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Nickel selenide/reduced graphene oxide nanocomposite as counter electrode for high efficient dye-sensitized solar cells

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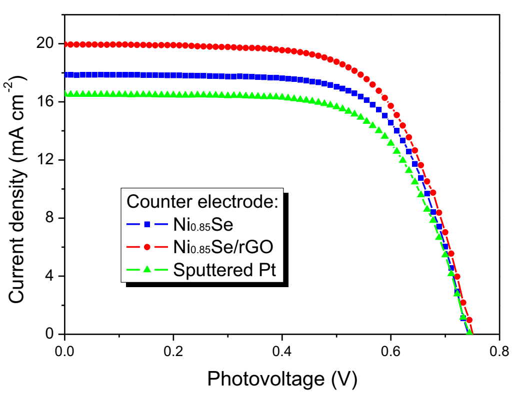

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Nickel selenide/reduced graphene oxide ($Ni_{0.85}Se/rGO$) nanosheet composite is synthesized by a facile hydrothermal process and used as counter electrode (CE) for dye-sensitized solar cells (DSSC). The $Ni_{0.85}Se/rGO$ film spin-coated on FTO show prominent electrocatalytic activity toward I_3^-/I^-. The electrocatalytic ability of $Ni_{0.85}Se/rGO$ film is verified by photocurrent-voltage curves, cyclic voltammetry, electrochemical impedance spectroscopy and Tafel polarization curves. On account of its decent electrical conductivity and superior electrocatalytic activity, the DSSC using optimal $Ni_{0.85}Se/rGO$ CE achieves a power conversion efficiency (PCE) of 9.75%, while the DSSC based on sputtered Pt CE only obtains a PCE of 8.15%.

1. Introduction

Dye-sensitized solar cell (DSSC) has received more and more attention for its application in green energy since its appearance in 1991 [1]. The best power conversion efficiency (PCE) of DSSC has come to 14.7% with a co-photosensitized method using alkoxysilyl-anchor dye and carboxy-anchor organic dye [2]. Generally, a DSSC is made up of three important components, dye-adsorbed TiO_2 film, electrolyte which comprises redox couple of iodide/triiodide (I^-/I_3^-), and a platinum (Pt) counter electrode (CE). Among them, CE adjusts the catalytic reduction of redox couples, exerting an influence on PCE [3]. On the other hand, Pt, the most-common used CE material, is high cost and low natural abundance, which impose restrictions on the commercialization of DSSC. Based on these thoughtfulness, many substitute materials have been proposed. These substitute materials cover carbon materials [4–7], alloy materials [8–10], conducting polymers

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[11–13] and transition metal compounds [14–16]. Also, transition metal compounds include carbides, nitrides and chalcogenide. Among these substitutes, transition metal compounds are less expensive and abundant on earth. What's more, they have excellent electrocatalytic activity, indicating the high potential of replace Pt as CEs in DSSC. In addition, grapheme, as a two-dimensional material, is endowed with versatile physical properties and tunable photoelectrochemical properties. Even though graphene has a poor electro-catalytic activity, it has an admirable electro-conductivity and a large surface area due to its two-dimensional structure [17]. Most important of all, its large surface area can support catalytic material, causing more active sites whose role is reducing I_3^- to I^- increase. Furthermore, a plenty of researches demonstrate that the introduction of graphene in CE

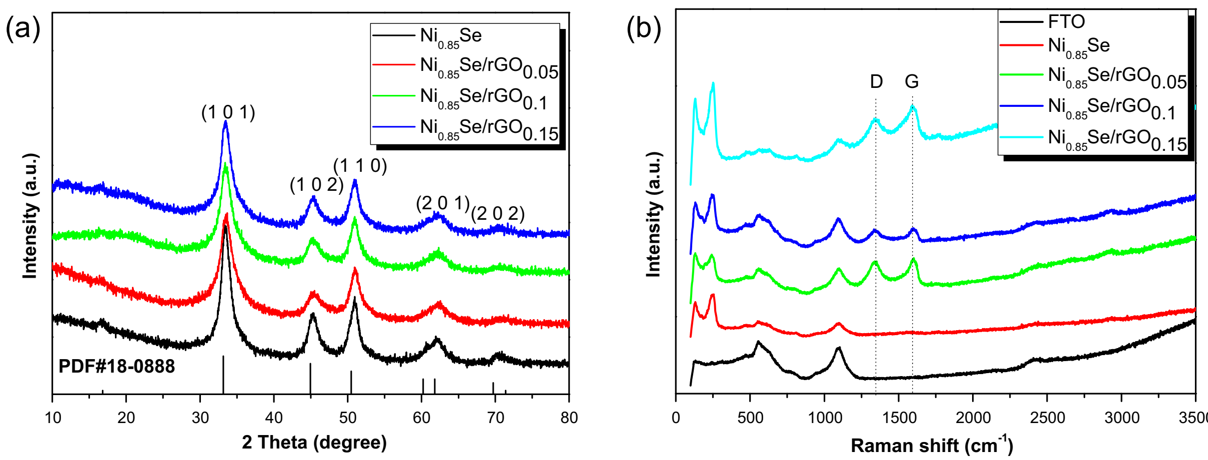

Fig. 1. (a) XRD pattern of $Ni_{0.85}Se$ and $Ni_{0.85}Se/rGO$ powder, (b) Raman spectra for $Ni_{0.85}Se$ CE and $Ni_{0.85}Se/rGO$ CEs.

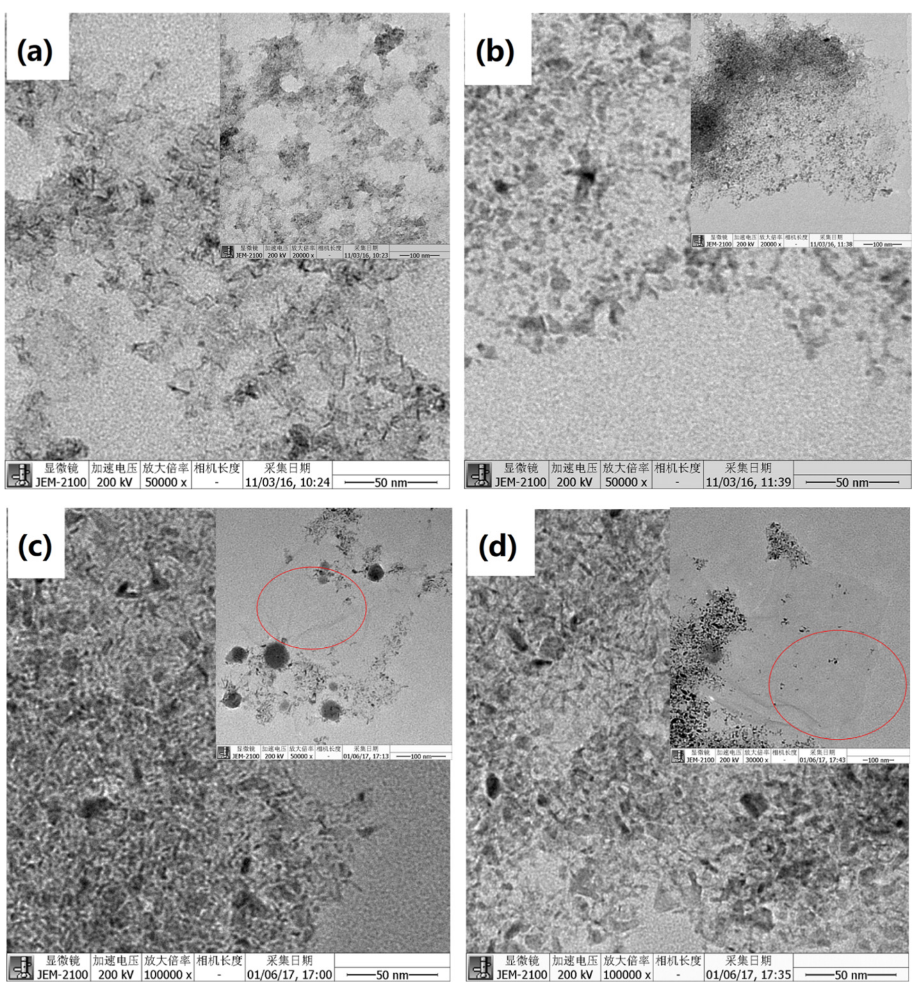

Fig. 2. TEM images of (a) $Ni_{0.85}Se$, (b) $Ni_{0.85}Se/rGO_{0.05}$, (c) $Ni_{0.85}Se/rGO_{0.1}$, and (d) $Ni_{0.85}Se/rGO_{0.15}$.