UNIVERSITI TEKNOLOGI MARA

PREPARATION AND CHARACTERIZATION OF MULTILAYER POROUS SILICON NANOSTRUCTURE FOR BRAGG GRATING WAVEGUIDE

AHMAD AFIF SAFWAN BIN MOHD RADZI

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

Faculty of Applied Sciences

June 2017

ABSTRACT

Materials characterization for Bragg grating application was presented in this thesis. Multilayer porous silicon is the basic material for Bragg grating structure and was directly etched on silicon wafer. Multilayer porous silicon with alternating values of thickness and refractive index were characterized and verified. The optimization of parameters during electrochemical etching process of silicon wafer has leads to the realization of multilayer properties of porous silicon. The optical properties of Bragg grating structure depends highly on the thickness and periods of multilayer porous structure, meanwhile electrical properties relies on surface homogeneity and internal structure of porous silicon. It is well known from previous studies that the modulation of multilayer porous silicon was much affected by the hydrofluoric acid concentration of electrolyte, etching time, and current density during the etching process. Surface morphology investigation from atomic force microscopy shows that surface roughness was decreased when higher etching time applied to the samples. FESEM shows the multilayer porous silicon structure with alternating contrast of high and low porosity layer. The average refractive index, n for 15.38 mA/cm^2etching current density is from 1.530 to 1.850 and for 46.15 mA/cm^2current density is from 1.350 to 1.450. Average alternating thickness for multilayer structure is 163-200 nm for 10 seconds etching time, 255-300 nm for 20 seconds etching time and 341-387 nm for 30 seconds etching. Reflectance measured from multilayer porous silicon structure has produced a significant reflectivity of approaching 40% within the telecom C-band regions. Low reflectivity of around 2-10% within the visible region is corresponding to high light absorption from photoluminescence effect on the porous silicon surface. Photoluminescence study also revealed that higher etching time will produce higher electronic band gap energy. Nitrogen gas isotherm shows a good pore size distribution and high specific surface area also obtained from samples. This fabricated multilayer porous silicon with Bragg grating waveguide ability has a big potential as optical and gas sensor in many areas such as aerospace, safety and industry.

ACKNOWLEDGEMENT

First and foremost, I would like to say Alhamdullillah, thank you Allah for giving me strength and mercy throughout my research work and upon completing this thesis. I would like to thank my parents, Mohd Radzi Bin Mohd Salleh and , my sisters and brothers-in-law for their patience and support during my study.

I would like to extend my gratitude to my main research supervisor, Professor Dr. Saifollah Abdullah for his assistance, advices and encouragement throughout my research and guiding my thesis work. A special thanks to my co-supervisor, Professor Engr. Dr. Mohamad Rusop Mahmood for his advices and guidance during my stay at NANO-SciTech Centre. I would like to express my gratitude to Mrs. Nurul Izrini Ikhsan for trusting me to assist her FRGS project and FYP students and providing me allowances during my study.

I would like to thank all the technical support I received throughout my study especially from Mr. Salifairus, Mrs. NurulWahida and Mr. Azlan of NANO-SciTech and NANO-ElecTronic Centres. Special thanks to my laboratory associates at NANO-SciTech and NANO-ElecTronic Centres. Thank you all for making my stay wonderful and resourceful.

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CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND OF STUDY

1.2 BRAGG GRATING WAVEGUIDE

Bragg grating waveguide (BGW), also known as fiber Bragg grating (FBG) in optical fiber study is playing an increasingly important role in cutting-edge communications and sensors architectures [2, 3]. As the trend toward expanding bandwidth gains additional momentum, so will the demands on Bragg grating technology. An FBG in optical fiber field is a type of distributed Bragg reflector (DBR) mated in a short segment of optical fiber [4-6]. The reflector reflects particular wavelengths of light and transmits all others. This is achieved by adding a periodic variation to the refractive index of the fiber core, which generates a wavelength specific dielectric mirror. Therefore this device can be used as an inline optical filter to block certain wavelengths, or as a wavelength-specific reflector.

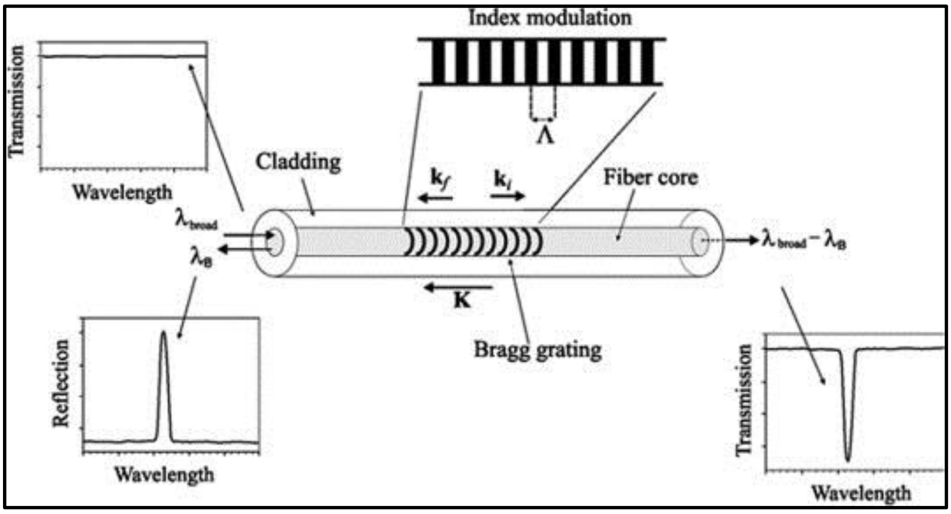

Figure 1.1: Principle of reflection and transmission from a FBG [7]

Figure 1.1 shows the working principle of a FBG [7]. As λ_{broad} move towards the Bragg grating structure, index modulation of the FBG reflects a particular wavelength, λ_B and transmits all other wavelengths, λ_{broad}-λ_B. From wavelength