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**Leszek R. Jaroszewicz**  
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**Maciek Wieczorek**, WIMA Convention (Poland)  
**Magda Wieczorek**, WIMA Convention (Poland)

## Introduction

Following the successful Workshops in Peebles (1998), Santander (2004), Napoli (2007), and Porto (2010), the Photonics Society of Poland invites the optical fibre sensors community to Kraków (Poland) in 2013 for the fifth edition of the European Workshop on Optical Fibre Sensors, 5th EWOFs'2013. This initiative aimed to promote a scientific meeting with a high level of interaction between participants, enabling an open debate and the assessment of new concepts, technologies and applications in the domain of optical fibre sensors, as well as establishment of new collaborations and networks. EWOFs'2013 also intended to complement in time and geographical location the international conferences in this area, and in particular the International Conference on Optical Fibre Sensors (OFS).

Addressing scientific achievements, technological applications, and commercial exploitation, our goal was to create a programme that would be attractive for both academics and professionals working in this area. We intended to assure a set of high-level invited talks that would consider, not only topics related to optical fibre sensors, but also other scientific domains that might cause an impact on their future development. Also, we were seeking to strengthen the Workshop's unique features, including the discussion of technical contributions between young researchers and experienced scientists, identifying and highlighting the most significant contributions. Since everyone's active participation was an important issue, we also intended to organize a Workshop with an invigorating and appealing Social Programme that would encourage a true scientific socialisation.

Since past and future meet in the present, we intended to make EWOFs'2013 an opportunity to promote productive interactions between young scientists, engineers, and mature practitioners in this scientific and technological adventure around the subject of optical fibre sensors. At the same time, we wanted to honour the pioneers who have significantly contributed to its development, and encourage young researchers who had chosen to work in this field. EWOFs'2013 took place a decade after the beginning of this new century, of this new millennium. Humankind is currently facing great challenges in the search for a future characterized by global justice, fair and sustainable progress, as well as economic and social wealth. This is a demanding, yet necessary purpose, and science and technology create opportunities so that society may evolve in that sense. In its specific domain, EWOFs'2013 should encourage scientific and technological advances, and provide a forum where young and experienced researchers and entrepreneurs may interact in a mutually profitable relationship that is oriented to the development of optical fibre sensors and its impact on society. Pursuing this central objective, we committed ourselves to do our best to create the proper atmosphere. Therefore, our intention was to invite all of you to

participate in this meeting that took place in the metropolitan area of Kraków, a historical capital of Poland, in May 2013.

**Tomasz R. Woliński**  
**Wojciech Gawlik**  
**Brian Culshaw**  
**José Miguel López-Higuera**  
**William N. MacPherson**

## Invited Lectures

### 1 Special session (Monday, 20 May 2013)

#### **Novel fibres for sensing**

Jonathan Knight, University of Bath, United Kingdom

Conventional optical fibres have been widely exploited in sensing systems, and have led to fibre sensing systems being a preferred solution in many environments. Recent and current developments in fibre-optic technology are leading not just to a range of new fibres, but to possibilities for designing future systems incorporating purpose-designed fibre structures. We describe recent developments in the burgeoning field of speciality and microstructured fibre optics, in the context of their relevance for future sensing applications.

#### **The ever-surprising supercontinuum**

John M. Dudley, University of Franche-Comté, CNRS Institute FEMTO-ST, Besançon, France

The generation of new frequencies from laser light has been extensively studied since the early 1960s since shortly after the invention of the laser itself. The particular process of supercontinuum generation arises when a narrowband laser undergoes extreme spectral broadening in a nonlinear medium to yield a spectrally continuous output. Supercontinuum generation was first reported by focusing pulsed lasers into bulk crystals and glasses, but it was its observation in photonic crystal fiber in 1999 that revolutionized the field. Bright, broadband and spatially coherent, supercontinuum light reveals has enabled new applications in precision metrology, imaging and microscopy, and also reveals fascinating nonlinear physics with unexpected links to the infamous and destructive "rogue waves" on the ocean. This talk will provide a survey of recent results in our understanding of supercontinuum generation and its applications.

#### **Minimally invasive 3D tissue imaging and elastography with optical fibre needles**

David D. Sampson, Optical+Biomedical Engineering Laboratory, School of Electrical, Electronic and Computer Engineering Centre for Microscopy, Characterisation and Analysis The University of Western Australia, Perth, Australia

Optical fibers provide a unique vehicle for designing ultra-small, minimally invasive microscopic imaging and monitoring systems for use within the human body. Embedding of such optical probes within a rigid needle provides access to deep tissues impossible with surface-based imaging, and as well, a natural actuator for optical elastography. In this talk, we present a series of advances in

engineering the optics of such systems, and in their use in 3D tissue morphological micro-imaging and probing of the micro-mechanical properties of tissue. We describe applications in the breast, lungs and skeletal muscle.

### **Optofluidics: a new tool for sensing**

Romeo Bernini, CNR-IREA, Italy in cooperation with Genni Testa, Gianluca Perisichetti, IREA-CNR, Italy; Luigi Zeni, DII-SUN, Italy and Pasqualina M. Sarro, TuDelft, the Netherlands

Over the last years optofluidics has emerged has a very promising field for sensing applications. Optofluidics essentially merges optics and microfluidics at micro and nano scales. This approach permits to realize innovative optical system in which fluids can act as an optical material providing a providing significantly enhanced performance and functionality that cannot be achieved without this seamless integration. In particular, the possibility to guiding light through a fluid offers very interesting applications in sensing fields enabling unprecedented sensitivity and limit-of-detection.

This paper reviews the present state of the art on optofluidics devices and microsystems for sensing applications, discusses emerging trends, and presents recent results of research into optofluidic sensors at the Institute for Electromagnetic Monitoring of the Environment (IREA-CNR), Naples. The developments discussed in detail include optofluidic waveguides and devices like photonic crystals and photonic crystal fibres, as well as interferometric structures such as ring resonators, Mach-Zehnder interferometers, and Fabry-Pérot cavities. Examples of applications of optofluidic sensors for chemical and biological analysis are given.

### **Nanoscale optical and magnetic imaging using color centers in diamond nanoparticles**

Jean-François Roch, Laboratoire Aimé Cotton, CNRS, Université Paris-Sud & ENS Cachan, France

Numerous works have been devoted to the development of efficient probes for nanoscale imaging. I will report the application of optically and magnetically active nanodiamonds to nanoscale mapping using the unique properties of the nitrogen-vacancy (NV) color center. The NV center is hosted in a diamond nanocrystal which is attached to the tip of an atomic force microscope. Combining nanometer scale spatial resolution, high sensitivity and room temperature operation, this NV-based scanning microscope opens up numerous perspectives in nanotechnology.



2 Regular session (Monday, 20 May 2013)

**Fibre optics as a functional platform to combine new science**

Kyunghwan Oh, Yonsei University, South Korea

Fibre optics has paved a solid pathway to information revolution in 20th century, and optical fibres are recently becoming a technical commodity with well-defined international standards. With maturing communication applications, fibre optics has been applied to other related areas such as sensing, and metrology but these applications have been moderate expansions. In this talk, a few innovative and venturesome attempts to combine fibre optics with other areas of emerging science will be reviewed as below:

1. Combining fibre optics and Fourier optics for micro beam shaping
2. Combining Plasmonics with fibre optics for novel light source
3. Combining Atmospheric Plasma with fibre optics for new active fibre devices

Social event (Monday, 20 May 2013)

**Sagnac effect centenary: a special occasion to share the "serendipity" of the fibre-optic gyroscope**

Herve C. Lefevre, iXBlue, Marly le Roi, France

One hundred years ago, Georges Sagnac demonstrated that a closed ring interferometer detects rotation with respect to inertial space. This effect, bearing now his name, remained a physics curiosity for many decades until the laser, in the 1960s, and fibre optics, in the 1970s, opened ways to enhance the effect by recirculation and make sensitive measurement. The word "serendipity" was used very early about the fibre-optic gyroscope, or FOG, and this talk will present several examples showing that "nature is rarely that cooperative."

There was also an important engineering work, but taking big advantage of technologies developed for optical fibre communication. Today, best results of FOG long-term bias stability go down to the  $10^{-5}$  °/h range, which corresponds to a phase difference of  $10^{-9}$  radian! FOG was firstly seen in the 90's as limited to medium-grade performance, but it has actually a unique potential and today it surpasses its well-established competitor, the ring-laser gyroscope, or RLG.

3 Regular session (Tuesday, 21 May 2013)

**Multicomponent fibres: a new platform for nanophotonic devices**

Markus A. Schmidt, Institute for Photonic Technologies, Jena and Max Planck  
Institute for the Science of Light, Erlangen, Germany

Hybrid optical fibres are fibre-type waveguides including multimaterial large-aspect ratio nano- and microstructures. Using our pressure-assisted melt-filling approach various hybrid waveguides have been fabricated inside photonic crystal fibres by filling the air holes with materials such as noble metals, semiconductors, fluids or low-melting compound glasses. In this talk I will review our latest results on fibre-based plasmonics and nonlinear optics. I will also give an outlook about ongoing experiments in our lab and future developments of the entire field of in-fiber devices.

4 Regular session (Tuesday, 21 May 2013)

**Enhanced sensing sensitivity using slow light: myths and realities**

Luc Thévenaz, EPFL Swiss Federal Institute of Technology, Switzerland

The common belief that sensing sensitivity can be improved by slowing down a light signal – with the underlying idea to let more time for the interaction – turns out to be misleading and results in erroneous concepts. The interaction efficiency is actually strengthened by optical systems enhancing the electric field intensity, which can lead only coincidentally to a slowing down of the light. After explaining the physical nature of the light-atom interaction and the essential differences between material and structural slow light, it will be demonstrated through simple experimental tests that slowing down the light does not lead automatically to enhanced sensing and a better sensitivity can be only obtained using smartly designed structural slow light systems.

Gala dinner (Tuesday, 21 May 2013)

**Novel light-matter interactions in microstructured fibers**

Philip St. J. Russell, Max Planck Institute for the Science of Light, Erlangen,  
Germany

The talk will touch on optomechanical and optoacoustic nonlinearities in nanostructured fibres, optothermal particle trapping in hollow core photonic crystal fibre (PCF) and the optical properties of helical solid-core PCF.

5 Regular session (Wednesday, 22 May 2013)

**Fibre optic sensing based on modal interferometry**

José Luís Santos, INESC Porto in cooperate with O. Frazão INESC Porto,  
J.M. Baptista, Universidade de Madera, P.A.S. Jorge INESC Porto, Portugal

Fibre optic modal interferometry has been around as a sensing concept since the outcome of fibre optic sensing. Initially supported by the utilization of standard Hi-Bi fibres associated to polarimetric modal interference, later this sensing approach evolved to modal interference based on spatial modes propagating in the core and in the cladding with coupling performed by fibre devices such as long period gratings and tapers, and more recently on several types of modes propagating in photonic crystal fibres. This presentation will address fibre optic sensing based on modal interferometry and configurations of different type researched in last years will be presented and their performance compared.

