UNIVERSITI TEKNOLOGI MARA

PREPARATION AND CHARACTERIZATION OF SiO_2-ZrO_2 DOPED WITH Er^{3+} AND Er^{3+}/Yb^{3+} GLASS CERAMIC THIN FILM

NURUL IZNIE RAZAKI

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

Faculty of Applied Sciences

May 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 thesis has not been submitted to any other academic institution or non-academic institution for any 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.

Name of Student	:	Nurul Iznie Razaki
Student ID	:	2008741551
Programme	:	Master of Science
Faculty	:	Applied Science
Thesis Title	:	Preparation and Characterization of SiO_2-ZrO_2 Doped With Er^{3+} and Er^{3+}/Yb^{3+} Glass Ceramic Thin Film
Signature of Student	:	....
Date	:	May 2013

ABSTRACT

In this thesis, the Er^{3+} and Er^{3+}/Yb^{3+} doping dependents of $70SiO_2$-$30ZrO_2$ glass ceramics thin film are studied. All the samples were prepared via sol-gel dip coating technique and annealed at 900 to 980°C. Full film densification was achieved for the deposited film, which indicates hydroxyl group was successfully removed, as depicted by Raman spectra. Presence of higher rare earth ions raises the refractive index of the films, thus enabling the guiding of light in the film structure. Green and red emissions of Er^{3+} were observed upon 514.5nm excitation. At higher doping of Er^{3+} (0.58 mol %), concentration quenching occurs as depicted by a decrement of green emission. Meanwhile, the red emission increases as a function of Er^{3+}-doping. Addition of Yb^{3+} as co-dopant with Er^{3+}/Yb^{3+} proportions of 1/3, 1/5 and 1/10 in the highly doped of Er^{3+} (0.58 mol %) decreases the both emission with the red emission dominates the radiative transition. With further increased of Er^{3+} in highly doped of Yb^{3+} (5.8 mol %), there is no significant changes on the emission as the amount of Er^{3+} reached up to 0.9 mol%. Existence of ZrO_2 tetragonal phase at lower temperature is due to presence of RE doping and rapid thermal annealing of the film. Crystallization of the film gives rise to sharp and narrow peak of Er^{3+} emission spectrum. Films with Yb^{3+} ions co-doping demonstrate less crystallinity, as characterized by Raman spectroscopy and X-Ray Diffraction (XRD). XRD study also show that the samples with Yb^{3+} co-doping have small crystallite size, which is consistent with Atomic Force Microscopy (AFM) measurement as the samples demonstrate low surface roughness.

ACKNOWLEDGEMENT

In the name of Allah The Most Beneficent and The Most Merciful for giving me the strength in completing this work and thesis. In the first place, I sincerely would like to thank to my supervisor, Prof. Dr. Mohd Kamil Abd. Rahman for his patient supervising, valuable advice, attention and guidance at all stages in my research work. With his guidance and support, I was able to complete this study. I also owe great thanks to my co-supervisor, Assoc. Prof. Dr. Umi Sarah Jais for useful discussion and teaching me the ways of the sol gel method and thin films preparation. Many thank to Prof. Dr. Maurizio Ferrari from *Consiglio Nazionale delle Ricerche – Institute of Photonics and Nanotechnologies* (CNR-IFN), University of Trento,Italy for his cooperation. Science officer, Nurul Wahida is thanked for helping me with the Photoluminescence, Raman Spectroscopy and Atomic Force Microscopy measurements. I would like to thank Ministry of Science, Technology and Innovation (MOSTI), Malaysia for providing scholarship for my Masters study. Furthermore, I am grateful for the excellent laboratory facilities provided by Faculty of Applied Sciences, Universiti Teknologi MARA, Shah Alam during my study. Most importantly, thanks to my beloved parent their love, trust and support throughout my study. I appreciate the support of my colleagues from the UiTM Photonics Research Group for whom I had the pleasure of knowing and working with. Not to forget, thanks to my friends who always support and motivate me during my study.

CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND

Optical communication systems have proven a great potential for high speed data transmission over the last decades. There are a huge number of end users of online data transfer and telecommunication systems. This trend leads into a demand for higher capacity and speed of the data transmission rate in the optical network. Optical fiber technology has been used for telecommunication system to transmit data, voice and video in the late of 1970's (Yeh, 1979).

Erbium Doped Fiber Amplifier (EDFA) operates in the standard telecommunication wavelength of 1.5μm and it is used in long distance communication network since it has compatibility with the fiber optic transmission link. The EDFA, commonly has a length of more than 10 meters has been used in the telecommunication and internet networks due to high gains, low threshold powers, etc. (Bonar and Aitchison, 1996). With large end product up to 50 meters, which is consuming space, it is a limitation for EDFA to be integrated with other devices on the compact devices (Jagerska, 2005). Furthermore, the needs for small (few centimetre of dimension) and low cost amplifier for short haul metropolitan networks is increased rapidly (Mukherjee, 2000) since the EDFA is high cost for home network and it uses up high pump power which is very pricey.

Due to fast technology and desire to make an improvement of the system network capacity, planar optical waveguide amplifier for photonic integrated circuit (PIC) has been developed. Erbium Doped Waveguides Amplifier (EDWA) in planar thin film form which is more compact is a good candidate and it is under development. In small and compact size of photonic integrated circuit, amplification is achieved in a short path of few cm long, but in highly doped of erbium compared to the fiber (typically 40m). Higher doping of erbium ion is needed to attain the same optical gain as in fiber amplifier (Snoeks, Hoven and Polman 1996; Kik and Polman, 1998). The working principle of the planar optical thin film is same as the fiber amplifiers, which imply the confinement of light (Lifante, 2003). Furthermore, active