APPLICATION OF FIBER BRAGG GRATING SENSORS IN MONITORING CIVIL ENGINEERING STRUCTURES

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ABSTRACT

Fiber Bragg grating (FBG) is finding increasing usage in aerospace guidance, marine structures and civil engineering applications. This is due to their lightweight, non-obtrusive, immunity to electromagnetic interference, high bandwidth and sensitivity, and solid-state properties. Analysis of case studies is carried out to study the applications of Fiber Bragg grating sensors in civil engineering structures. In this research, a fiber Bragg grating sensing system for strain measurement is being described. Low cost and simple grating-based FBG has been used to produce the strain and induce Bragg wavelength shifts. A brief experimental testing on an instrumented metal plate showed that the proposed system is able to perform strain measurements with linear response. A general guideline is proposed on the fabrication and installation of fiber Bragg gratings for structural monitoring in local conditions.

ABSTRAK

Gentian optik parutan *Bragg* semakin banyak digunakan dalam bidang aerospace, struktur marine dan juga bidang kejuruteraan awam. Ini adalah disebabkan oleh ciri gentian optik yang ringan, kurang kelihatan, terjamin selamat daripada gangguan elektromagnet dan mempunyai sensitiviti yang tinggi. Analisa ke atas beberapa kes telah dijalankan untuk menyelidik aplikasi gentian optik parutan *Bragg* dalam struktur kejuruteraan awam. Dalam penyelidikan ini, sistem pengesan gentian optik parutan *Bragg* untuk mengukur terikan telah digambarkan. Gentian optik *Bragg* harga rendah telah digunakan untuk menghasilkan terikan dan menyebabkan perubahan panjang gelombang *Bragg*. Kajian yang ringkas telah dijalankan ke atas plat aluminium dan menunjukkan sistem pengesan terikan yang dicadangkan berupaya mungukur terikan. Panduan umum mengenai pemprosesan dan pemasangan gentian optik parutan *Bragg* telah dicadangkan untuk penggunaan dalam keadaan tempatan.

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LIST OF SYMBOLS

C	-	Celcius
cm	-	centimeters
CW	-	continuous wave
DFB	-	Distributed FeedBack
FBG	-	Fiber Bragg Gratings
FRC	-	Fiber-reinforced concrete
J	-	Joule
K	-	wave vector
kN	-	kilo Newton
m	-	meters
MCMV	-	Mine Counters Measures Vessel
MHz	-	Mega Hertz
nm	-	nanometers
OTDR	-	Optical Time Domain Reflector
RNN	-	Royal Norwegian Navy
T	-	temperature
UV	-	ultraviolet
ε	-	strain
π	-	Pie
Λ	-	period of the grating
λ_B	-	Bragg wavelength
Λ_0	-	starting period
Λ_1	-	linear change (slope) along the length of the grating
Δn	-	Ct^b ($C = 4.3x10^{-5}$, $b = 0.32$, t is in minutes)

με	-	micro strain
°	-	degree
v_i	-	magnitudes of the incident
v_s	-	magnitudes of the scattered
θ b	-	angle with respect to the fiber axis

CHAPTER 1

INTRODUCTION

1.1 General

Strain gauges are important for their ability to measure mechanical strain in materials and structures. A wide variety of existing methods are used and being developed for measuring strain and in many situations there is a need to make contact strain measurements at high temperature.

A number of researchers have developed fiber-optic strain measurement methods using a wide variety of optical sensor concepts since the late 1970s which includes fiber Bragg gratings. Fiber Bragg gratings have a potential to operate in high temperature environments, provided the fiber is suitably protected. Several different optical sensing techniques have found their way into the market place but fiber Bragg gratings (FBGs) are commercially one of the most successful. It is finding increase usage in aerospace guidance, marine structures and civil engineering applications. This is due to their lightweight, non-obtrusive, immunity to electromagnetic interference, high bandwidth and sensitivity, and solid-state.

The usage of fiber Bragg gratings in civil engineering applications include vibrations sensors, damage detection, and strain, temperature and electromagnetic field sensors.

The development of modern optical-based sensors like fiber Bragg gratings sensors and its usage can lead to real time measurements, monitoring the formation and growth of defects. Optical fiber sensors also allow for data to be transmitted over long distances to a central monitoring location. The main advantage of optical fiber in civil engineering applications is that they may either be attached to an existing structure or embedded into concrete decks and supports.

There are several types of fiber Bragg gratings which includes common Bragg reflector, the blazed Bragg grating, and the chirped Bragg grating. Different types of Bragg gratings show different characteristics and provide different applications to civil engineering structures.

1.2 Significance of Research

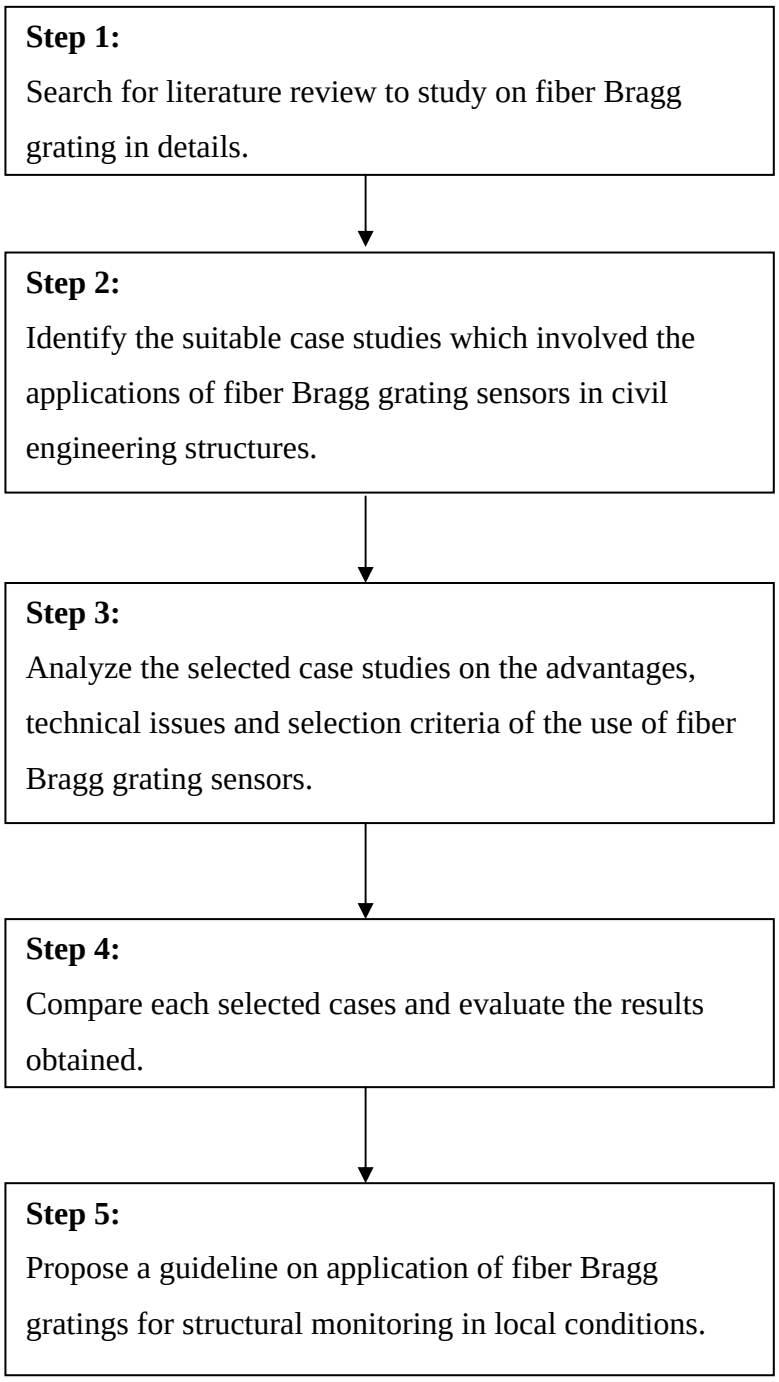
There is a growing concern over the state of civil infrastructure in countries over the world. High fraction of infrastructure is deficient and deteriorating which leads to a high demand of maintenance and rehabilitation in civil engineering structure. Owing to the harsh environment found in the construction industry and the large size of civil structures, conventional methods like electrical strain gauges have found to be less efficient in real time measurement. Therefore, techniques have recently been researched that allow the benefits of optical precision while minimizing the disadvantages of conventional instruments. Fiber optic based sensors especially fiber Bragg gratings offers excellent means of a stable strain measurement for long term monitoring. However, there are little knowledge and applications of fiber Bragg grating sensors in civil engineering in this region. Fiber Bragg gratings base sensors are expected to be of significant influence on the development of structural health monitoring techniques.

1.3 Objectives and Scope of Study

The objectives and scope of the study are:

1. To study the material properties, working principles and instrumentation requirements of fiber Bragg gratings sensors.
2. To study the applications of fiber Bragg gratings in structural monitoring.
3. To carry out comparison study of different application of fiber Bragg gratings in bridge structures.
4. To propose a general guidelines on application of fiber Bragg gratings for structural monitoring in local conditions.

1.4 Methodology



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