

UNIVERSITI TEKNOLOGI MARA

**EFFECT OF DIVALENT Ca^{2+} AND
 Mg^{2+} SUBSTITUTIONS ON OXYGEN
SENSING PROPERTIES OF HOT-
SPOT BASED $(\text{Eu}_{1-x}\text{Ca}_x)\text{Ba}_2\text{Cu}_3\text{O}_{7-\delta}$
AND $(\text{Eu}_{1-y}\text{Mg}_y)\text{Ba}_2\text{Cu}_3\text{O}_{7-\delta}$ CERAMIC
RODS**

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Thesis submitted in fulfillment
of the requirements for the degree of
Master of Science

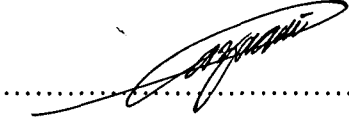
Faculty of Applied Sciences

November 2013

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my own work, unless otherwise indicated or acknowledged as referenced work. This research has not been submitted to any other academic institution or non-academic institution for any other degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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Based $(\text{Eu}_{1-x}\text{Ca}_x)\text{Ba}_2\text{Cu}_3\text{O}_{7-\delta}$ and
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ABSTRACT

This thesis describes the effects of Ca^{2+} and Mg^{2+} substitution on oxygen sensing properties of hot spot-based Eu123 rods. $\text{Eu}_{1-x}\text{Ca}_x\text{Ba}_2\text{Cu}_3\text{O}_{7-\delta}$ ($x=0-0.5$) and $\text{Eu}_{1-y}\text{Mg}_y\text{Ba}_2\text{Cu}_3\text{O}_{7-\delta}$ ($y=0-0.5$) ceramics were synthesized from oxide powders using the standard solid state method and fabricated into short rods. For unsubstituted $x=0$ rod the $I-V$ behavior after formation of hot spot showed decreasing output current with increasing voltage under different $p\text{O}_2$ concentration. However, for Ca-substituted rods, after appearance of a visible hot spot, a constant current plateau in the $I-V$ curve was formed. The output current response of the rod in periodically changing $p\text{O}_2$ between 20% and 100% showed improved stability and reproducibility for $x=0.1$, $x=0.4$ and $x=0.5$ compared to $x=0.2$ and $x=0.3$. Improved oxygen absorption and desorption time was observed for $\text{Eu}_{1-x}\text{Ca}_x\text{Ba}_2\text{Cu}_3\text{O}_{7-\delta}$ ($x=0.1, 0.4, 0.5$) compared to the unsubstituted rod. Among the Ca-substituted samples, the $x=0.4$ rod produces oxygen absorption and desorption time of 64.5 s and 93.1 s, respectively. On the other hand, for Mg-substituted rods $I-V$ behavior after formation of hot spot showed a negative slope. Faster absorption time of 3.0 s and desorption time of 6.9 s were observed for $y=0.4$ compared to other Mg-substituted rods. The improved output current stability, reproducibility and response time is suggested to be due to changes in oxygen activation energy and increased hole concentration as a result of $\text{Ca}^{2+}/\text{Mg}^{2+}$ substitutions. The Mg-substituted rods showed better performance compared to Ca-substituted rods possibly due to higher porosity and vacancy concentration. However, the difference in PTCR behavior for the same substitution level between Ca-substituted and Mg-substituted rods is suggested to be due to the differences in ionic size of Ca^{2+} and Mg^{2+} which caused differences in reduction of oxygen activation energy. For the unsubstituted and Mg-substituted series, the relation between output current and $p\text{O}_2$ shows a good agreement with the ideal case of oxygen excess material, derived from the mass action law.

ACKNOWLEDGEMENTS

Assalamualaikum w.b.t.

First and foremost, in the name of Allah, Most Gracious and Most Merciful. Alhamdulillah, all praises to Allah for all the blessings and guidance for giving me the inspiration to embark on this research and instilling me in all of the strengths to complete this thesis and Master's research.

I would like to express my gratitude to all who helped in one way or another in the planning, brainstorming, writing and editing this research study. My special appreciation goes to my supervisor Prof. Dr. Ahmad Kamal Hayati Yahya for his continuous encouragement, guidance, advice, criticisms, suggestions and lasting patience in helping me complete this research.

I would also like to express my sincere thanks to lecturers in Faculty of Applied sciences especially to Tuan Hj. Mohd Isa Bin Mohd Yusof and Dr. Misbah Hassan for their guidance, advice and suggestions, especially on experimental set up to complete this research.

I wish to express my special thanks from the bottom of my heart to my husband and my daughter for their great deal of understanding and to my parents for their encouragement morally, prayers and materially during my study.

I also wish to thank to my friends for their encouragement, opinions, help, cooperation and involvement directly or indirectly in completing this piece of work. I offer my prayers, love and almost appreciation to all who have supported me in any way during the completion of this project.

Finally, the financial support from the Ministry of Science, Technology and Innovation (MOSTI) in the period of Jun 2009 to December 2010 and Faculty of Applied Sciences, Universiti Teknologi MARA are also gratefully acknowledged and appreciated. Without the financial assistance this research may not be possible. Thank you.

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