Construction of Schottky junction solar cell using mechanically exfoliated graphene and silicon nanowires

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1. Introduction

Graphene can act as a transparent conductive electrode owing to its high optical transmittance. Generally, Schottky junction can be achieved by transferring doped graphene directly on semiconductor. In addition, textured semiconductors, which can enhance the light harvesting efficiency, have been used for Schottky junction solar cells [1]. However, simply transferring chemical vapor deposition (CVD) graphene on textured semiconductor would lead to limited contact area between graphene and textured semiconductor [2]. To improve this drawback, mechanically exfoliated graphene dispersed in N-Methyl-2-Pyrrolidone (NMP) solution is used instead of CVD graphene to achieve the contact of the graphene with the inner part of the textured substrate in this work. Performances of Schottky junction solar cells made from CVD graphene and mechanically exfoliated graphene were also compared.

2. Experiments

The nanostructures of substrates were fabricated by metal assisted chemical etching (MACE) [3]. Firstly, silver was deposited on silicon substrates using the heat evaporator, and it was agglomerated to form an island-like structure, which would act as a catalyst to catalyze the hole generation underneath from the local reaction with the oxidant in an acidic solution. For MACE, the substrates deposited with Ag films were immersed in the etching solution of $HF/H_2O_2/H_2O$ (with the molar ratio defined by $[HF]/([HF] + [H_2O_2]) = 0.904$ and $[H_2O] = 40.1$ M) at room temperature. Finally, Ag films were removed by dipping the specimens into nitric acid solution. Schottky junction solar cells with CVD graphene and mechanically exfoliated graphene were achieved, respectively, by transferring CVD graphene and by spinning coating of mechanically exfoliated graphene dispersed in NMP solution on textured silicon substrates. Finally, p-type doping of graphene was achieved by exposing the devices to HNO_3 vapor to form Schottky junction solar cells. The devices of the CVD graphene and mechanically exfoliated graphene solar cells are shown schematically in Figure 1(a) and 1(b), respectively.

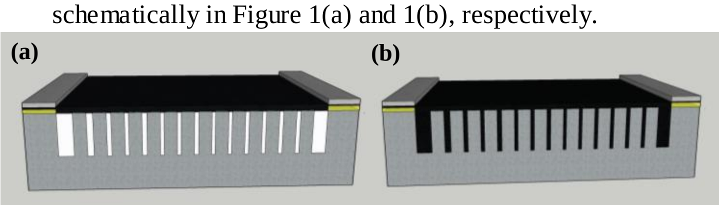

Figure 1. Schematics of (a) the CVD graphene and, (b) the mechanically exfoliated graphene solar cells.

3. Results and discussions

Microstructure was investigated by scanning electron microscope. Figure 2 shows the top view image, in which nanowires are uniformly distributed. The inset shows the cross-sectional view with an average height of ~1.1 μm. The doping results of mechanically exfoliated graphene were examined by X-ray photoelectron spectroscopy and are shown in Figure 3(a) and (b). In Figure 3(a), the appearance of N 1 s peak at 400 eV was shown in the full spectrum when graphene was exposed to HNO_3 (blue line). In Figure 3(b), the N 1s spectrum of graphene without doping and doped with 65% HNO_3 at room temperature are shown. The spectrum of doped graphene (blue line) showed two peaks at 399 eV and 406 eV, which were attributed to C-N bonding and NO_3 radicals, respectively.

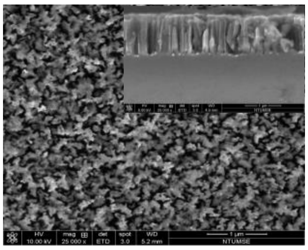

Figure 2. Top-view and side-view (inset) SEM images of silicon nanowire array.

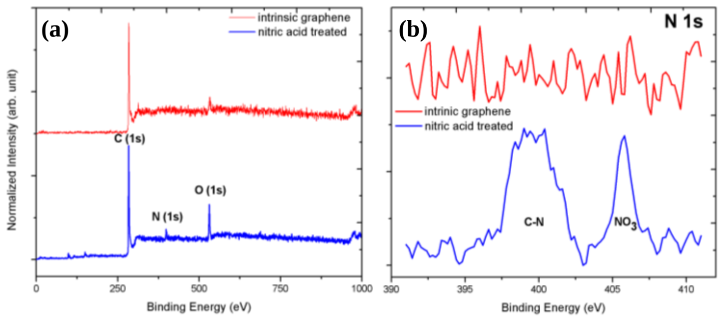

Figure 3. (a) XPS full spectrum of the intrinsic graphene and doped graphene and (b) XPS N 1s spectrum of the intrinsic graphene and doped graphene with two peaks of C-N and NO_3.

Acknowledgements

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