UNIVERSITI PUTRA MALAYSIA

SYNTHESIS AND FABRICATION OF NANOCOMPOSITE MAGNESIA DOPED BARIUM STRONTIUM TITANATE FOR THICK FILM HUMIDITY SENSOR

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By

HAMID BARZABADI FARAHANI

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

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Dedicated to my parents Fahimeh and Amir

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

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November 2013

Chair: Mr. Rahman Wagiran, MSc

Faculty: Engineering

Water vapour is a highly interactive matter around the earth glob. Accordingly, monitoring and control of the surrounded humidity is extremely demanded in different areas, i.e., domestic and industrial applications. By virtue of the indispensable demands in such fields, moisture sensing technology has rapidly progressed to overcome the drawbacks. Thick film technology has been discerned as a convenient technology from the last decades which exhibits high integration, design flexibility, affordable cost and material intermingled design. A provskite family of compound ceramics with the chemical formula of ABX_3, are natural minerals in nature.

The scope of this dissertation research is to fabricate and configure of miniaturized double layer thick film humidity sensors which is realized based on the nanocomposite sensing elements. The humidity sensitive properties of nano aggregates were examined in view point of their potential applications for humidity

sensors. $BaTiO_3$ and $SrTiO_3$ provskites were proposed as precursors. To examine the microstructure and improve the moisture-sensitive behaviour of the $(Ba_{0.5},Sr_{0.5})TiO_3$ compound, the MgO admixtures were added with 1,3 and 5mol% concentration. Nano-powders were mixed based on molar ratio and prepared via conventional solid state reaction. The thick film inks were prepared by mixing appropriate ratio of an organic vehicle and heat treated nanocomposites, and screen printed onto an alumina substrate utilizing DEK-J1202RS automatic machine. The surface morphology and electrical properties of the nano grains and developed thick film specimens were studied. The performance characteristics of the proposed prototype ceramic and sensors (BST, BSTM1, BSTM3, and BSTM5) were evaluated and analyzed by means of Impedance Analyzer and LCR meter with respond to 20%-95% RH through laboratory humidity simulation chamber, and frequency variations in range of 20Hz to 2MHz. The validation of the sensors analytical model is illustrated and processed using experimental outcomes.

The novel contributions of this research are contained of two major parts. First, the characterizations have shown that all the four different compounds met the criteria to be used as humidity sensing elements. Addition of admixtures has led to particle size diminution (~ 2nm per concentration). Second, the results from the DC and AC analysis have shown that all the sensors are operating based on the ionic-conduction mechanism, and applicable for being dual functional. The structural outcomes of the films have revealed that the grains had matured by dopant additions (~ 5nm per doping value), and highly contributed in transduction process. Overall, the BSTM3 has shown to be the most promising compound to be used as a thick film humidity sensor.

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

SINTESIS DAN FABRIKASI PENDERIA KELEMBAPAN SAPUT TEBAL NANO-KOMPOSIT BARIUM STRONTIUM TITANAT TERDOP MAGNESIA

Oleh

HAMID BARZABADI FARAHANI

November 2013

Pengerusi: Mr. Rahman Wagiran, MSc

Fakulti: Kejuruteraan

Dalam persekitaran wap air merupakan bahan yang mudah bertindakbalas dengan unsure-unsur dipersekitaran. Justeru, pemantauan serta kawalan kelembapan persekitaran amat memerlukan perhatian dalam semua aspek berkaitan domestic dan industri. Atas keperluan ini, teknologi penderiaan kelembapan berkembang pesat khusus untuk mengatasi masalah berkaitan. Teknologi saput tebal telah dikenalpastisebagai teknologi yang sesuai kerana memiliki sifat-sifat seperti mudah diintegrasi, rekabentuk yang fleksibel, kos mampu milik dan campuran komposisi bahan yang berbagai. Seramik sebatian keluarga provskite dengan formula kimia ABX_3 mudah diperolehi dari bahan semulajadi.

Skop kajian yang dibentangkan di sini adalah untuk membuat dan mencari rupa bentuk penderia kelembapan dua lapisan saput tebal miniatur yang dihasilkan berasaskan bahan penderiaan nano-komposit. Ciri-ciri bahan nano-agregat yang sensitif kepada kelembapan dikaji dari segi keupayaannya diguna sebagai penderia

kelembapan. Provskit $BaTiO_3$ dan $SrTiO_3$ dicadangkan sebagai pelopor. Untuk mengkaji sifat mikro-struktur bahan dan meningkatkan sensitif kelembapan bahan kompaun $(Ba_{0.5},Sr_{0.5})TiO_3$ bahan tambah MgO dicampurkan pada kadar kepekatan 1, 3 dan 5mol%. Campuran tepung nano dibuat berdasarkan nisbah molar dan disediakan menggunakan tindak balas keadaan pepejal yang biasa. Dakwat saput tebal disediakan dengan cara mencampurkan bahan pembawa organic dan bahan nano-composit yang diterapi haba pada kadar yang tertentu, dan kemudian dicetak di atas substrat alumina menggunakan mesin otomatik DEK-J1202RS. Morfologi permukaan dan sifat dielektrik nano-bijian dan specimen saput tebal yang dibina telah dikaji selidik. Performans ciri-ciri seramik yang dicadangkan dan prototip penderia (BST, BSTM1, BSTM3 and BSTM5) dinilai dan dianalisis menggunakan Penganalisis Impedens dan meter LCR untuk nilai 20%-95% RH dalam kebuk kelembapan makmal, dan pada julat frekuensi antara 20Hz ke 2MHz. Validasi dan pemodelan penderia analitik ditunjukkan dan diproses dari dapatan secara ujikaji.

Sumbangan penting dalam kerja penyelidikan ini terkandung dalam dua bahagian. Pertamanya, pencirian yang dibuat menunjukkan kesemua empat sebatian yang dikaji memenuhi kriteria sebagai unsure penderia kelembapan. Penambahan bahan campuran boleh mengecilkan saiz zarah (~2nm per kepekatan). Keduanya, hasil dari analisis DC dan AC menunjukkan yang semua penderia beroperasi berdasarkan mekanisma konduksi-terion, dan boleh digunakan dalam dua fungsi. Struktur saput yang dihasilkan menunjukkan butir menjadi lebih matang dengan penambahan bendasing (~ 5nm per nilai pengedopan bendasing), dan ini meningkatkan proses transkondusi. Secara keseluruhan, BSTM3 telah menunjukkan sebagai sebatian yang paling sesuai diguna sebagai penderia kelembapan saput tebal.

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APPROVAL

I certify that a Thesis Examination Committee has met on 28/11/2013 to conduct the final examination of Hamid Barzabadi Farahani on his Master of Science thesis entitled "Synthesis and Fabrication of Nanocomposite Magnesia Doped Barium Strontium Titanate for Thick Film Humidity Sensor" 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 of Science degree.

Members of the Thesis Examination Committee were as follows:

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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 were as follows:

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DECLARATION

Declaration by graduate student

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