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Research Article

New Resistive Switching and Self-Regulating Heating in Foliated Graphite/Nickel Polyvinyl Chloride Nanocomposites

Omar A. Al-Hartomy,[1,2] Falleh Al-Salamy,[3] A. A. Al-Ghamdi,[2] Attieh A. Al-Ghamdi,[4] A. M. Abdel Daiem,[2,5] and Farid El-Tantawy[6]

[1] *Department of Physics, Faculty of Science, University of Tabuk, Tabuk 71491, Saudi Arabia*
[2] *Department of Physics, Faculty of Science, King Abdulaziz University, Jeddah, P.O. Box 80203, Jeddah 21569, Saudi Arabia*
[3] *Department of Mathematics, Faculty of Science, University of Tabuk, Tabuk 71491, Saudi Arabia*
[4] *Electronics, Communications, and Photonics Program, King Abdulaziz City for Science and Technology, Riyadh, Saudi Arabia*
[5] *Department of Physics, Faculty of Science, Zagazig University, Zagazig 44519, Egypt*
[6] *Department of Physics, Faculty of Science, Suez Canal University, Ismailia 41522, Egypt*

Correspondence should be addressed to Farid El-Tantawy, faridtantawy@yahoo.com

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Polyvinyl chloride- (PVC-) based nanocomposites containing nanosized graphite and nickel nanoparticles (GN) as conductive fillers to achieve positive temperature coefficient of resistance (PTCR) thermistors and self-regulating heater function have been successfully fabricated. The microstructure of the foliated graphite and nanocomposites was examined by scanning electron microscopy (SEM). The effect of GN content on the static electrical conductivity, carrier's mobility, and number of charge carriers of the nanocomposites was studied. The applicability of nanocomposites as PTCR thermistors was examined by monitoring the conductivity as a function of temperature. It is found that the conduction mechanism in PVC/GN nanocomposites is governed by tunneling mechanism. Also, the applied voltage versus current and temperature were studied to check the applicability of composites as self-regulating heater. The results show that the PVC/GN nanocomposites might have potential applications in PTCR devices, self-regulating heater, and temperature sensors.

1. Introduction

The design and applications of electroactive conductive polymer nanocomposites in the electrical and electronic fields have significantly affected the modern technology and added a new dimension to scientific interest [1–3]. The most economical route for fabrication of electro active conducting polymer composites is the inclusion of a conductive filler such as carbon black, carbon nanotubes, graphite, metal powders, ceramic oxides, polyaniline, and others in an insulating polymer matrix and subsequent compaction by compression molding [4–8]. These electro active nanocomposites attracted great interests due to their potential applications in various hi-tech aspects, for example, positive and/or negative temperature coefficient of resistance (PTCR/NTCR) thermistors [9], electrochemical displayers [10], sensors [11, 12], catalysis [13], redox capacitors [14], electromagnetic shielding [15, 16], radar evasion [17], rechargeable batteries [18, 19], conductive inks and antistatic textiles [20, 21], and aero space [3, 12] as well as in secondary battery and bipolar plates in the polymer electrolyte membrane fuel cell, and so forth [20]. A PTCR composite is a grain-boundary resistive effect which is characterized by an increase in resistivity with increasing temperature [14–16]. The traditionally thermistor materials irrespective of its applications can be broadly divided into three categories, namely, metals (such as titanium and platinum), semiconductors (such as Si, Ge, and SiC), and ceramic oxide semiconductors (like single- and multicomponent oxides) [17, 18]. The use of traditional thermistors has been confined because of the low room temperature conductivity and the oxidation of the metallic particles that severely limits