



PhD in Information Technology and Electrical Engineering

Università degli Studi di Napoli Federico II

PhD Student: Vincenzo Romano Marrazzo

XXXIII Cycle

Training and Research Activities Report – First Year

Tutor: Giovanni Breglio



1. Information

I Graduated in Electronics Engineering from University of Naples “Federico II” in March 2017 with the thesis “Design and Characterization of an Interferometric Module for High Gamma Measurement” developed at TUDELFT (NL). I participated at XXXIII cycle of Information Technology and Electrical Engineering (ITEE) PhD, winning a not founded scholarship. My tutor is Prof. Giovanni Breglio and my research activity concerns Photonic and Optoelectronic topics.

2. Study and Training activities

During my first year I attended many courses and seminars to improve my knowledge in many different topics and earn module and seminar credits.

Courses:

- Circuiti e Componenti Ottici;
- System on Chip;
- Elettromagnetismo e Relatività.

Seminars:

- Logic-Based Languages and Systems for Big Data Applications;
- Tailoring Waves at the Extreme with Metamaterials;
- Near-Zero-Index Photonics;
- How to publish a scientific paper.

External courses:

- Ph.D. Summer School of Information Engineering “Cyber Physical Systems: Sensors, Signal Processing and Applications”;
- SIE Ph.D. School “Reliability in Electronics”.

Credits year 1								
	1	2	3	4	5	6		
Estimated	bimonth	bimonth	bimonth	bimonth	bimonth	bimonth	Summary	
Modules	20	0	0	4	5	0	9,4	18,4
Seminars	5	0	1	1	0,2	0	0	2,2
Research	35	10	9,2	5	4,8	10	0,6	40
	60	10	10	10	10	10	10	60

3. Research activity

My research activity is about the optical fiber sensors (Fiber Bragg Grating) application in many environment and the development of an innovative fast and low cost interrogator device to pick up the information from the sensor measurement. A fiber Bragg grating (FBG) is a type of distributed Bragg reflector constructed in a short segment of optical fiber that reflects particular wavelengths of light and transmits all others. This is achieved by creating a periodic variation in the refractive index of the fiber core, which generates a wavelength-specific dielectric mirror. A fiber Bragg grating can therefore be used as an inline optical filter to block certain wavelengths, or as a wavelength-specific reflector. FBGs are used not only as a selective mirror or filter to block certain wavelengths, Bragg

wavelength characteristic is sensible even to temperature and strain: with temperature the period become wider or smaller in relation to temperature coefficient, also the refractive index is sensible to thermo-optic effect, so even Bragg wavelength have to be sensible with temperature. Further it's known that it is sensible also to the strain of material.

The intrinsic characteristics of FBG sensors (lightness, small dimensions, immunity to electromagnetic fields, multiplexing and simplicity of cabling) make them suitable to a wide number of applications in different environments such as: harsh environments, structure health monitoring, aeronautical, automotive, biomedical and others. An example is given in a field of interest that is becoming more and more attractive due to several properties of FBG sensors (biocompatibility, chemical inertness and low size above all) that is the robot-assisted microsurgery. During my first year, thanks to the collaboration with ICAROS (Interdepartmental Centre for Advances in Robotic Surgery) centre Federico II, a three-fingered underactuated miniature tool for minimally invasive surgery is being developed. In this field of application, the force sensing ability can give to the surgeon operator to have tactile and palpate feedback. Nowadays, at the state of art, a sensor with a reliable force sensing ability is not available. A possible solution is given by FBG sensors: integrating three FBGs along a distal finger and using them as force sensor. One of the aim of the work has been to experimentally characterize the sensor system to obtain the calibration of 6-axes degree of freedom coefficient matrix that relates the wavelength variation in function of 3D forces applied to the finger.

In another topic, due to the collaboration with OptoSmart s.r.l and Leonardo s.p.a, an airplane anti ice system is under development. A test bench has been proposed and a numerical simulation approach as well to validate a prototype in which FBGs are used to monitor the external temperature and trigger the defrosting system.

As already said the FBGs are the most popular technology for the measurement of temperature, deformations, strains and vibrations, but the expensiveness intrinsic in many FBG interrogation technique severely limits the range of potential application. During this year, the main research topic was about the development of an inexpensive, fast, compact and wide-range FBG interrogator. Due to the employing of an Array Waveguide Grating (AWG), that works as an integrated prism, is possible to filter the wavelength reflected by the sensor in function of strain or temperature that is applied on. By the power ratio of two adjacent channels is possible to extract information, by mathematical manipulations, about the wavelength value. This is possible since every AWG output channel can be approximated with a gaussian shape of a certain order (the same for the FBG output spectrum). The better the AWG is in term of ripple, crosstalk and same frequency spacing for all channels, the better will be the wavelength sensing in terms of precision. Actually, analytical and numerical simulations has been done obtaining really good results in accordance with literature. The interrogator has no movable part and needs only of a broadband light spectrum, a circulator, an Array Waveguide Grating as wavelength filter, many photodetectors to convert the optical in electrical signal and a customized post-processing electronic section.

Collaborations:

- ICAROS (Interdepartmental Centre for Advances in Robotic Surgery), Università di Napoli "Federico II";
- Leonardo s.p.a;
- DII (Dipartimento di Ingegneria Industriale), Università di Napoli "Federico II".

4. Products

Journal:

- i. Selvaggio M. et al., “The MUSHA underactuated hand for robot-aided minimally invasive surgery”. *Int J Med Robotics Comput Assist Surg*. 2018;e1981

Conference:

- i. Marrazzo V.R. et al., “Fiber Bragg Grating sensors for biomedical and automotive applications”, In SIE2018, 50th Annual Meeting of Associazione Societa' Italiana di Elettronica;
- ii. Marrazzo V.R. et al., “Analytical and Numerical Simulations of a Fast Wide-Range AWG-Based Interrogation Technique for FBG Sensor”, in 7th International Symposium on Sensor Science (under revision);
- iii. Marrazzo V.R. et al., “FBG-based monitoring system for smart tires application with wireless instrumentation under real- time rolling condition”, in 7th International Symposium on Sensor Science (under revision);
- iv. Riccio M. et al., “Wireless electronic sensing system for real-time monitoring of pneumatic tires”, in 7th International Symposium on Sensor Science (under revision).

5. Conferences and Seminars

- i. 50th SIE meeting – Naples – Italy – June 2018 – Poster.

6. Activity abroad

I didn't spend time abroad.

7. Tutorship

- As Bachelor of Science correlator, the students Eliana La Frazia and Valerio Rosiello have been supported by me for their BSc thesis during the collaboration with ICAROS.
- During this year I've won a tutor scholarship. My work as tutor consists of exercises explanation about Analisi I and Fisica I subjects (26 hours total).
- I also had laboratory exercise in Integrated Photonics subject (2 hours).