SYNTHESIS OF TIN-DOPED ZINC OXIDE NANOSTRUCTURES **BY FLAME SPRAY PYROLYSIS AND** THEIR APPLICATIONS

KHATCHARIN WETCHAKUN

DOCTOR OF PHILOSOPHY IN NANOSCIENCE AND NANOTECHNOLOGY

CODYNESSIC THE GRADUATE SCHOOL CHIANG MAI UNIVERSITY FEBRUARY 2012 C S C V C

SYNTHESIS OF TIN-DOPED ZINC OXIDE NANOSTRUCTURES BY FLAME SPRAY PYROLYSIS AND THEIR APPLICATIONS

KHATCHARIN WETCHAKUN

A THESIS SUBMITTED TO THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN NANOSCIENCE AND NANOTECHNOLOGY

> THE GRADUATE SCHOOL CHIANG MAI UNIVERSITY FEBRUARY 2012

SYNTHESIS OF TIN-DOPED ZINC OXIDE NANOSTRUCTURES BY FLAME SPRAY PYROLYSIS AND THEIR APPLICATIONS

KHATCHARIN WETCHAKUN

THIS THESIS HAS BEEN APPROVED TO BE A PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN NANOSCIENCE AND NANOTHECNOLOGY

EXAMINING COMMITTEE

THESIS ADVISORY COMMITTEE

Dr. Pichai Pirakitikulr

Sukon MEMBER

Assoc. Prof. Dr. Sukon Phanichphant

Assoc. Prof. Dr. Udom Sriyotha

Dr. Chaikarn Liewhiran

chart

aengla Wee MEMBER Dr. Saengrawee Sriwichai

> 3 February 2012 © Copyright by Chiang Mai University

Sukon_____ADVISOR Assoc. Prof. Dr. Sukon Phanichphant ______OM____UUUOKO-ADVISOR Assoc. Prof. Dr. Udom Sriyotha

...... CO-ADVISOR

Dr. Chaikarn Liewhiran

ACKNOWLEDGEMENTS

This Ph.D. thesis was completed with many helps and supports from several important persons and organizations. First and foremost the author would like to express the sincerest gratitude to my supervisor, Assoc. Prof. Dr. Sukon Phanichphant, who planed me into the program of Strategic Scholarships for Frontier Research Network for the Join Ph.D. Program Thai Doctoral degree in 2008 of the Office of Higher Education Commission. She gave me many supports, opportunities, knowledge and advices plus visions, etc. throughout since my master's degree, getting a Ph.D. and getting out of student life to be a researcher. My big thanks, would like to give to the program Strategic Scholarships for Frontier Research Network for the Join Ph.D. Program Thai Doctoral degree of the Office of Higher Education Commission, Ministry of Education, Thailand, for its full financial support; Nanoscience and Nanotechnology Program, Graduate School, Chiang Mai University; and Nanoscience Research Laboratory, Department of Chemistry, Faculty of Science, Chiang Mai University, for their supporting area and provided me to utilize the critical experimental equipment, such as flame spray pyrolysis and photocatalytic reactor, to coalesce all my works.

I would like to thank you the following persons who are also my co-advisors and who serving as examination committees: Assoc. Prof. Dr. Udom Sriyotha, Dr. Pichai Pirakittikulr, Dr. Chaikarn Liewhiran, Dr. Saengrawee Sriwichai, Dr. Natda Wetchakun, Dr. Burapat Inseesungvorn and Dr. Paralee Waenkaew and for their kind suggestions and helps, in flame spray pyrolysis synthesis, gas sensing, photocatalysis and many other technological techniques in order, to complete this thesis.

I would like to thank Dr. Vladimir Golovko for giving me a chance to work as an intern in his Department of Chemistry, University of Canterbury, in Christchurch, New Zealand. Many thanks to give to Dr. Adisorn Tuantranont and Dr. Anurat Wisitsoraat for all their kind helps and for giving the opportunity to work on gas sensing at the National Electronics and Computer Technology Center (NECTEC), the National Science and Technology Development Agency (NSTDA), Thailand, which was a significant part in this research.

Moreover, I now would also like to thank friends and coworkers, all members of the Nanoscience Research Laboratory, and Dr. Anurat's and Vladimir's associated group for their lovely friendships and assistant in many ways, including others whom I did not mention but always in my grateful mind.

Last but not least, I would like to express the best thanks to my family for their love understanding and stand by me, and all my past and present teachers who always in my conscious.

Khatcharin Wetchakun

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่ Copyright[©] by Chiang Mai University All rights reserved