
- A minimum ideality factor of n=2.9 was obtained for p-Si/n-B-doped Graphene diode fabricated with 156μL.

Abstract

In this work, boron doped graphene nanoparticles (NPs) were synthesized by the hydrothermal route with different boron tribromide concentrations such as 52, 104, and 156 μL. The structural, morphological and optical properties of the prepared NPs were studied using different characterization techniques such as X-ray diffraction (XRD), scanning electron microscope (SEM), transmission electron microscope (TEM), atomic force microscopy (AFM), UV–vis spectroscopy and photoluminescence spectroscopy (PL). The XRD pattern reveals the hexagonal crystal structure. The SEM image showed textured sheet-like layers which got agglomerated to form fluffy structures. The TEM images recorded single-crystalline nature and also confirms the particle size was reduced upon increasing boron tribromide solution concentration with recognizable particle shape. The topographic properties of the synthesized B-doped graphene NPs were also studied through AFM images. The UV visible absorbance characteristics peaks 243 and 372 nm were observed correspond to π – π* in C–C bands and n- π* transition. After that as grown NPs were used to fabricate diode junctions on p-Si substrates (p-Si/n-B-doped graphene). The electrical performance of each p-Si/n-B-doped graphene diodes junction was examined using I–V characteristics and electrical parameters of diode junction such as ideality factor, barrier height and reverse saturation current were found 2.9–4.3, 0.75–0.83 eV and 4.88×10^{-6}-7.26×10^{-6} A. The calculated ideality factor values of the p-Si/n-B-doped graphene diodes are decreased with increase in boron tribromide solution concentration.

Graphical abstract



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Introduction

Two-dimensional materials are highly attractive optoelectronic industry due to their exceptional physicochemical properties [[1], [2], [3]]. Graphene materials with extremely low-dimensional crystallinity and semiconducting nature are great advantageous for developing optoelectronic, catalytic energy generation, and energy storage applications [[4], [5], [6]]. Graphene facilitates the doping of various metal or nonmetal ions in the sites and functionalization of carbon which interestingly tunes their physicochemical and electronic properties. Graphene-based nanostructures such as doping, co-doping, and graphene decorative composites were receiving high attention among optoelectronic and environmental researchers to overcome the toxicity [7,8]. Various doping techniques were followed to achieve highly precise material for targeted applications [[9], [10], [11]]. Non-metal hetero-atoms are usually preferred for doping graphene-based materials to retain the