UNIVERSITI PUTRA MALAYSIA

FABRICATION AND CHARACTERIZATION OF VARISTOR-POLYMER COMPOSITE BASED ON ZINC OXIDE

ASMA FATEHI

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By

ASMA FATEHI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfillment of the Requirements for the Degree of Master of Science

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FABRICATION AND CHARACTERIZATION OF VARISTOR-POLYMER COMPOSITE BASED ON ZINC OXIDE

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December 2012

Chairman: Mansor Bin Ahmad, PhD
Faculty: Science

This research focuses on fabricating a varistor-polymer composite based on nano-sized ZnO and micro-sized ZnO, and comparing their current-voltage characteristics. In addition, the influence of each dopant (Bi$_2$O$_3$, MnO, Co$_3$O$_4$) on the physical and electrical properties of varistor-polymer composite based on zinc oxide is investigated.

Nano-sized varistor powder, micro-sized varistor powder and Bi$_2$O$_3$-MnO-Co$_3$O$_4$ doped ZnO micro powder were prepared via a combined solution and standard ceramic processing. Fabrication of a varistor-polymer nanocomposite and microcomposite was accomplished by the melt-blending technique. The characterization of varistor-polymer composites was carried out by X-ray diffraction data (XRD) analysis, Transmission Electron Microscopy (TEM), Field Emission Scanning Electron Microscopy (FESEM), Energy dispersive X-ray (EDAX),
Thermal Gravimetry Analysis (TGA) and Fourier Transform Infra-red (FTIR) spectroscopy.

The XRD pattern of nanocomposite revealed the high crystallinity of the composite compared to microcomposite. FTIR spectra confirmed physical interacting of polymer and varistor powder. TGA and DSC results revealed that temperature degradation and melting temperatures of nano composite were increased compared to micro composite. Manganese Oxide as one dopant of varistor powder stabilize thermal resistivity of the varistor-polymer composite compared to other metal oxides. The TEM image showed the spherical morphology of the nano-sized filler with the average size below 50 nm which were distributed homogeneously within the polymer. While, the SEM micrograph revealed the non uniform distribution of micro-sized fillers. FESEM and EDAX showed the presence of a bismuth-rich phase and a ZnO phase in the varistor powder. The current-voltage (I-V) characteristics suggested varistor-like behaviour when the concentration of nano-sized filler increased in contrast to micro-sized filler. Bismuth Oxide (as one dopant of varistor powder) has an important role in nonlinear properties of varistor-polymer composites.
Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

FABRIKASI DAN PENCIRIAN KOMPOSIT VARISTOR-POLIMER BERDASARKAN ZINK OKSIDA

Oleh
ASMA FATEHI
Disember 2012

Pengerusi: Mansor Bin Ahmad, PhD
Fakulti: Sains

Kajian ini memberi tumpuan kepada penghasilan komposit varistor-polimer berdasarkan ZnO bersaiz nano dan ZnO bersaiz mikro, dan membandingkan ciri-ciri arus voltan semasa mereka. Di samping itu, pengaruh setiap bahan dop (Bi$_2$O$_3$, MnO, Co$_3$O$_4$) pada sifat fizikal dan elektrik komposit varistor-polimer berdasarkan Zink Oksida dikaji.

Serbuk varistor bersaiz nano, serbuk varistor bersaiz mikro dan Bi$_2$O$_3$-MnO-Co$_3$O$_4$ terdop serbuk mikro ZnO telah disediakan melalui penyelesaian gabungan dan pemprosesan seramik standard. Fabrikasi komposit nano dan komposit mikro varistor-polimer telah dicapai oleh teknik adunan cair. Pencirian komposit varistor-polimer telah dijalankan oleh analisis Data Pembelauan Sinar-X (XRD), Mikroskopi Elektron Transmisi (TEM), Mikroskopi Pengimbasan Elektron Pelepasan medan (FESEM), Tenaga Serakan Sinar-X (EDAX), Analisis Gravimetry Terma (TGA) dan Spektroskopi Jelmaan Fourier Infra-merah (FTIR).
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I attribute the level of my master degree to all your supports. To you all I dedicate this thesis.
I certify that a Thesis Examination Committee has met on 3th December 2012 to conduct the final examination of ASMA FATEHI on her thesis entitled “FABRICATION AND CHARACTERIZATION OF VARISTOR-POLYMER COMPOSITE BASED ON ZINC OXIDE” in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master Degree.

Members of the Thesis Examination Committee are as follows:

**Prof.Dr. Mahiran Basri**
Faculty of Science
Universiti Putra Malaysia
(Chairman)

**Prof.Dr. Zulkarnain Zainal**
Faculty of Science
Universiti Putra Malaysia
(Internal Examiner)

**Dr. Tan Yen Ping**
Faculty of Science
Universiti Putra Malaysia
(Internal Examiner)

**Prof. Madya Dr. Hazizan Md Akil**
School of Materials & Mineral Resources Engineering
Universiti Sains Malaysia
(External Examiner)

________________________________________

**Seow Heng Fong, PhD**
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:
This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

**Mansor Bin Ahmad @ Ayob, PhD**
Associate Professor  
Faculty of Science  
Universiti Putra Malaysia  
(Chairman)

**Azmi Bin Zakaria, PhD**
Professor  
Faculty of Science  
Universiti Putra Malaysia  
(Member)

**Shahrom Mahmud, PhD**
Senior lecturer School of Physics Universiti Sains Malaysia (Member)

___________________________________________________________

**BUJANG BIN KIM HUAT, PhD**
Professor and Dean  
School of Graduate Studies  
Universiti Putra Malaysia

Date:
DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

________________________________________
ASMA FATEHI

Date: 3 December 2012
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