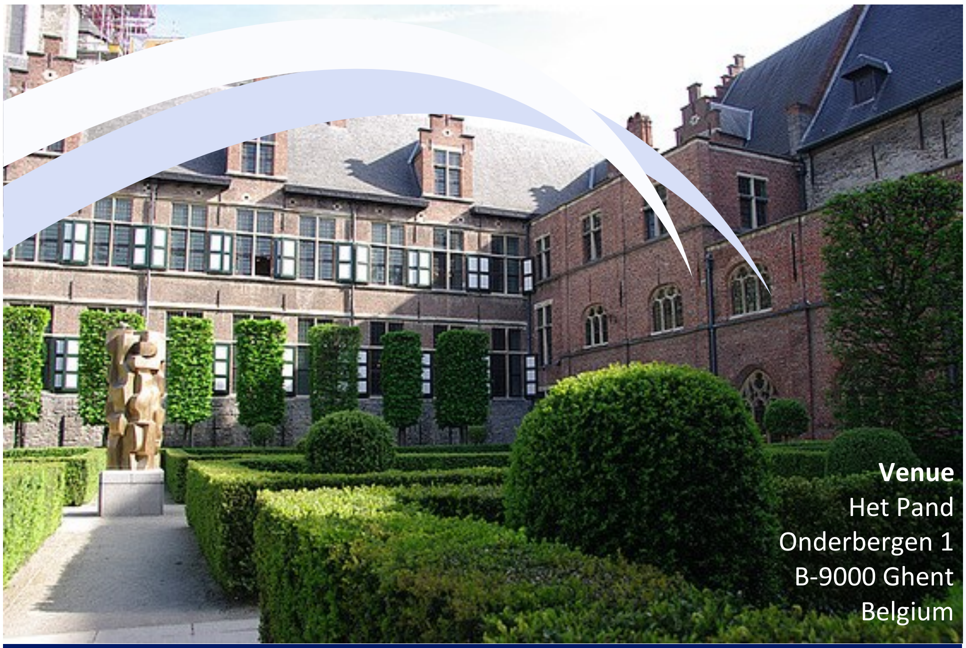
1st International Workshop on EMBEDDED OPTICAL SENSORS FOR COMPOSITE MATERIALS

PROGRAMME and INFORMATION

7-8 October 2013

Ghent, Belgium



Venue
Het Pand
Onderbergen 1
B-9000 Ghent
Belgium

PROGRAMME OUTLINE

07 October 2013

09h00—10h45 SESSION 1—Introduction

11h15—13h00 SESSION 2—Production and Cure Cycle Monitoring

14h30—16h00 SESSION 3—Structural Health Monitoring

16h30—17h30 SESSION 4—European Projects

18h00—19h30 WELCOME RECEPTION

08 October 2013

09h00—11h00 SESSION 5—Novel Sensors

11h30—13h00 SESSION 6—Applications and Engineering

14h00—15h00 SESSION 7—Demonstrations

15h15—16h15 SESSION 8—Panel Discussion

PARTNERS

WORKSHOP COMMITTEE

Prof. Francis Berghmans
Vrije Univ. Brussel (BE) & COST TD1001

Prof. Gerald Farrell
Dublin Inst. of Technology (IE) & COST TD1001

Dr. Wolfgang Habel
BAM (DE) & COST TD1001

Dr. Markus Kaufmann
Sirris Leuven-Gent Composites Application Lab (BE)

Dr. Geert Luyckx
IMEC / Univ. Gent (BE)

Dr. Sinead O'Keeffe
Univ. Limerick (IE) & COST TD1001

Prof. Steve Vanlanduit
Vrije Univ. Brussel (BE)

Prof. Geert Van Steenberge
Univ. Gent (BE)

Prof. Marc Wuilpart
Univ. Mons-Hainaut (BE) & COST TD1001

Prof. Francis Collombet
Institut Clément Ader – Univ. Toulouse (FR)

Prof. Laurent Robert
Institut Clément Ader - Ecole des Mines (FR)

1st International Workshop on EMBEDDED OPTICAL SENSORS FOR COMPOSITE MATERIALS

07 October 2013

SESSION 1: Introduction—09.00 to 10.45

Session Chair: Francis Berghmans, Vrije Univ. Brussel (Belgium)

09.00: Welcome and Introduction, Francis Berghmans, Vrije Univ. Brussel (Belgium)

09.15: Composite Materials: State-of-the-art and Future Challenges, Markus Kaufmann, SLC-Lab (Belgium)

Abstract: The use of composite materials proves a great potential for weight saving. Due to the higher process complexity and the high material cost, however, the low weight often comes with a significant increase in development and production cost. Besides lowering the cost, scientists and engineers push the process envelope in order to produce bigger and more complex parts at shorter cycle times. In this talk, we look at state-of-the-art processing, at challenges and trends, illustrated by applications in aerospace, automotive and general industry.

10.00: Sensors and Composites: Requirements, Opportunities and Complexity, Gerard Fernando, Birmingham Univ. (UK)

Abstract: The manufacturing of advanced fibre reinforced composites (AFRCs), using thermosetting matrices, starts with the impregnation of the reinforcement by the matrix; this is followed by consolidation of the laminated preform, and cross-linking of the matrix, generally by the application of heat. The rate and extent of chemical conversion of the functional groups present in the matrix can be influenced by parameters such as: (i) the chemical integrity of the constituent components of the resin; (ii) the number of freeze/thaw cycles experienced (relevant to prepregs that are stored at sub-ambient temperatures; (iv) the moisture content on the surface or the fibres or binder; (v) the rate of heating and the heat-transfer efficiency in and out of the preform; and (vi) the surface chemistry of the reinforcing fibres and the chemistry of the binder. With reference to structural health monitoring, the requirements and long-term demands under service conditions are equally complex. This talk will give an overview of the above-mentioned issues and highlight conventional novel sensor systems that have been designed and developed to enable real-time process and structural health monitoring of advanced fibre reinforced composites.

10.45 to 11.15: Coffee Break

SESSION 2: Production and Cure Cycle Monitoring—11.15 to 13.00

Session Chair: Francis Collombet, Institut Clément Ader – Univ. Toulouse (France)

11.15: From Material Characterization to Product Quality Control: Applicability of Fibre-Optic Sensors to Composites Process Monitoring, Shu Minakuchi, Univ. Tokyo (Japan)

Abstract: This presentation provides two application examples on composites process monitoring, highlighting wide applicability of embedded fibre-optic sensors. The first one is on characterization of chemical cure shrinkage in thermosetting composites. It shows a new fibre-optic-based measurement method that can evaluate directional dependency of cure shrinkage in industrial conditions (i.e., under high cure pressure). The second one is on life cycle monitoring and quality control of L-shaped composite corner parts. Cross-sectional strain history continuously measured during cure, demoulding, assembly and a simulated operation is presented and advanced quality assurance concept based on the sensor response is proposed. These examples will clearly demonstrate that embedded fibre-optic sensors can provide valuable information for improving composite design/manufacturing and for product quality control.

12.00: Polarization-assisted Fibre Grating Sensors to Monitor Residual Stresses in Composite Materials during Curing, Christophe Caucheteur , Univ. Mons (Belgium)

Abstract: The manufacturing process of composite materials and the physical nature of their composition generate residual stresses during the curing process. As they can be detrimental for the resilience and lifetime of the final product, there is a need to monitor these stresses. With their miniaturized shape that allows them to be embedded without affecting the composite material performances, optical fibre sensors and more particularly fibre Bragg grating (FBG) sensors are well suited for such a purpose. Standard interrogations based on the FBG amplitude spectrum only reveal sufficiently high stress, yielding a pronounced difference between the two orthogonal polarization modes of the FBG. In this work, we make use of another parameter, so-called polarization dependent loss (PDL), which allows computing the stress evolution from the start of the curing process.

12.30: Monitoring process parameters using optical fibre sensors in composite production, Edmon Chehura, Cranfield Univ. (UK)

Abstract: Optical fibre sensors have been, for some time, touted as the future for applications where embedded sensors are vital, but their potential is yet to be fully realised practically. Potential benefits from the implementation of embedded optical fibre sensors in composite manufacturing technology include the provision of quality assessment during and after production as well as the structural health assessment of the component when in use after production. Optical fibre sensors have well documented characteristics which render them the most viable of the sensors that can be embedded within the fabric of the composites. Key issues of interest in composite production processes include the need to determine the presence of resin in complex shaped parts during resin infusion, the need to measure and ascertain the uniformity of temperature throughout the component, the need to ascertain the degree of cure of the resin and the need to determine the residual stresses in the component after production. Research into sensor development for these processes is widespread and is an on-going activity. The work presented here explores the suitability of various fibre optic sensor configurations for measuring process parameters as embedded sensors within composite parts during manufacture.

13.00 to 14.30: Lunch

SESSION 3: Structural Health Monitoring—14.30 to 16.00

Session Chair: Steve Vanlanduit, Vrije Univ. Brussel (Belgium)

14.30: New Trends in Structural Health Monitoring, Wieslaw Ostachowicz, Polish Academy of Sciences (Poland)

Abstract: The scope of Structural Health Monitoring (SHM) includes constant monitoring of the structure's material condition (in real-time), of the elements of the structure as well as of the whole structure during its useful lifetime. SHM is a multidisciplinary technology devoted to the development and implementation of methods and systems that realize inspection and damage detection by integration with structures. This presentation covers the main SHM disciplines, based on topics such as piezoelectric transducers, elastic wave propagation phenomena, fibre Bragg gratings, structural vibration analysis, phased array techniques, electro-mechanical impedance methods, acoustic emission, comparative vacuum monitoring, damage mechanics and 3D laser vibrometry applications. Among various techniques available the paper presents selected numerical simulations and experimental validations of considered structures. Also the paper provides helpful information about dispersion, mode conversion, thermo–mechanical processes and wave scattering from stiffeners and boundaries. It can allow one to optimise excitation signal parameters and sensor placement, as well as enable analysis of signals reflected from damage. It also includes a variety of techniques being related to diagnostics (damage size estimation and damage type recognition) and prognostics.

07 October 2013

15.00: International Standardization Activities to Establish Fibre-Optic Sensor Technologies in Structural Health Monitoring, Wolfgang Habel, BAM (Germany)

Abstract: Reliable operation of integrated fibre-optic systems is absolutely necessary to establish this relatively new sensor technology in practice. Various monitoring systems use different fibre-optic sensor types, however, especially for use in safety-relevant structures and systems solid understanding of sensor function under real and possibly difficult environmental conditions must be available. Other aspects concern statements about lifetime, stability of performance parameters and maintenance/repair. Established use of measurement systems requires guidelines and standards on how to test, characterize, install and evaluate them. In order to formulate such standards, some scientific investigation must be carried out. Statements in standards also require confirmation by experimental testing. Some important aspects and also testing methods to find out answers for standards will be presented. Current activities in standardization will be presented. An outlook to the fibre-optic standardization family being developed will be given.

15.30: Fibre Bragg Grating Spectral Features for Structural Health Monitoring of Composite Structures, Kara Peters, North Carolina State Univ. (USA)

Abstract: Optical fibre sensors embedded in composite materials can provide a high sensitivity to subsurface damage due to their proximity to the damage. In particular, fibre Bragg gratings (FBG) are easily embedded into composite laminates with a minimum of perturbation to the surrounding material microstructure. However, spectral distortion due to the local microstructure can lead to errors in the interpretation of strain values when peak waveforms are assumed. This distortion is highly dependent upon the local microstructure surrounding the sensor and therefore cannot be compensated a-priori through calibration factor. This presentation summarizes some recent advances derived from full-spectral interrogation of FBG sensors for structural health monitoring and damage identification in composites. Several issues related to the interpretation of the FBG spectral signatures and their correlation to the stress state within the composite laminate are addressed. First, the definition of spectral damage features based on the reflected spectrum of FBG sensors is discussed. In particular, the correlation of these spectral damage features to stress states observed in composite laminates with impact-induced damage is addressed. Second, recent advances in interrogation systems for FBG sensors will also be discussed which permit the dynamic evaluation of full-spectral features. Finally, the application of this interrogation system to FBG sensors embedded in composite laminates is presented for two examples: in-situ monitoring of the dynamic response to low-velocity impacts and vibration monitoring of adhesively bonded composite joints. These results demonstrate the richness of information that can be obtained from full-spectral interrogation of FBG sensors in the complex multiple stress component environments experienced by embedded sensors.

16.00 to 16.30: Coffee Break

SESSION 4: European Projects—16.30 to 17.30

Session Chair: Wolfgang Habel, BAM (Germany)

16.30: SMARTFIBER, Geert Luyckx, Univ. Gent (Belgium)

Abstract: The FP7 European-project “SmartFiber” has been set up with the aim of developing the first fully embedded Fiber Bragg Grating health monitoring system for composite materials. This smart system combines state-of-the-art optical fiber sensor, nano-photonic chip, and wireless power and data transmission technology. By integrating these innovative micro-technologies, SmartFiber enables a smart sensing system so small that it can be embedded entirely within the fiber reinforced polymer. Embedding of both fiber sensor and fiber interrogator takes away the main technical roadblock for the industrial uptake of optical fiber sensors as structural health monitoring technology in composite structures: the fragile external fiber coupling to an external interrogator. SMARTFIBER will drive ICT to make truly intelligent composites.

17.00: SARISTU, Moshe Tur, Tel-Aviv Univ. (Israel)

Preliminary Abstract: It appears that the potential benefits of embedding optical fibre sensors in aircraft structures have been recently recognized in several advanced research projects, as well as in actual applications. The talk will first describe the role of optical fibre sensors the in the Structural Health Monitoring aspects of the SARISTU (Smart Intelligent Aircraft Structures) project. This wide scale innovative project focuses on the cost reduction of air travel through a variety of individual applications as well as their combination. For the first time ever in smart material concepts, SARISTU offers the opportunity to virtually and physically assess the interaction of different technological solutions and their combined effects at aircraft level. Specifically, the joint integration of different conformal morphing concepts in a laminar wing is intended to improve aircraft performance through a 6% drag reduction, with a positive effect on fuel consumption and required take-off fuel load. A side effect will be a decrease of up to 6dB(A) of the airframe generated noise, thus reducing the impact of air traffic noise in the vicinity of airports. Another important objective is to limit the integration cost of Structural Health Monitoring (SHM) systems by moving the system integration as far forward in the manufacturing chain as possible. In this manner, SHM integration becomes a feasible concept to enable in-service inspection cost reductions of up to 1%. Finally, the incorporation of Carbon Nanotubes into aeronautical resins is expected to enable weight savings of up to 3% when compared to the unmodified skin/stringer/frame system, while a combination of technologies is expected to decrease Electrical Structure Network installation costs by up to 15%. A few more applications of flying applications of fibre-optic sensors, embedded in composite structures will be also presented and discussed.

18.00 to 19.30: Welcome Reception

08 October 2013

SESSION 5: Novel Sensors—09.00 to 11.00

Session Chair: Geert Van Steenberge, IMEC / Univ. Gent (Belgium)

09.00: Novel Glass Fibre Sensors, Thomas Geernaert, Vrije Univ. Brussel (Belgium)

Abstract: Glass fibre sensors have been used since many years in the field of composite material production and structural health monitoring with varying levels of success. We review the state-of-the-art of both point sensors and distributed sensing techniques and summarize their potential to detect the mechanical parameters of interest. We line up the trending technologies in silica fibre sensors such as high-resolution Brillouin sensing and photonic crystal fibres. We then introduce our recently developed highly birefringent Butterfly photonic crystal fibre that allows stress and strain sensing when combined with a fibre Bragg grating sensor. We explain how the integration of this specialty fibre sensor technology with fibre-reinforced composite materials provides great opportunities for internal multidimensional strain monitoring. Such devices can therefore play an important role in the domain of structural health monitoring instrumentation.

09.30: Bragg Grating Strain Sensors – the Plastic Alternative, David J. Webb, Aston Univ. (UK)

Abstract: This presentation will discuss recent developments in polymer fibre grating technology and in what ways these devices may extend the capabilities of the existing silica fibre sensors. Potential advantages include higher strain sensing and a greater stress sensitivity, but the complex material properties of plastics have raised a number of challenges that are only now starting to be met.

10.00: Photonic skins for pressure, shear and strain sensing, Bram Van Hoe, IMEC / Univ. Gent (Belgium)

Abstract: Several concepts for new types of artificial skin with integrated pressure and shear sensors will be discussed, based on a process that allows embedding optical components into very thin and flexible substrates. A flexible shear sensor foil is developed, based on the shear stress dependent coupling change of optical power between a laser and photodiode chip that are separated by a deformable sensing layer. A flexible tactile sensor is constructed in a similar built-up, in which the principle relies on optical feedback in a vertical cavity surface emitting laser. Novel ways to interrogate optical fibre sensors based on fibre Bragg gratings are introduced, using low cost optoelectronic chips, resulting in a fully flexible sensing foil.

10.30: Roll-to-roll Printed Sensors for Large Area Monitoring Applications, Jukka Hast, VTT (Finland)

Abstract: In this presentation we introduce roll-to-roll printing processes and materials for manufacturing sensors for different large area monitoring applications. Applications include 1) screen printed sensors for moisture sensing embedded inside walls structures, 2) capacitive switches printed on wall paper for room lighting control, 3) printing strain gauges for structural monitoring and 4) gravure printed gas sensors for O_2 and CO monitoring.

11.00 to 11.30: Coffee Break

SESSION 6: Applications and Engineering—11.30 to 13.00

Session Chair: Geert Luyckx, Univ. Gent (Belgium)

11.30: Integration of optical fibres during automated preform production, Tahira Ahmed, Airborne (The Netherlands)

Abstract: A key factor in applying optical fibre sensors in composites is the embedding process. Current methods for embedding are labour intensive due to manual placement of the sensors at the desired locations. On an industrial scale, reliability is vital, especially as the sensors are brittle and therefore prone to breakage. Embedding of optical fibres are not yet adopted to novel automated processes being developed for composite manufacturing. This lecture will provide details on how automation technology is being implemented at the Airborne Technology Centre. A dedicated automated fibre placement head has been designed and developed to place optical fibres repeatedly and reliably during preform production. Above all the flexibility of the head will be demonstrated for preform production of different products.

12.00: In-situ Strain Monitoring During Processing of Composite Laminates - Experimental and Numerical Comparisons, Michael W. Nielsen, Denmark Tekniske Univ. Ctr. (Denmark)

Abstract: For large composite structures, such as wind turbine blades, thick laminates are required to withstand large in-service loads. Embedded FBG sensors have been used to monitor process-induced strains during vacuum infusion of a glass/epoxy laminate. The measured strains are compared with good agreement to numerical finite element (FE) predictions from a thermomechanical process model where different mechanical boundary conditions are employed. Furthermore, a holistic approach to strain- and health monitoring in composites is presented. It is shown how embedded FBG sensors can successfully monitor resin flow front progression during infusion in thick composite laminates, as well as strain development during matrix curing representative of the cure cycle temperatures and tool/part interactions prescribed. Substantial process-induced compressive strains are developed, especially in the transverse fibre reinforcement direction, while smaller strains develop longitudinally. These strains should be taken into consideration when designing FRP laminates.

12.30: Investigation of perturbation effects on the measurement signal of optical sensors embedded in composite materials, Vivien Schukar, BAM (Germany)

Abstract: Embedded fibre Bragg grating (FBG) strain sensors can be used for monitoring of safety-relevant structures and characterization of high-performance composite materials. For the reliable use of the embedded sensor and the determination of the sensor performance under long-term and high-loading conditions, it is necessary to characterize the sensor's response signal and to validate the sensor's functioning. The analysis of the spectral response signal of the embedded strain sensor and the characterization of the different signal parameters allows the interpretation of the sensor's functional status and its interconnection to the surrounding composite material. Moreover, the influence of specific perturbation effects and their combinations can be studied using simple experimental model. The understanding of signal changes of embedded FBG strain sensors in anisotropic laminates under load is of principle meaning for the interpretation of these sensor signals as reliable measurement results of the structure's behaviour.

13.00 to 14.00: Lunch

SESSION 7: Demonstrations—14.00 to 15.00

Session Chair: Markus Kaufmann, SLC-Lab (Belgium)

Abstract: In the demonstration session we will introduce different techniques to monitor a composite structure during its life cycle. Demonstrations on four topics will be presented: polymer waveguides and flexible electronics, strain mapping using multiple FBG sensors, dynamic monitoring with optical sensors, and process monitoring during vacuum infusion. In addition to the demonstration of opportunities and challenges of the presented technologies on a laboratory scale, this session forms a starting point for the subsequent panel discussion on embedded optical sensors.

15.00 to 15.15: Coffee Break

SESSION 8: Panel Discussion—15.15 to 16.15

Moderator: Francis Berghmans, Vrije Univ. Brussel (Belgium)

Abstract: This panel discussion will summarize the main issues and the challenges pointed out during the presentations and will attempt to outline a roadmap for this field of research, to be maintained and disseminated via the COST TD1001 website.

16.00: END

1st International Workshop on
EMBEDDED OPTICAL SENSORS
FOR COMPOSITE MATERIALS

Travel and Hotel Information

VENUE

Het Pand, Onderbergen 1, B-9000 Ghent, Belgium

http://www.ugent.be/het-pand/en

WELCOME TO GHENT

Ghent is a historic city, yet at the same time a contemporary one. The modern daily life of the city's active inhabitants plays itself out against a gorgeous historical backdrop. In Ghent, they live, work and enjoy life over and over again each day.

A couple enjoys the peace of an authentic beguinage. Parents and children stroll through the traffic-free streets of the city centre. A tourist snaps a photo of the three towers, as so many have before, but just a little differently. A businessman with an iPhone walks along the distinctive Graslei, crosses the Lys and enters his stylish four-star hotel hiding behind a medieval facade. Dozens of pavement cafes invite you to discover Ghent's specialities. The sun is reflected in the many waterways.

The city is alive and bids you welcome.

The text above is taken from

http://www.visitgent.be/en/home

Visit this webpage for more information about the city of Ghent.

TRAVEL TO GHENT

For information on how to travel to Ghent please visit

http://www.visitgent.be/en/how-get-ghent.

1. By train

There are two railway stations in Ghent: Gent Sint-Pieters and Gent Dampoort, which allow smooth access to the Belgian railway network. For information about trains to Ghent visit:

- http://www.b-europe.com/Travel/
- http://www.europeanrailguide.com
- http://www.interrail.eu

2. By air

Belgium's international airport is situated in Zaventem, on the outskirts of Brussels. From Brussels Airport you can easily travel to Ghent by train. In the airport, follow the signs to the train station, which is below ground level. Buy a ticket for Gent St-Pieters station at the counter. A single fare (Brussels Airport – Gent St-Pieters station) will cost around 14,40 EUR. You can board the direct train to Ghent, or you can take the shuttle train to Brussels Central Station, which runs every 15 minutes. There, you can change to a train to Ghent. From Gent St-Pieters station, you can take several buses and trams to the city centre.

You can also fly to Brussels-Charleroi. From Charleroi Airport, you can take the bus to Brussels Zuid/Midi station (a 45 minute ride) for only 13 EUR, which runs every 30 minutes. From Zuid/Midi station you can get on the train to Ghent. Buy a ticket for Gent St-Pieters station in the train station. A single fare (Brussels Zuid/Midi station – Gent St-Pieters station) costs around 8,70 EUR. There are usually three trains an hour to Ghent from Brussels. From Gent St-Pieters station, you can take several buses and trams to the city centre.

Note that the train schedule on weekdays differs from that during weekends.

3. By bus

If you are planning to travel by bus or coach, you can contact Eurolines through http://www.eurolines.be. The bus stops at Koningin Elisabethlaan 73, which is near Gent St-Pieters station.

4. By car

Please note that Ghent's city centre is a pedestrian zone, so no cars are allowed. There are nevertheless many public parking lots all over the city, with parking fees ranging from 5 EURO for 3 hours up to 10 EURO for 24 hours. If you decide to come by car, you will find Ghent at the crossroads of 2 large motorways:

- E17 connecting Lisbon, Paris, Gent, Antwerp, Köln, Copenhagen, Stockholm;
- E40 connecting Calais, Gent, Brussels, Frankfurt, Vienna, Budapest, Sophia, Istanbul.

WORKSHOP HOTELS IN GHENT

The organising committee has managed to negotiate advantageous rates with 3 hotels. These rates are breakfast-inclusive. The hotels can be booked using the special promotion code "COSTTD1001". Only direct booking using the hotel website entitles you to benefit from these rates. Booking these hotels through websites such as booking.com or trivago.com does not allow obtaining these rates. The 3 hotels are:

1. Hotel Monasterium Poortackere (***)

Address: Oude Houtlei 56, 9000 Gent, Belgium

Distance from workshop venue: 300 m

http://monasterium.be, info@monasterium.be, tel. +32 9 2692210

Single: 105 EURO, Double: 120 EURO, City tax: 2.5 EURO p.p.

2. Hotel Astoria (***)

Address: Achilles Musschestraat 39, 9000 Gent (Belgium)

Distance from workshop venue: 2.5 km

http://www.astoria.be/, info@astoria.be,tel. +32 9 2228413

Standard Single: 85 EURO, Standard Double: 95 EURO, City Tax: 2.5 EURO p.p.

Comfort Single: 104 EURO, Comfort Double: 119 EURO, City Tax: 2.5 EURO p.p.

3. Marriott Ghent (****)

Address: Korenlei 10, 9000 Gent, Belgium

Distance from workshop venue: 400 m

http://www.marriott.com/hotels/travel/gnemc-ghent-marriott-hotel/

tel. +32 9 2339393

Standard Single/Double: 150 EURO, City Tax: 2.5 EURO p.p.

OTHER HOTELS IN GHENT

There are many other hotels in Gent which are all located in the city centre within walking distance from the workshop venue. Feel free to check the most advantageous rates and to book any other hotel through well known hotel booking sites.

1st International Workshop on
EMBEDDED OPTICAL SENSORS
FOR COMPOSITE MATERIALS

Registration Information

HOW TO REGISTER

Register online. It is fast and easy.

http://www.amiando.com/STODYGS

Upon registration, you will immediately receive a confirmation, your ticket for the event and an invoice in pdf format, sent to the e-mail address that you entered to register. Registration requires payment by credit card. The fees are detailed below.

REGISTRATION FEES

- COST TD1001 MC Member: 40 EURO
- COST TD1001 Member (non-MC): 75 EURO
- Student: 75 EURO
- Speakers: 0 EURO
- All other participants: 120 EURO

Workshop registration includes: admittance to the talks, coffee breaks on 7th October and 8th October, sandwich lunches on 7th October and 8th October, reception (drinks and appetizers only) on 7th October, and web access to those slides made available for distribution by the speakers. Details on how to access the slides will be provided after the workshop.

REGISTRATION DEADLINE

Registration deadline is September 8th 2013 at midnight.

REFUND POLICY

There is a 40 EURO service charge for processing refunds. Requests for refunds must be received by 15th September 2013 at midnight. Past this date and time, all registration fees will be forfeited.

Refund requests must be sent by e-mail before 15th September 2013 at midnight to costtd1001@b-phot.org.