Graphene Oxide Based Schottky Barrier Solar Cells

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A transparent conductive oxide (TCO) and silicon based hybrid junction including soluble Graphene Oxide (GO) has been realized. Schottky barrier diode with the structure of TCO/GO/p-Si/Al was fabricated. The obtained device exhibits interesting performances in terms of external quantum efficiency (EQE) and power conversion efficiency (PCE) respect to a reference device without GO interfacial layer.

Metal-semiconductor (MS) Schottky barrier is one of the simplest solar cell structure. It is well known that the interfacial properties of metal-semiconductor contacts have a dominant influence on device performance, reliability and stability. The solution proposed is the adjunction of a thin insulating layer on the surface of the semiconductor: this layer converts the MS structure into a metal–insulator–semiconductor (MIS) device [1-3]. Graphene and GO are increasingly attracting worldwide attention from academia and industry. Graphene is a two-dimentional sheet of sp^2 hybrid carbon atoms and is highly attractive for numerous applications such as optoelectronics, energy storage. In contrast, GO, an oxidized graphene sheet with carboxylic acid at the edges and phenol hydroxyl and epoxide groups on the basal plane, is generally considered to be an insulating material [4-6].

In this paper, we have realized a Schottky barrier solar cell (SBSC) using GO as insulating layer, compared to a cell without GO. The frontal electrode is a transparent conductive oxide (TCO) with a proper workfunction.

The graphene oxide (GO) was purchased from Cheap Tubes, Inc. (USA). Milligrams of GO powder was suspended in a volume of distilled water (D.I. was purchased from Aldrich Chemical Co.) to obtain the opportune concentration and sonicated by means of an ultrasonic processor (Misonix Incorporeted Ultrasonic liquid Processors, U.S.A.) for 4 h at room temperature in order to produce a stable yellow−brown colloidal suspension of GO sheets. For thin-film fabrication from GO, the powder was first suspended in water by ultrasonication and centrifugated at 10000 rpm to remove multilayer species, which constituted 10% of the powder by weight. The carefully recovered supernatant is a solution of single layer GO. Such aqueous dispersion of GO could stay stable for several weeks, free of any obvious precipitates [7-9].

An n-type c-Si (100) test wafer, (resistivity: 1-10 cm) was immersed in diluted HF solution (with weight ratio of 5%) for 5 min to remove the native SiO_x. Then Si substrate was dipped in the GO aqueous solution at different concentrations (2, 6 and 10 mg/ml) by means of a dip coater (KSV NIMA, Finland) and dried. Wafer passivation is monitored through contactless determination of the effective minority carriers lifetime (τ_{eff}) from quasi-steady-state photoconductance (QSSPC) data acquired with a WCT Lifetime Tester (Sinton Consulting, see Figure 2b) [10, 11].

Table 1 reports the measured τ_{eff} values; low GO concentration results in a no passivating effect of silicon films, so we have chosen a 10 mg/ml dispersion to realize the interfacial layer in the cells. Figure 1 reports the Raman spectrum of GO coated on Si.

In Figure 2(a) the scheme of the realized solar cell is shown, while in Figure 2(b) and 2(c) there are respectively a photograph of the lifetime tester and the operating scheme to monitor silicon wafer passivation. Electrical characterization of TCO/GO/p-Si/Al device displayed better performance than the TCO/p-Si/Al reference device.

GO (mg/ml)	τ_{eff} (µs)
2	5
6	25
10	88

Table 1: Silicon wafer minority carrier lifetime for different GO concentrations

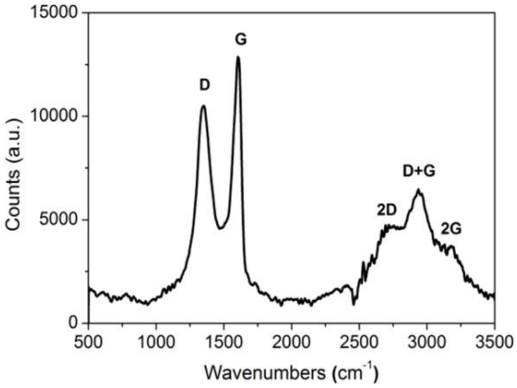

Figure 1: Raman spectrum of GO coated on Si

Figure 2: a) device architecture of TCO/GO/Si/Al solar cell; b)WCT lifetime tester; c)operating scheme to monitor silicon wafer passivation.

This work demonstrates the possibility to realize a Schottky barrier solar cell (SBSC) using a solution processable GO as insulating layer.

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