UNIVERSITI PUTRA MALAYSIA

THERMAL DIFFUSIVITY AND ELECTRICAL CONDUCTIVITY OF ZnOCuO CERAMIC COMPOSITES AT HIGH TEMPERATURES

RABIATULADAWIYAH BT MD AKHIR

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THERMAL DIFFUSIVITY AND ELECTRICAL CONDUCTIVITY OF ZnO-CuO CERAMIC COMPOSITES AT HIGH TEMPERATURES

By

RABIATULADAWIYAH BT MD AKHIR

Thesis Submitted to the School of Graduate Studies Universiti Putra Malaysia in Fulfilment of the Requirement for the Degree of Master of Science

December 2012

DEDICATION

To my beloved parents Md Akhir Ahmad and Rusmani Husin

for their understanding, unconditional love, great inspiration and repeated encouragement…

To my beloved family members

for their care and unlimited support…

To my beloved Mohd Rozaimin Abd Hamid

for his concern and endless support…

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

THERMAL DIFFUSIVITY AND ELECTRICAL CONDUCTIVITY OF ZnO-CuO CERAMIC COMPOSITES AT HIGH TEMPERATURES

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RABIATULADAWIYAH BINTI MD AKHIR

December 2012

Chairman: Associate Professor Zaidan Abdul Wahab, PhD

Faculty: Science

In this work, thermal diffusivity and electrical conductivity of CuO-ZnO ceramic composites were studied by using laser flash and two point probe technique respectively. I-V characteristic of samples were obtained at temperatures between 100 °C to 450 °C whereas thermal diffusivity was measured at temperatures between 27 °C to 400 °C. Pure ZnO and CuO-ZnO ceramics were prepared by the dry pressing method using a pressure of 2000 $kgcm^{-2}$ and sintered at 1000 °C for 3 hours in air. Both thermal and electrical properties are preliminary data for future gas sensor application.

The way that the thermal diffusivity behaves towards the change of dopant concentration and different temperatures was investigated. The decreased of thermal diffusivity of pure and composite sample with temperature suggests that the dominant contribution to the thermal diffusivity is due to the thermally enhanced phonon-phonon scattering. It was found that there was increment of 32% of thermal diffusivity from 10 wt% CuO (3.46 $x10^{-6}$ m^2s^{-1}) to 40 wt% CuO (4.58 $x10^{-6}$ m^2s^{-1}). Beyond 40 wt% of

CuO, a sudden decrease in the thermal diffusivity to 2.59 $x10^{-6}$ m^2s^{-1} was exhibited. The thermal diffusivity was reduced to 43% as it reaches the CuO composition of 50 wt%. It was found that thermal diffusivity of sample decreased with porosity as evidence in SEM micrograph.

The average electrical conductivity of pure ZnO and CuO was 1.134 x 10^{-2} $q^{-1}m^{-1}$ and 2.577 x 10^{-2} $q^{-1}m^{-1}$ respectively. The increasing of CuO compositions in CuO-ZnO system had increased the overall electrical conductivity of sample due to the more conductive ZnO/CuO interfaces than that for ZnO/ZnO interfaces. The highest value of electrical conductivity was contributed by sample with 50 wt% CuO (5.906 x 10^{-2} $q^{-1}m^{-1}$). Effect of grain size, dopant compositions, density/porosity and changes of free electron concentration has been suggested to be responsible for the variation in thermal and electrical behavior and this was supported by XRD and SEM micrographs.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains.

KEMERESAPAN TERMA DAN KEKONDUKSIAN ELEKTRIK BAGI SERAMIK KOMPOSIT ZNO-CUO PADA SUHU TINGGI

Oleh

RABIATULADAWIYAH BINTI MD AKHIR

Disember 2012

Pengerusi: Profesor Madya Zaidan Abdul Wahab, PhD

Fakulti: Sains

Dalam kajian ini, kemeresapan terma dan kekonduksian elektrik seramik komposit CuO-ZnO telah dikaji dengan masing-masing menggunakan teknik laser kilat dan kaedah penduga dua titik. Pencirian IV sampel telah diperolehi pada suhu antara 100 ° C hingga 450 ° C manakala keresapan terma diukur pada suhu antara 27 °C hingga 400 °C. ZnO tulen dan CuO-ZnO seramik telah disediakan melalui kaedah tekanan kering menggunakan tekanan 2000 $kgcm^{-2}$ dan dibakar pada 1000 °C selama 3 jam di udara. Kedua-dua ciri haba dan elektrik adalah maklumat awal untuk aplikasi penderia gas pada masa akan datang.

Cara kemeresapan terma bertindak ke arah perubahan kepekatan pendopan dan suhu yang berbeza telah dikaji. Penurunan kemeresapan terma sampel asal dan campuran dengan suhu mencadangkan bahawa sumbangan yang dominan kepada kemeresapan terma adalah disebabkan oleh serakan fonon-fonon yang dipertingkatkan. Didapati bahawa terdapat peningkatan sebanyak 32% daripada kemeresapan haba dari 10% berat

CuO (3.46 $x10^{-6}$ m^2s^{-1}) hingga 40% berat CuO (4.58 $x10^{-6}$ m^2s^{-1}). Selepas 40% berat CuO, penurunan kemeresapan terma yang dramatik iaitu 2.59 $x10^{-6}$ m^2s^{-1} telah dipamerkan. Kemeresapan terma telah dikurangkan kepada 43% apabila ia mencapai komposisi CuO 50% berat. Didapati bahawa kemeresapan terma menurun dengan keliangan seperti yang terbukti dalam grafmikro SEM .

Purata kekonduksian elektrik ZnO tulen dan CuO masing-masing adalah 1.134 x 10^{-2} $q^{-1}m^{-1}$ dan 2.577 x 10^{-2} $q^{-1}m^{-1}$. Peningkatan komposisi CuO dalam sistem CuO-ZnO telah meningkatkan kekonduksian elektrik keseluruhan sampel kerana antara muka ZnO / CuO yang lebih yang konduktif daripada antara muka ZnO / ZnO. Nilai kekonduksian elektrik yang tertinggi disumbangkan oleh sampel dengan 50% berat CuO (5.906 x 10^{-2} $q^{-1}m^{-1}$). Kesan saiz butiran, komposisi pendopan, ketumpatan / keliangan dan perubahan kepekatan elektron bebas telah dicadangkan untuk bertanggungjawab bagi perubahan dalam tingkah laku terma dan elektrik dan ia disokong oleh XRD dan grafmikro-grafmikro SEM.

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I certify that a Thesis Examination Committee has met on 27 December 2012 to conduct the final examination of Rabiatuladawiyah binti Md Akhir on her thesis entitled "Thermal Diffusivity and Electrical Conductivity of ZnO-CuO Ceramic Composites at High Temperatures" in accordance with the Universities and University College 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 of Science.

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

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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.

RABIATULADAWIYAH MD AKHIR

Date:

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