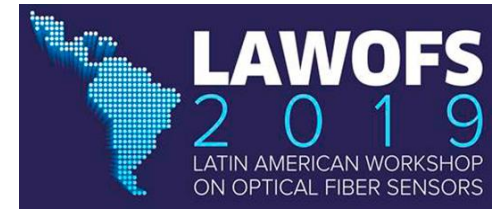


# LAWOFS 2019 – FINAL PROGRAM



## Wednesday, July 17

Wednesday, July 17 8:50 - 10:00

Registration

Wednesday, July 17 10:00 - 10:30

Coffee break 1 & Registration

Wednesday, July 17 10:30 - 11:00

Opening Session

Chairs: Maria Aparecida Martinez, Maria Thereza Rocco Giraldi

Wednesday, July 17 11:00 - 12:00

Invited Talk 1

Optical Fiber Sensors: A 40 Year Retrospective

Prof. ALEXIS MENDEZ - MCH ENGINEERING - USA

Wednesday, July 17 12:00 - 13:30

Lunch 1

Wednesday, July 17 13:30 - 15:10

## Oral Session 1

Physical Sensors - 1

### 13:30 *A Temperature-Compensated FBG Sensor Interrogator*

Gustavo Mattos, Alex Dante, Regina Allil, Cesar Carvalho and Marcelo Werneck

In this paper, we present a closed-loop interrogation system for temperature compensation of FBG sensors in measurements of AC voltage. In the proposed system, a filter FBG tracks a sensing FBG under temperature variation. Experimental results show that the proposed system allows for stable measurements of AC voltage in a delta T of 20 °C.

### 13:50 *Optical Technology for Remote Monitoring of Leakage Current in Isolators of 500-kV Transmission Lines*

Daniel Sá de Oliveira, Marcelo Werneck, Regina Allil, Alex Dante and Cesar Carvalho

This work describes an online monitoring system of leakage current in isolators in transmission line towers. The system has a sensor that transforms the leakage current into luminosity and transmits it via optical fiber to a remote unit, the information is sent and stored in a datacenter, which provides the data to the users.

### 14:10 *Humidity Monitoring in Acidic Sewer Environments Using Fibre Bragg Grating-based Sensors*

[Matthias Fabian](#), Heriberto Bustamante, Louisa Vorreiter, Bruno Rente, Miodrag Vidakovic, Ye Chen, Tong Sun and Kenneth Grattan

Innovative fibre Bragg grating-based sensors have been designed and implemented to monitor reliably the relative humidity and temperature in the challenging harsh, corrosive environment of a working sewer. The robustness and long-term performance of the sensor system has been demonstrated through an extensive 2-month field test, showing excellent performance with no major signs of deterioration.

### 14:30 *Strain Measurements for a Magnetostrictive Material Using Fiber Bragg Gratings*

Oscar Sosa Puerto, Christian Camilo Cano and Gloria Margarita Varón Durán

Magnetostrictive materials change their crystal network structure properties due to an external magnetic field action. These changes also affect a macroscopic property such as their physical dimension. Optical fiber Bragg gratings could be used to monitor any elongation in a piece of a magnetostrictive material, mainly because of their complete electromagnetic immunity. In this paper, we present the design and complete characterization of the system that uses a Helmholtz coil to produce a controlled magnetic field that is applied to a sample of the magnetostrictive material. Current results include a characterization for both strain and temperature sensitivity of the FBGs to be used.

### 14:50 *Macrobending SMS Fiber-Optic Arc Sensor Using Fixed Curvature Radius*

Jesse Werner Costa, Maria Thereza Rocco Giraldi and Marcos A. R. Franco

A simple and high sensitivity fiber-optic arc sensor based on single mode-multimode-single mode (SMS) structure is reported. The output power intensity of SMS bend sensors may increase or decrease with the rise of curvature, depending on Multimodal Interference (MMI) conditions. In order to avoid slope inversions due to wide range bend applications, it is possible to choose a fixed curvature radius and let MMI effects happen due to arc variation, as demonstrated with experimental tests. Absolute output power peak sensitivity of 35.82 dB/m is reported.

Wednesday, July 17 15:10 - 15:40

Coffee break 2

Wednesday, July 17 15:40 - 17:20

## Oral Session 2

### Chemical Sensors

**15:40 External Refractive Index Sensitivity Enhancement of a Long Period Grating by Graphene Oxide Overlay**

Kasun Dissanayake, Bruno Rente, Tong Sun, Kenneth Grattan, Leonardo Binetti, Lourdes Alwis and Souvik Ghosh

In this paper, an external refractive index sensor is presented based on a graphene oxide coated long period grating. Graphene oxide was coated on the fibre surface using a drop casting technique. Wavelength shift sensitivity was improved by 43% compared to the response of a bare long period grating against external refractive index.

**16:00 Development of a Solid Substrate for Surface Enhanced Raman Spectroscopy**

Felipe Hornung, Marcia Muller and José L Fabris

In this work, a solid substrate for Surface Enhanced Raman Spectroscopy was developed and characterized. The interaction of silver nanoparticles with the probe molecule rhodamine 6G was compared for both liquid and solid substrates. Parameters of the solid substrate were optimized for use with an optical fiber Raman spectrometer.

**16:20 Optical Sensor to Monitor the Fermentation Process of Beers Based on Etched Fibre Bragg Gratings**

Vicente Oliveira, Vinicius Nunes Henrique Silva, Andrés Pablo López Barbero, Fernando Peixoto, Leandro Sphaier and Jean Kuhne

In this paper, it is presented preliminary results in the development of a sensor to monitor the fermentation process of beers in real time based on Etched Fibre Bragg Gratings (EFBG). The experiments show that these sensors are extremely responsive to the density variations, which makes them useful for the monitoring beer fermentation.

**16:40 Optical Fiber Bragg Grating Sensors for Temperature Measurements in the Hyperthermia Treatment**

Nicolas Ospina Mendivelso, Juan Coronel-Rico, Hector Fabian Guarnizo, Christian Camilo Cano and Gloria Margarita Varón Durán

The hyperthermia is a treatment consisting in raising the temperature of a part of or the whole body above normal (usually between 35 °C and 45 °C) for a defined period of time using microwave radiation as an adjuvant for the treatment of tumors. However, the use of conventional sensors (thermocouples, thermistors, RTD) presents interference issues linked to the microwave energy scattering that can affect surrounding tissues of the body. The goal of these proposal is to give a proof of concept of the feasibility of using an optical fiber based temperature measurement system taking advantage of the transparency of optical fiber materials when facing microwave energy. This means no undesired reflections or scattering inside the body. In this stage of the work a gelatin phantom was built in order to measure the temperature reached when it is irradiated using a 2.45 GHz and 800 W microwave source. From these results can be inferred a linear relation between the temperature reached and the irradiation time, it is given a proof of concept of real time measurement for hyperthermia applications.

**17:00 Fiber Bragg Grating Coated with Diphenylalanine Nanotubes for Methanol Vapor Detection**

Ricardo Kamikawachi, Bruno Cunha, Raguél Corotti, Rafael Barreto and André Conceição

In this work, etched fiber Bragg gratings (EFBG) coated with diphenylalanine nanotubes (DNT) are studied for methanol vapor detection. The DNT morphology is characterized by Scanning Electron Microscopy and the temperature transition is determinate by Small-Angle X-Ray Scattering technique. After the phase transition, a significant increase in wavelength shift can be observed.

Thursday, July 18

Thursday, July 18 8:50 - 10:30

### Oral Session 3

Signal Processing for Sensing

**8:50 *Interrogation of Long-Period Grating Temperature Sensor Using Fiber Bragg Gratings and Artificial Neural Network***

[Marco Aurélio Jucá](#) and Alexandre dos Santos Bessa

Considering the increasingly wide application of optical fiber sensors, this paper aims to present an alternative form of interrogation without the use of an optical spectrum analyzer or any other high-cost devices. The sensor studied here is a long-period grating being used to measure temperature. The interrogator is composed of optical filters and photodetectors whose responses are processed by a suitably trained artificial neural network. Results show that this technique enables effective interrogation of a range limited only by the optical bandwidth of the light source.

**9:10 *Adaptive Data Compression Method for Distributed Temperature Sensors***

[Luis Silva](#), Jorge Samatelo, Marcelo Segatto and Maria Jose Pontes

This paper presents a new method of adaptive data compression for DTS systems that preserve the curve profile, spatial resolution and temperature resolution of the sensor. The approach allows compressing the data at a compression ratio of 2.65x, saving 62.3% of the hard disk memory, and reducing the processing time of the generated data.

**9:30 *Study on the Best Reflection Spectra of FBGs for Dynamic Sensing***

Talitha Trovão, Alex Dante, Juan D Lopez, Cesar Carvalho, Regina Allil and Marcelo Werneck

This paper presents a study of FBG reflection spectrum for application in dynamic measurements, such as AC current and voltage. In this work, we show the best reflection spectra of two FBGs employed in a twin-grating interrogation technique that guarantees the best linearity levels possible in the response of the dynamic measurement sensor.

**9:50 *LPG Spectrum Estimation Using Neural Networks and Temperature Modulated FBG Array***

[Felipe O Barino](#) and Alexandre dos Santos Bessa

This work proposes a novel approach to Long Period Fiber Grating (LPG) interrogation involving power measurements to estimate the transmission spectra. The aim of this work is to develop a cheap alternative to the Optical Spectrum Analyzer. To accomplish this task a temperature modulated Fiber Bragg Gratings array was used. Accuracy close to half input spectrum resolution was obtained.

**10:10 *A Simple Optoelectronic Load Cell***

Camila Moura, Lorena Jeranoski, Pedro Lima, Fernando Castaldo, Valmir de Oliveira and Hypolito J. Kalinowski

In this work, an optical load cell was developed based on the intensity light variation get as a distance function between a light emitting diode (LED) and a FC-PC multimode optical fiber connector. The load cell is composed by a spring return and mass displacement system. The optical system consists of a LED in the infrared band whose emission is directed to a FC-PC multimode optical cord (MMF 62.5/125), at another end of the optical cord the power was applied to a phototransistor. The resulting current in the phototransistor was amplified in a two-stage transimpedance circuit using general purpose operational amplifier. The voltage response was correlated to the value of the load applied to the system. Four tests were carried out, in which they exchanged the springs for return and loads intensities. Through the tests, the transducer's calibration curves were done. The optical load cell shown in this work was developed for the cost reduction purpose and the reasonableness simple solution.

**Thursday, July 18 10:30 - 11:00**

**Coffee break 3**

**Thursday, July 18 11:00 - 12:00**

**Invited Talk 2**

Distributed Brillouin Fibre Sensing: From Fundamentals to Advanced Techniques

**Prof. MARCELO SOTO - UTFSM - Chile**

**Thursday, July 18 12:00 - 13:30**

**Lunch 2**

Thursday, July 18 13:30 - 15:10

## Oral Session 4

Physical Sensors - 2

### 13:30 *Study of Core Diameter Mismatch Based Optical Fiber Sensors for Salinity and Temperature*

[Tanushree Selokar](#) and [Maria Thereza Rocco Giraldi](#)

In this paper it is presented core diameter mismatch structured devices that use multimode interference technique as optical fiber sensors. Singlemode-MultimodeSinglemode (SMS) and Singlemode-Multimode-Singlemode-Multimode-Singlemode (SMSMS) configurations are used for measurement of refractive index (RI) and temperature. The best sensitivity achieved for RI measurements is obtained with the SMS sensor: 273.63 nm/RIU. For temperature sensing, the best sensitivity attained is accomplished using the SMSMS sensor: 312.75 pm/°C.

### 13:50 *Multi-parameter Non-Invasive Monitoring of Lithium-Ion Batteries Using Fibre Bragg Gratings*

[Bruno Rente](#), [Matthias Fabian](#), [Tong Sun](#) and [Kenneth Grattan](#)

The integration of Fibre Bragg Gratings (FBG) into the body of Lithium-Ion battery cells, for measuring both their strain and temperature to achieve better overall condition monitoring is reported. Sufficient data have thus been gathered to develop an appropriate model for the prediction and thus the prevention of battery failure.

### 14:10 *Fabrication of a Flexible Tactile Sensing System with Macro-Bend Optical Fiber Sensors*

[Diogo Lugarini](#), [Vinicius Carvalho](#), [Marcos Aleksandro Kamizi](#), [José L Fabris](#) and [Marcia Muller](#)

Fabrication steps of a sensing system composed of four optical fiber macro-bend sensors embedded in silicone sheet are described. Sensing ability was tested by individually applying loads from 0.0 kg to 3.0 kg on the sheet surface. Preliminary results show the system ability of detecting loads applied in areas not coinciding with the sensors positions.

### 14:30 *Experimental and Simulated Curvature Analysis in Structure Based on Core Diameter Mismatch*

[Felipe Takeda](#), [Victor Rodrigues Cardoso](#), [Cindy Fernandes](#), [Joao Weyl Costa](#) and [Maria Thereza Rocco Giraldi](#)

In this paper study of multimodal interferences in optical fiber curvature sensor is presented. The sensor consist of a Mach-Zender interferometer based in Core Diameter Mismatch technique. The analysis provided a numerical model of adjustment by the diameter in the multimode section with the purpose of acquiring better linear results.

### 14:50 *Fabrication of Arc-Induced Long Period Fiber Grating with Opposite Point-by-point Modulation*

[Felipe Delgado](#), [Deivid Campos](#), [Thiago Coelho](#) and [Alexandre dos Santos Bessa](#)

We demonstrate the fabrication of an arc-induced long period fiber grating (LPPG) with opposite point-by-point modulation. The produced LPPG exhibited low polarization dependent loss (PDL) and a linear torsion sensitivity up to 0.197 nm/(rad/m), which is higher than that of the traditional arc-induced LPPGs

Thursday, July 18 15:10 - 15:40

## Coffee break 4

Thursday, July 18 15:40 - 17:20

## Oral Session 5

Electromagnetic & Special fiber sensors

**15:40 *Optical Current Sensor Based on Magnetostrictive Composites***

Juan D Lopez, Alex Dante, Talitha Trovão, Roberto Mok, Cesar Carvalho, Regina Allil, Fabricio Borghi and Marcelo Werneck

This paper presents a novel compact fiber-optic current sensor (FOCS) based on magnetostrictive composites that employ only 1 gram of Terfenol-D. Finite element method (FEM) simulations supported the design and construction of two versions of FOCS, which were capable to measure on a.c. current from 200 to 800 Arms in laboratory.

**16:00 *Analysis of Magnetic Field Sensor Based on Intermodal Interference Using Tapered Square No-Core Fiber***

Wilson Morais, Jr. and Maria Thereza Rocco Giraldi

This paper presents the computational implementation of a magnetic field sensor model, based on the principle of intermodal interference using a taper with square section in an optical fiber. Simulations were performed varying its constructive dimensions in order to analyze the influence of them in the sensor performance.

**16:20 *Electromagnetic Contactor Core Temperature and Dynamic Strain Evaluation Using Fiber Bragg Gratings***

Cesar Tapia, Jorge Luis Roel Ortiz, Uilian José Dreyer and Kleiton Sousa

This paper presents the dynamic strain and temperature measurements for a electromagnetic contactor core using the Fiber Bragg Grating (FBG). These measurements are used to predict future preventative maintenance of this device. The temperature variation is approximately 76 °C. In the steady state, for dynamic strain measurement, the fundamental frequency is 120 Hz.

**16:40 *Influence of Gold Nanoparticles Film on the Sensitivity of Long Period Fiber Grating***

[Robsson Pereira Dias](#), Carla Klimpovuz, Marcela Oliveira, José L Fabris and Marcia Muller

The responses of three coated and uncoated long period gratings to the refractive index of the surroundings are compared. Gratings operate at the visible spectral range close to the plasmon resonance band of gold nanoparticles. Sensitivity increase up to 85.2% was achieved after coating the grating.

**17:00 *D-shaped Photonic Crystal Fiber Biosensor for Glucose Concentration Using a Graphene-Sheet***

[Amanda F Romeiro](#), Patrick Gaia, Markos Cardoso, Anderson Silva and Joao Weyl Costa

We design a graphene-based D-shaped photonic crystal fiber refractive index sensor to detect changes in the levels of glucose concentration. Its sensing performance is theoretically analyzed using the Finite Element Method (FEM). The sensor has an average sensitivity of 2560.6 nm/RIU when we vary the glucose concentration from 0 to 200g/L.

Thursday, July 18 19:00 - 21:00

Workshop Dinner

Friday, July 19

Friday, July 19 8:50 - 10:30

## Oral Session 6

Chemical & Special fiber sensors

### 8:50 *Plastic Fiber Optic for Ultrasensitive Gas Detector Applications*

Meysam Keley, Juan D Lopez, Alex Dante, Talitha Trovão, Roberto Mok, Pedro Henrique Romualdo, Fabricio Borghi, Cesar Carvalho, Regina Allil and Marcelo Werneck

In the present study, an ultrasensitive hydrogen sulfide sensor is developed via functionalization of U-shaped Plastic optical fiber. The results of the sensor demonstrate low response time and full recovery while exposed to a gas mixture containing 200ppm concentration of measurand.

### 9:10 *Rehabilitation Tools on Biomedical Using Fiber Bragg Grating Sensors*

Alessandra Kalinowski, José Galvão, Talita Paes De Bastos, Eduardo Dureck, Uilian José Dreyer, Carlos Zamarréño, Cicero Martelli and Jean Carlos Cardozo da Silva

The Sensing Technology Group, from Federal University of Technology - Paraná, in partnership with Public University of Navarra are developing some projects using Optical Fiber Bragg gratings (FBG) for biomechanical area, such as: dynamic analysis of lower limb walking prosthesis; mechanical analysis of femur external fixators; wrist and finger movement analysis using forearm muscular displacement.

### 9:30 *Etched Fiber Bragg Gratings Functionalized with PCDTBT:PDI Thin Film for Ammonia Detection*

Jean Kuhne, Anderson Gavim, Paula Rodrigues, Bruno Torres, Andréia Macedo, Jeferson de Deus and Ricardo Kamikawachi

The functionalization of an etched fiber Bragg grating with a drop casted thin film improved the sensor sensitivity to ammonia vapors. The film was obtained from a solution of a perylene derivative along with the copolymer PCDTBT, in chlorobenzene. The resulting sensor detects ammonia vapors ranging from 27 to 6954 ppm, at room temperature.

### 9:50 *Hole-Assisted Helically Twisted Twin-Core Fiber Coupler*

[Juan E Úsuga](#), [William M Guimarães](#) and [Marcos A. R. Franco](#)

Coupling characteristics of helically twisted twin-core fibers with hole-assisted structure were numerically evaluated. It was observed the increase of coupling beat length with the increase of twist rate, and it was confirmed the effectiveness of hole-assisted guidance to loss reduction. The proposed twisted fiber, with 66 mm length, works as a circular polarization splitter.

### 10:10 *Fiber Specklegram Analysis for Monitoring Evaporation Inside a Capillary-like Optical Fiber*

[Thiago D Cabral](#), [Luiz da Silva](#), [Eric Fujiwara](#) and [Cristiano MB Cordeiro](#)

A liquid filled capillary-like fiber sensor for monitoring the evaporation rate of the filling liquid through fiber specklegram analysis is proposed and evaluated. Experimental data shows a clear relation between the specklegram shift over time and evaporation, prospectively allowing the assessment of multiple parameters of the liquid by modeling evaporation in a capillary.



**Friday, July 19 10:30 - 11:00**

**Coffee break 5**

**Friday, July 19 11:00 - 12:00**

**Round table**

Optical Fiber Sensors: Markets & Products

**Dr. Ed Mendoza - Redondo Optics; Dr. Alexis Mendez - MHC Engineering; Dr. João Batista Rosolem - Fundação CPqD**

Chair: Hypolito J. Kalinowski

**Friday, July 19 12:00 - 13:30**

**Lunch 3**

Friday, July 19 13:30 - 15:10

## Oral Session 7

Field applications & Sensor development

**13:30 *Fibre Bragg Grating Based Sensor System for Pantograph - Overhead Line Interface Condition Monitoring During Electrified Train Operation***

[Miodrag Vidakovic](#), Tong Sun, Ye Chen, Matthias Fabian, Kenneth Grattan, Matt Askill, Lee Brun, Rod Fawcett, Peter Dearman and Simon Warren

Efficient current collection and monitoring railway current-collecting pantographs is one of the key challenges for railway sector in electrical train operation. Fibre Bragg grating (FBG) sensors integrated into a pantograph are used to provide accurate contact force and contact location measurements at the crucial pantograph-overhead line (OHL) interface. Data collected during field trials are reported in the paper.

**13:50 *Optical Current Transducer Metrological Characterization for Current Transformer on Site Calibration***

Marcelo Costa

This paper presents metrological characterization of an optical current transducer solution for high voltage current transformers on site calibration. In metrological tests, from 150 A to 1700 A, ratio errors were between  $\pm 0.1\%$  and phase errors were between  $\pm 5'$ . Although the good results, some strategies are suggested for uncertainty improvement in field application.

**14:10 *Evaluation of Coupling to Symmetric and Asymmetric Cladding Modes in Long-Period Fiber Gratings***

Felipe Delgado, Renato Luiz, Daniel D. Silveira and Alexandre dos Santos Bessa

We analyze the influence of coupling to symmetric and asymmetric cladding modes in arc-induced Long-Period Fiber Gratings for temperature and strain sensing. The origin of this difference in energy coupling is related to the fabrication process of these gratings and depends on the electric arc discharge conditions, which modulates the refractive index and geometry of the optical fiber. Finally, results demonstrate the performance of different cladding modes excited in arc-induced LPPGs to temperature and strain applications and, in addition, indicate which coupling might be appropriate to certain sensing applications.

**14:30 *Inertial Compensation in an Electrified Railway Pantograph Condition Monitoring System Using FBG-based Accelerometers***

[Ye Chen](#), Miodrag Vidakovic, Matthias Fabian, Tong Sun, Kenneth Grattan, Matt Askill and Lee Brun

This paper presents the results from an assessment of dynamic force inertial compensation, obtained using two Fibre Bragg Grating (FBG)-based accelerometers integrated into a railway current-collecting pantograph, allowing more accurate measurement of contact force and contact location are presented. In the tests carried out, a high level of transfer function accuracy in the monitoring of dynamic contact force was achieved.

**14:50 *Optical Fiber Sensor for Carbon Dioxide Measurement Using Tapered Long Period Grating***

Manuella Oliveira, Alexandre dos Santos Bessa, Felipe Delgado, Marco Aurélio Jucá, Daniel Discini, Thiago Coelho and Renato Luiz

This paper presents the development of a refractive index (RI) sensing methodology for measuring CO<sub>2</sub> concentration in environments considering the temperature effect. We propose and demonstrate the modulated tapered Long Period Gratings to enhance the RI sensitivity of the sensor. The results show it is possible to measure the CO<sub>2</sub> considering the temperature cross-sensitivity effect.

Friday, July 19 15:10 - 15:40

Coffee break 6

Friday, July 19 15:40 - 16:00

Closing Session