materials proceedings

Proceeding Paper

Electronic Properties of Single-Walled Carbon Nanotubes Filled with Cobalt Diiodide †

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† Presented at the 4th International Online Conference on Nanomaterials, 5–19 May 2023; Available online: https://iocn2023.sciforum.net.

Abstract: In this work, I filled the single-walled carbon nanotubes (SWCNTs) with cobalt diiodide. The electronic properties were investigated by optical absorption spectroscopy, Raman spectroscopy, photoemission spectroscopy. It was proven that there is the charge transfer in the filled SWCNTs. The p-doping of SWCNTs in filled SWCNTs was confirmed. This is important for applications of filled SWCNTs in light emitters, thermoelectric power generation devices, sensors, nanoelectronics.

Keywords: electronic properties; cobalt diiodide; carbon nanotube; optical absorption spectroscopy; Raman spectroscopy; photoemission spectroscopy

Citation: Kharlamova, M.V. Electronic Properties of Single-Walled Carbon Nanotubes Filled with Cobalt Diiodide. *Mater. Proc.* **2023**, *14*, x. https://doi.org/10.3390/xxxxx

Academic Editors:

Published: 5 May 2023

1. Introduction

Single-walled carbon nanotubes (SWCNTs) attract attention of research, because of unique chemical, and physical properties [1,2]. The atomic structure of SWCNTs defines the electronic properties of SWCNTs. The electronic properties of SWCNTs can be metallic, or semiconducting. The SWCNTs are synthesized by arc-discharge, laser ablation, and chemical vapor deposition methods. In all cases, the mixture of SWCNTs with different electronic properties are obtained. It is impossible to use these samples in applications, because they have inhomogeneous properties [3]. The approach to control the electronic properties of SWCNTs is the filling of channels of SWCNTs. It was shown that channels of SWCNTs can be filled with metals, inorganic substances, and metalorganic compounds. These substances allow tailoring the electronic properties of SWCNTs for applications. The application of SWCNTs are presented in Figure 1 [4].

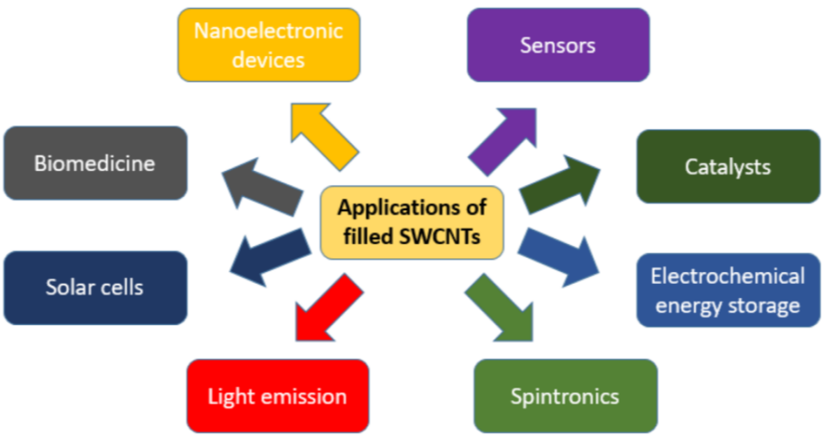

Figure 1. Applications of filled SWCNTs [4].

2. Experiments

The SWCNTs were mixed with cobal diiodide (CoI_2) in a quartz ampoule. The ampoule was sealed under vacuum. The ampoule was heated to the temperature above the melting point of CoI_2 ($T_{synthesis}$ = 615 °C). The ampoule was slowly cooled down to achieve the good crystallization of substances inside nanotubes. The details on the synthesis can be found in paper [5].

3. Results

The samples were investigated by optical absorption spectroscopy (OAS), Raman spectroscopy, photoemission spectroscopy. The optical absorption spectroscopy is the method of investigation of the electronic properties of SWCNTs that allows extract the information on charge transfer. The OAS spectra of CoI_2-filled SWCNTs is presented in Figure 2 [5]. It is visible that there is the vanishing of the first peak in the spectrum of the filled SWCNTs. This is because of the depletion of optical transitions between the valence band, and conduction band. This is a result of charge transfer between the introduced substance, and carbon nanotubes. There are similar results of investigations of filled SWCNTs with OAS for other fillers [6–12].

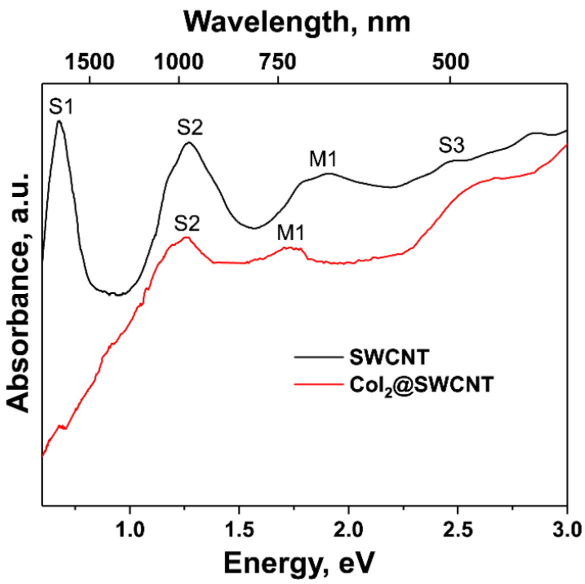

Figure 2. The OAS spectra of cobalt diiodide–filled SWCNTs [5].

Raman spectroscopy is a method of investigation of the electronic properties of SWCNTs that gives the information about charge transfer. The results of Raman spectroscopy for CoI_2-filled SWCNTs confirmed the charge transfer in filled SWCNTs, and these results are in agreement with the OAS data.

Photoemission spectroscopy results also provide valuable information on the charge transfer in the filed SWCNTs. They confirm p-doping of SWCNTs. These results are very important for applications of filled SWCNTs in light emitters, thermoelectric power generation devices, sensors, nanoelectronics.

4. Conclusions

In this work, I filled the SWCNTs with cobalt diiodide. I investigated the electronic properties of filled SWCNTs by OAS, Raman spectroscopy, and photoemission spectroscopy. It was proven that there is the charge transfer between the encapsulated substances, and carbon nanotubes. The p-doping of SWCNTs was confirmed in the filled SWCNTs.

Author Contributions: The manuscript is written solely by M.V.K. All authors have read and agreed to the published version of the manuscript.

Funding: These studies were partly performed during the implementation of the project Building-up Centre for advanced materials application of the Slovak Academy of Sciences, ITMS project code 313021T081 supported by Research & Innovation Operational Programme funded by the ERDF.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data are available on request of Marianna V. Kharlamova.

Conflicts of Interest: The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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