

ACKNOWLEDGEMENTS

This thesis has been successfully accomplished with the invaluable support and assistance provided by many people. I would like to extend my heartfelt gratitude to all the people who directly and indirectly encourage me.

I would like to express my sincere gratitude to my advisor, Dr. Wiwat Nuansing, for providing insightful guidance and advise during the entire duration of my academic journey. The successful completion of this work would not have been feasible without the invaluable assistance, counsel, and support based upon his expert knowledge and experience. I express my profound gratitude to Asst. Prof. Dr. Oratai Weeranantanapan for her kindly assistance and invaluable recommendations. I express my gratitude to Dr. Phakkhananan Pakawanit, Dr. Wiwat Nuansing, Prof. Dr. Santi Maensiri, Assist. Prof. Dr. Wittawat Saenrang and Asst. Prof. Dr. Oratai Weeranantanapan for their participation as my examination committees during the evaluation of my Ph.D. Their insightful feedback and suggestions have been highly beneficial to me.

I would like to express my appreciation to all members and staffs in 3D Printing and Advanced Materials Physics (AMP) laboratory, the School of Physics, Institute of Science, Suranaree University of Technology, and Synchrotron Light Research Institute (SLRI) for all assistance, support, and friendship.

I would like to gratefully acknowledge financial support to the Science Achievement Scholarship of Thailand (SAST) from Ministry of Higher Education, Science, Research and Innovation, Thailand throughout the whole period of my bachelor's and doctoral studies. In addition, I am thankful to the Fundamental Fund (FF), Suranaree University of Technology for all supports.

I would like to express my gratitude to Dr. Ali Zolfagharian of the 4D Printing Society Group at Deakin University's School of Engineering, Faculty of Science, Engineering and Built Environment in Australia for granting me the opportunity to engage in a short-term research project as a visiting student. Furthermore, I am grateful

for all assistance and support provide by my colleagues and staffs at Deakin University. It was an incredibly remarkable experience collaborating with you and your team.

I express my gratitude to Dr.Jessada Khajonrit, Dr. Thongsuk Sichumsaeng, Dr. Ornuma Kalawa, Miss Suphawi Chaisit, Mr. Yanwarute Soi-neong, Miss Weraporn Sukchanta, and Mr. Niwat Hema for their assistance and friendship throughout my Ph.D. study. In addition, I would like to thank Mr. Wanchaloem Khwammai for supporting me and providing suggestions on the experiment during my Ph.D. journey.

Finally, my graduation would not have been achieved without best wishes from parents, who assist me in everything, as well as the financial and mental support I received during this time to complete my thesis. I express my sincere gratitude to all of you once again, with utmost sincerest.

Atchara Chinnakorn