第76回応用物理学会秋季学術講演会 講演予稿集 (2015 名古屋国際会議場)

Optical properties of Cu_2ZnSnS_4 decorated reduced graphene oxide nanocomposites

D. Thangaraju,[1] R. Karthikeyan,[2] N. Prakash,[2] T. Koyama[1] and Y. Hayakawa,[1,2]

[1] RIE, Shizuoka University, Hamamatsu 432-8011, Japan
2 GSST, Shizuoka University, Hamamatsu 432-8011, Japan
E-mail: royhaya@ipc.shizuoka.ac.jp

1. Introduction

Two-dimensional (2D) composite nanostructures have received considerable attention for use in future ultrathin photodetectors. Hybrid 2D materials grown on graphene possess excellent dimensional-dependent properties, like low-cost fabrication and an environmentally friendly nature. Recently, semiconductor/graphene hybrid composite preparations are in development to enhance the light detection properties of graphene-related materials.[1] Cu_2ZnSnS_4 (CZTS) is a p-type material with a direct band gap energy of ~ 1–1.6 eV and high absorption coefficient (~104 cm−1). CZTS nanoparticles are potential materials for photodetecting applications.[2] In this article, we report the functionalization of a CZTS NP-decorated reduced graphene oxide (rGO) hybrid nanocomposite and their absorption properties were measured.

2. Synthesis of CZTS-decorated rGO

Synthesis of Reduced graphene oxide

The rGO was synthesized from graphite flakes by an improved version of Hummer's method. A mixture of concentrated H_2SO_4/H_3PO_4 was added to a mixture of graphite flakes under stirring for 30 min. $KMnO_4$ was added to the above mixture at 0 °C. It was heated to 40–45 °C for about 15 h. With the addition of distilled water, oxidation was initiated and was terminated by addition of H_2O_2. Synthesized GO was further mixed with hydrazine hydrate to prepare rGO. The product was washed several times with de-ionized water and vacuum dried.

CZTS-decorated rGO

As-synthesized rGO was dispersed in cyclohexane and 5 mL of oleylamine. The metal precursors acetates of Cu (2 mmol), Zn (1 mmol), and $SnCl_2$ (1 mmol) were mixed with the above solution and degassed for another 30 min at 140 °C. Sulfur (4 mmol) was degassed at 140 °C in a separate container and was injected into the rGO metal precursor solution. The temperature of the mixture was further raised to 270 °C and kept for 1 h. The final solution was cooled down to 80 °C and washed with ethanol two times.

3. Result and discussion

Powder XRD

Powder XRD was performed to confirm the crystalline phase of the synthesized CZTS/rGO nanocomposite as shown in Figure 1. The diffraction peaks of as-synthesized CZTS and CZTS/rGO nanoparticles were well matched with the kesterite structure of CZTS.

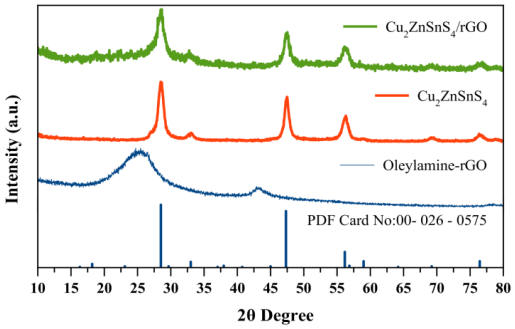

Figure 1. Powder XRD patterns of CZTS standard, Oleylamine –rGO, synthesized CZTS and CZTS decorated rGO

TEM analysis

Figure 2 show typical TEM of as-synthesized CZTS, rGo and CZTS/rGO. The TEM image of CZTS (Figure 2(a)) revealed that the morphology of the derived nanoparticles was like a bulging spheres. TEM images of rGO clearly show the sheet-like morphology of the material, as shown in Figure 2(b). TEM images of CZTS/rGO (Figure (c)) confirm the formation of CZTS particles on the surface of the rGO sheets, indicating that the highly dense distribution of particles on the surface of the rGO sheets.

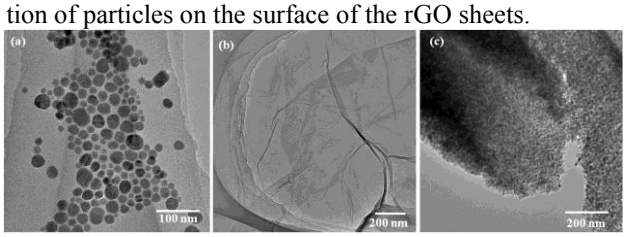

Figure 2. TEM images of Cu2ZnSnS4(a), rGO (b) and Cu2ZnSnS4 decorated rGO (c).

3. Conclusions

CZTS NP decorated rGO nanocomposite were successfully synthesized. This method of growth enabled the uniform spherical-shaped single phase CZTS nanoparticles on the surface of rGO. The absorption nature of CZTS in the presence of rGO changed in the visible and near IR regions.

Acknowledgements

This work was financially supported by a Grant-in-Aid for JSPS Fellows (No.26–04050) and the cooperative research project of the Research Institute of Electronics, Shizuoka University.

References

[1] G. Konstantatos, et. al, Nat. Nanotechnol., 7 (2012) 363
[2] J. J. Wang et. al., NPG Asia Mater., 4, (2012) 1