

DEVELOPMENT OF TEMPERATURE-  
INSENSITIVE FIBRE BRAGG GRATING  
BASED PRESSURE TRANSDUCER

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I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

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## **STUDENT'S DECLARATION**

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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## ABSTRAK

Penderia tekanan adalah peralatan penting dalam bidang pengukuran tekanan. Dalam kajian ini, penderia tekanan dengan diafragma aluminium yang berasaskan penderia fiber Bragg grating (FBG) dengan strategi pampasan suhu dibentangkan. Penderia yang berasaskan FBG adalah baik untuk aplikasi tertentu seperti dalam bidang biomedikal, dalam kebuk pembakaran dan kebuk tekanan; terutamanya yang melibatkan persekitaran yang kasar dan gangguan elektromagnetik yang tinggi. Salah satu cabaran terbesar dalam penggunaan penderia berdasarkan FBG adalah paparan spektrum yang tidak stabil kerana wujudnya variasi suhu persekitaran. Fenomena ini menghasilkan perubahan besar dalam bacaan tekanan, dan seterusnya menyumbang kepada masalah ketepatan dalam pengukuran. Untuk mengatasi masalah ini, kajian ini memperkenalkan satu pendekatan untuk menyelesaikan ketidakseragaman paparan keluaran penderia dengan mengaplikasikan dua FBGs, yang mana salah satu dilekatkan pada pusat diafragma (sensor FBG) dan satu lagi pada tapak transduser tekanan (rujukan FBG). Ketidakseragaman paparan keluar spektrum dapat dihapuskan dengan menggunakan normalisasi variasi panjang gelombang Bragg dari sensor FBG ( $\Delta\lambda_{FBG1}$ ) dengan variasi panjang gelombang Bragg dari rujukan FBG ( $\Delta\lambda_{FBG2}$ ). Hasilnya, menunjukkan bahawa transduser tekanan FBG ini mempunyai sensitiviti 2.8485 nm/MPa pada suhu bilik dalam lingkungan 22.9°C hingga 27.8°C dan pekali pemasangan linear 99.97% dalam julat tekanan dari 0 MPa hingga 0.5 MPa. Penderia tekanan FBG ini dengan teknik pampasan suhu terbukti sesuai untuk pengukuran tekanan gas dengan ralat purata 2.32% berbanding dengan tolok tekanan konvensional yang terdapat di pasaran.

## ABSTRACT

Pressure sensors are the essential equipment in the field of pressure measurement. In this study, an aluminium diaphragm-based fibre Bragg grating (FBG) pressure transducer with temperature compensation strategy is presented. FBG-based sensors are good for certain applications, such as biomedical, combustion chamber and pressure vessel; particularly those involving harsh environment and high electromagnetic disturbance. One of the greatest challenges for utilising an FBG-sensor based transducer is the unstable output spectrum due to temperature variations. This phenomenon results in a huge variation in pressure readings, thus contributing to accuracy problem. To overcome the problem, this study introduced an approach to solve the inconsistency of sensor output by utilising two FBGs that were bonded at the centre of the diaphragm (FBG sensor) and at the base of the pressure transducer (FBG reference). The inconsistency of wavelength was eliminated by normalising the Bragg wavelength variation from the FBG sensor ( $\Delta\lambda_{FBG1}$ ) with respect to Bragg wavelength variation from the FBG reference ( $\Delta\lambda_{FBG2}$ ). The results indicated that the FBG pressure transducer had a sensitivity of 2.8485 nm/MPa at room temperature within the range of 22.9°C to 27.8°C and a linear fitting coefficient of 99.97% in a pressure that ranged from 0 MPa to 0.5 MPa. This FBG pressure transducer with temperature compensation technique was proven to be suitable for the pressure measurement of gas with an average error of 2.32% as compared to the conventional pressure gauge available in market.

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## LIST OF SYMBOLS

$A$	Area
$\lambda_B$	Bragg wavelength
$t$	Diaphragm thickness
$p_e$	Effective photoelastic
$n_{eff}$	Effective reflective index
$F$	Force
$\lambda_o$	Laser output
$y_{max}$	Maximum deflection
$\Lambda$	Period of Bragg grating
$\nu$	Poisson's ratio
$P$	Pressure
$P$	Pressure applied
$r$	Radius of diaphragm
$\varepsilon$	Strain applied
$\Delta T$	Temperature changes
$\alpha$	Thermal coefficient
$\xi$	Thermo-optic coefficient
$x$	Value of pressure
$y$	Value of wavelength
$\Delta\lambda_B$	Wavelength changes
$E$	Young's modulus



## LIST OF ABBREVIATIONS

ABS	Acrylonitrile butadiene styrene
ASE	Amplified spontaneous emission
CRC	Canadian Communication Research Centre
CFRP	Carbon fibre reinforced polymer
EMI	Electromagnetic interference
EOM	Electro-optic modulator
FP	Fabry-Perot
FBG	Fibre Bragg grating
FEA	Finite element analysis
nm	Nanometre
N	Newton
OFS	Optical fibre sensor
OSA	Optical spectrum analyzer
Pa	Pascal
PD	Photodetector
SHM	Structural health monitoring
SLD	Superluminescent diode
SLED	Superluminescent light emitting diode
OTF	Tunable optical filter
UV	Ultra violet

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