



**UNIVERSITI PUTRA MALAYSIA**

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

**ASMA FATEHI**

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**MASTER OF SCIENCE  
UNIVERSITI PUTRA MALAYSIA  
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COMPOSITE BASED ON ZINC OXIDE**

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**

**December 2012**

Abstract of thesis presented to the Senate of University Putra Malaysia, in fulfillment of the requirement for the degree of Master of Science

**FABRICATION AND CHARACTERIZATION OF VARISTOR-POLYMER  
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By

**ASMA FATEHI**

**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 ( $\text{Bi}_2\text{O}_3$ , MnO,  $\text{Co}_3\text{O}_4$ ) 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  $\text{Bi}_2\text{O}_3$ -MnO- $\text{Co}_3\text{O}_4$  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**

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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 ( $\text{Bi}_2\text{O}_3$ ,  $\text{MnO}$ ,  $\text{Co}_3\text{O}_4$ ) pada sifat fizikal dan elektrik komposit varistor-polimer berdasarkan Zink Oksida dikaji.

Serbuk varistor bersaiz nano, serbuk varistor bersaiz mikro dan  $\text{Bi}_2\text{O}_3\text{-MnO-Co}_3\text{O}_4$  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).

Corak XRD komposit nano mendedahkan penghabluran tinggi komposit berbanding dengan komposit mikro. Spektra FTIR mengesahkan wujudnya interaksi fizikal polimer dan serbuk varistor. Keputusan TGA dan DSC menunjukkan bahawa degradasi suhu dan suhu peleburan komposit nano telah meningkat berbanding dengan komposit mikro. Mangan Oksida sebagai bahan dop serbuk varistor menstabilkan kerintangan haba komposit varistor-polimer berbanding dengan oksida logam lain. Imej TEM menunjukkan morfologi sfera pengisi bersaiz nano dengan saiz purata di bawah 50 nm yang ditaburkan dengan seragam dalam polimer. Manakala, mikrograf SEM mendedahkan taburan tidak seragam pengisi bersaiz mikro. FESEM and EDAX menunjukkan kehadiran satu fasa kaya dengan bismut dan fasa ZnO dalam serbuk varistor. Ciri-ciri arus voltan (I-V) mencadangkan tindakan seperti varistor apabila konsentrasi pengisi bersaiz nano meningkat berbeza dengan pengisi bersaiz mikro. Bismut Oksida (sebagai satu bahan dop serbuk varistor) mempunyai peranan yang penting dalam sifat-sifat tak linear komposit varistor-polimer.

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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 Uiversiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master Degree.

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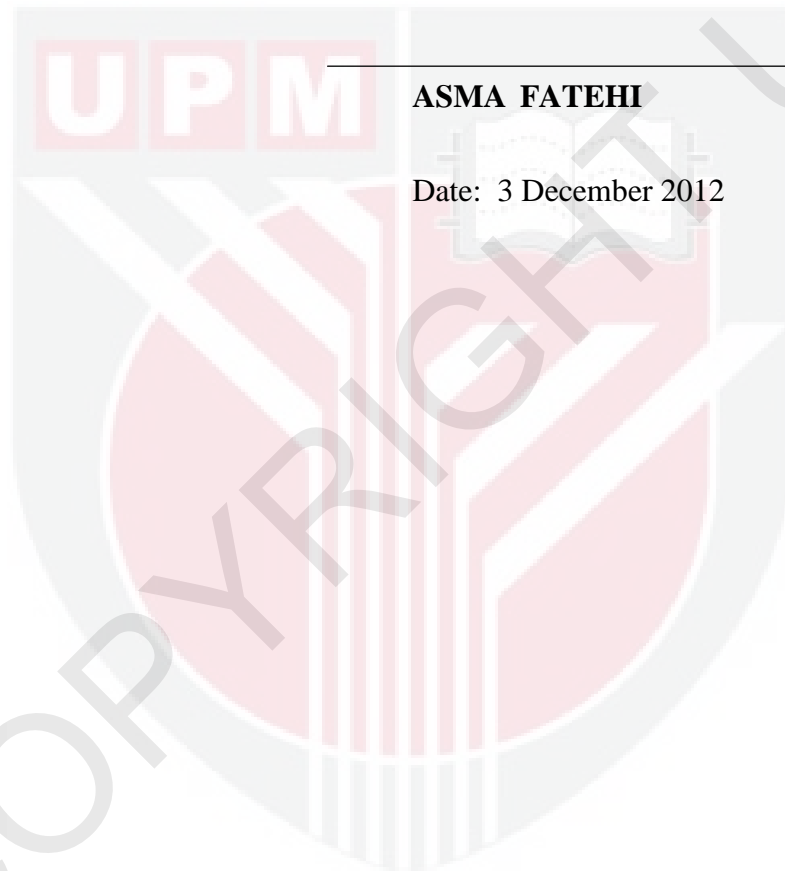
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## DECLARATION

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.



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