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Talks & Posters

Friday May 20th

Photonic Sensors and Biomedical Optics - Session 1

9:00 am to 10:15 am - Room 1334

UV LASER MODIFIED MEDICINE SOLUTIONS IN INTERACTION WITH TARGET SURFACES UNDER HYPERGRAVITY CONDITIONS

Ágota Simon, National Institute for Laser, Plasma and Radiation Physics & University of Bucharest 9:00 am

Laser modified phenothiazines may represent a remarkable tool in the fight against drug resistance acquired by pathogens, since their aqueous solutions exposed to UV pulsed laser radiation possess enhanced antimicrobial activities by inducing structural changes at the molecular level of the photosensitive medicines. The wettability of different target surfaces by such solutions plays a significant role in designing new procedures for targeted drug delivery. Experiments performed under hypergravity conditions within the European Space Agency's "Spin Your Thesis!" programme consisted in studying the interaction of laser exposed medicine solutions with hydrophilic/hydrophobic surfaces and determining the formed contact angles, in view of future long-term space mission applications.

REAL-TIME HYPERSPECTRAL IMAGING SYSTEM TO MEASURE HEMODYNAMIC RESPONSE DURING NEUROSURGERY

Audrey Laurence, Polytechnique Montréal 9:15 am

Hemodynamic changes following epileptiform activity are not well understood and their assessment could help improve patient treatment in epilepsy. We developed an intraoperative hyperspectral imaging system using a snapshot hyperspectral camera (16 bands) directly integrated into a surgical microscope to allow real-time analysis of hemodynamic changes. We present experiments on optical phantoms in which we were able to recover relative concentrations of three dyes at 30 frames per second. We also present data obtained during brain surgery of epileptic patients, where relative concentration maps of oxygenated and deoxygenated hemoglobin were extracted.

DUAL MODALITY OPTICAL BIOPSY PROBE FOR BRAIN NEEDLE BIOPSY GUIDANCE

Joannie Desroches, Polytechnique Montreal 9:30 am

We present an innovative device combining two optical spectroscopic modalities to reduce risks and improve diagnostic yield associated with brain needle biopsies. The needle probe integrates optical fibers directly on to the external cannula of a commercial biopsy needle. We use a sub-diffuse optical tomography technique to generate a reconstruction of the adjacent tissue to detect blood vessels, and Raman spectroscopy for tissue characterization, both modalities using the same optical fibers. We present the results of quantitative phantom experiments using the device, as well as results from in vivo swine experiments demonstrating capabilities of the system to detect the spectral signature of brain tissue and hemoglobin.

HANDHELD RAMAN IMAGER FOR INTRAOPERATIVE CANCER DETECTION

Karl St-Arnaud, Polytechnique Montreal 9:45 am

Identification of tumor margin during resection is a major issue in order to prevent recurrence. Over the last decade, several studies have shown the potential of single point Raman probe to help the surgeon discriminate between cancerous and normal tissues1. However, these probes are still limited to single point measurements and don't allow visualization of cancer margins, which could help improve the prognostic after resection. Here we propose a proof-of-concept for a Handheld Raman Imager through a coherent fiber bundle with a field of view of 5 mm^2. We show preliminary results where this imager has shown ability to differentiate tissues from pork samples based on their molecular contrast.

TEMPORAL RESOLUTION OF A 3D DOSIMETRY SYSTEM

Madison Rilling, Université Laval & Radiation oncology department (CHU de Québec) 10:00 am

Radiotherapy treatments are increasingly delivered using dynamic treatment modalities, which allow for highly conformal, yet complex dose distributions to be delivered to the targeted tumour. This work aims at characterizing the temporal limits of the first prototype of a 3D scintillation dosimetry system, which is currently the only medical physics tool capable of measuring complete 3D radiation doses in near real-time [1]. This system uses a static plenoptic camera to image a plastic scintillator volume during irradiation, and ray tracing-based tomographic algorithms to reconstruct the measured 3D dose distributions. It was found that the system's acquisition rate, set for signal optimization at low dose levels, currently limits the precise measurement of instantaneous dose gradients. The system's light collection efficiency must thus be optimized to reduce observed averaging effects.

Optical Engineering - Session 1

9:00 am to 10:15 am - Room 2415

Ga-La-S GLASS FOR UV AND IR APPLICATIONS

Andrea Ravagli, Optoelectronics Research Centre, Southampton, UK 9:00 am

Gallium lanthanum sulphide glass (GLS) have been widely studied in the last forty years for middle-infrared (MIR) applications. In this paper we report the results of the compositional substitution in GLS glass. The samples were prepared via melt-quenching method in an argon-purged atmosphere. A wide range of compositions was studied to define the glass forming region of the modified material. The samples exhibiting glassy characteristics were furtherly characterised. In particular, the optical and thermal properties of the sample were investigated in order to rationalise the role of selenium in the formation of the glass. The addition of heavy metals to GLS glass generally resulted in a lower glass transition temperature and an extended transmission window. Particularly, the IR edge was found to be extended from about 9µm for GLS glass to about 13µm for doped GLS glass. Furthermore, the addition of these modifications did not affect the UV edge dramatically. Hypothesis on changes within the glass network is also being considered to explain these modifications.

INCREASING THE COUNT RATE OF TIME-CORRELATED SINGLE PHOTON COUNTING TECHNIQUES WITH IMMERSION LENSES ON SINGLE PHOTON AVALANCHE DIODES

Charles Pichette, Université Laval 9:15 am

The small photosensitive area of single photon avalanche diodes (SPADs) restricts the photon counting rate when these detectors are used in time-correlated single photon counting (TCSPC). This is a severe limitation for many applications. This work shows the benefits of affixing an immersion lens on the photosensitive surface of a SPAD to increase the photon counting rate of a time-domain diffuse optical tomography scanner for intrinsic and fluorescence measurements. Zemax simulations have also been carried out and are in good agreement with the experimental data. We believe that this technology can also be used in other applications of TCSPC including microscopy.

VIDEO-RATE DENOISING OF LOW-LIGHT-LEVEL IMAGES ACQUIRED WITH A SPAD CAMERA

Eliot Bolduc, Institute of Photonics and Quantum Science, Heriot-Watt University 9:30 am

State-of-the-art camera technology enables the detection of single photons. A few examples of such technology include, but are not limited to, intensified CCDs, electron multiplying CCDs and single photon avalanche detector (SPAD) cameras. Image denoising involves finding the image most consistent with the data given some prior knowledge about both the image and the source of noise. Prior knowledge about a natural image can be the fact that it has a sparse representation in the discrete cosine basis, that it was acquired under blurring conditions or variations from one pixel to its neighbors are rather small [1]. In our work, we implement a fast denoising algorithm on a recently developed 240x320-pixel SPAD camera [2]. We consider noise that is Poisson distributed, modeling low-photon-number outcomes. The denoising process takes a tenth of a second, thus allowing for a frame rate of 10 Hz. Notably, low-light-level image denoising has a wide range of applications including astronomy, ghost imaging, CT scans and a wide range of fluorescent microscopy.

[1] Dutton, Neale AW, et al. VLSI Circuits Digest of Technical Papers, 2014 Symposium on. IEEE, pp. 1-2, 2014.
[2] Chambolle, Antonin. Journal of Mathematical imaging and vision, 20, 1-2, pp. 89-97, 2004.

DISCRETE RADIAL-HARMONIC-FOURIER MOMENTS FOR IMAGE DESCRIPTION

Kejia Wang, COPL, Université Laval 9:45 am

A new type of multi-distorted invariant discrete orthogonal moments, discrete Radial-Harmonic-Fourier moments was proposed. The kernel function of the moments was composed of radial discrete orthogonal triangular function and angular Fourier complex componential factor. The relationship between discrete Radial-Harmonic-Fourier moments and Radial-Harmonic-Fourier moments was also analyzed. The experimental results indicate that the discrete Radial-Harmonic-Fourier moments have excellent image description ability and can be effectively used as invariant image features in image analysis and pattern recognition.

BOOSTING SOLAR WATER SPLITTING IN HYBRID PLASMONIC PHOTOCATALYSTS

Xin Jin, INRS-EMT 10:00 am

Surface-plasmon-assisted photocatalysis has been extensively investigated in recent years for its promising applications in solar water splitting [1]. A large number of studies focusing on modifying the geometry and size of the plasmonic component in nanohybrids has appeared in the literature [2]. However, the fundamental role played by the resonances that can develop within the semiconducting part of the photocatalysts has been somehow overlooked. In this work, we exploit the properties of “whispering gallery modes” in properly-engineered nanohybrids to boost the activity of plasmonic photocatalysts.

[1] M. Brongersma et al. Nature Nanotech. 10, 25-34 (2015)
[2] C. Clavero. Nature Photon. 8, 95-103 (2014)

Laser Science and Ultrafast Optics - Session 1

1:15 pm to 2:30 pm - Room 1334

TRACKING MOVING OBJECTS HIDDEN FROM VIEW

Genevieve Gariepy, Heriot-Watt University, 1:15 pm

A technology with the ability to detect hidden objects, around a corner or behind a wall, could be a valuable asset when physically going around an obstacle is impossible or dangerous. Such a technology could be useful in rescue missions, hostage situations, and automated driving. We recently reported a method that uses an ultrafast laser and a singlephoton sensitive camera to locate the position of hidden objects with a 3-second acquisition time, allowing for real-time tracking of the hidden object's motion [1]. This proof-ofprinciple experiment was performed at small scales (30cm-high target placed 1m away from the device), and we are now working to extend the distances and scale at which our device operates. Preliminary results show that we can detect a signal from a person hidden up to 8 meters away from our camera. These promising results are a first step towards developing this technology into a compact, useful device for real-world applications.

[1] Gariepy et al. "Detection and tracking of moving objects hidden from view," Nat. Photon. 10, 23-26 (2016)

FLUOROPHOSPHATE GLASS AS A CANDIDATE FOR VOLUME BRAGG GRATINGS WRITING

Olivier Boily, COPL, Université Laval 1:30 pm

Photo-thermo-refractive glass (PTR glass) is a well-known photosensitive silicate-based glass that undergoes a permanent refractive index change after ultraviolet exposure followed by thermal treatment [1]. A similar approach is applied to a new fluorophosphate glass matrix. Refractive index changes up to 1*10-2 can be written into this glass. This fluorophosphate glass is thus a promising candidate for volume Bragg gratings writing. Raman spectroscopy reveals a complete and unprecedented structural modification upon ultraviolet exposure.

[1] G. P. Souza, V. M. Fokin, E. D. Zanotto, « Micro and nanostructures in partially crystallised photothermorefractive glass, » Eur. J. Glass. Sci. Technol. B. 50(5), 311-320 (2009).

TIME-RESOLVED PHOTOELECTRON IMAGING OF HETEROAROMATIC MOLECULES

Magdalena M. Zawadzki, Institute of Photonics & Quantum Sciences, Heriot-Watt University 1:45 pm

Nonlinear optics can be combined with state-of-the-art spectroscopic techniques forming a powerful tool to study aromatic bio-molecules, which have been of increasing interest in photochemistry for the last few years due to their great resistance to potential damage caused by the absorption of ultraviolet (UV) radiation. The underlying process of the photostability is the fast dissipation of this UV excess energy on a femtosecond (fs) timescale. Time-resolved photoelectron imaging (TRPEI) is a modern pump-probe spectroscopic technique, providing time-, energy- and angle-resolved information relating to non-adiabatic dynamics within molecular systems. Nonlinear optics is used for the generation of vacuum ultraviolet (VUV) light, which is utilized as a high energetic "probe" pulse in order to potentially map the full dynamical process of all participating states within a molecule.

PUSHING THE BOUNDARIES OF ELECTRON DIFFRACTION IMAGING

Pascal Hogan-Lamarre, University of Toronto 2:00 pm

Flourishing field in the last decade, electron diffraction (ED) methods are now allowing us to probe matter at an atomic spatial resolution and on the timescale of femtoseconds. Our research group is working to overcome the numerous limitations associated to it, such as the limited spatiotemporal resolution of current electron guns and the need for crystalline samples. We are exploring novel electron sources, notably laser-driven sources predicted to produce ultrashort electron bunches [1], as well as cutting edge ptychographic imaging techniques [2], to unravel the full potential of ED.

[1] V. Marceau, C. Varin, T. Brabec, and M. Piché, Phys. Rev. Lett. 111, 224801 (2013)
[2] M.J. Humphry, B. Kraus, A.C. Hurst, A.M. Maiden, and J.M. Rodenburg, Nat. Commun. (2012)

ATTOSECOND XUV PULSES FOR HIGH RESOLUTION IMAGERY

Vicențiu Iancu, University of Bucharest 2:15 pm

The aim of the study was to performed high harmonic generation (HHG) in Ar and Kr employing high energy TW femtosecond pulses. The spatially and spectrally characterization of the XUV beam was carried out by utilizing two XUV photodiodes and a flat-field XUV spectrometer [1]. It has been estimated that the number of XUV photons emitted after the HHG chamber was 16 108 photons/pulse. The influence of the iris diameter and the pressure in the gas cell on the XUV flux was also investigated. Additionally, the single shot IR and XUV spectra were recorded, being in good agreement with [2]. In the future, temporal measurements will be implemented in order to characterize the XUV radiation.

[1] A. Dubrouil, O. Hort, F. Catoire, D. Descamps, S. Petit, E. Mével, V.V. Strelkov and E. Constant, Nat. Comun. 5, 4637 (2014).
[2] C.F Dutin, A. Dubrouil, S. Petit, E. Mével, E. Constant and D. Descamps, Opt. Lett. 35(2), 253-255 (2010).

Telecommunications - Session 1

1:15 pm to 2:30 pm - Room 2415

TRANSMISSION LINES IN AN OPTICAL SILICON PHOTONIC MODULATOR

Bahareh Sherafati, Université Laval 1:15 pm

My project is designing and simulating the transmission lines in a silicon photonic modulator. My group has designed a silicon photonic IQ modulator that works with very high speed. There are two chips in this device and a package is needed for connecting these chips to the outside world so some carriers are needed to connect the bond pads on the chip to connectors. Drawing the transmission lines on the carrier is not as easy as it seems. The device size is comparable to the wavelength. As a result, it requires distributed systems. In this project I use ADS tool for simulating the transmission lines and the goal is to have a 50 ohm set of transmission lines to match perfectly to other parts.

SPATIALLY-MULTIPLEXED DATA IN SI PHOTONICS

Christine P. Chen, Columbia University 1:30 pm

On-chip mode-division multiplexing (MDM) offers the potential to increase bandwidth density for optical interconnects. Silicon photonics (SiPh) provide large bandwidth capacity while maintaining high energy efficiency. The asymmetric y-junction waveguide is used as the mode multiplexing/de-multiplexing unit with low crosstalk. MDM and polarization-division multiplexing (PDM) [1] can scale on top of wavelength-division multiplexing (WDM), reducing power consumption in a wavelength-multiplexed system by laser reduction. A 3-mode multiplexing/de-multiplexing Si photonic circuit is shown to support 240 Gb/s data (3 modes x 2 wavelengths x 40 Gb/s) [2], illustrating ways to continue scaling bandwidth. Key drivers for optimizing photonic circuit performance are discussed.

[1] C. P. Chen, J. B. Driscoll, R. R. Grote, B. Souhan, R. M. Osgood, Jr., and K. Bergman, IEEE Photon. Technol. Lett. 27 1 (2014).
[2] C. P. Chen, J. B. Driscoll, B. Souhan, R. M. Osgood, Jr., and K. Bergman, IEEE Opt. Int. Conference, TuA3 (2016).

MODE DIVISION MULTIPLEXING USING OAM MODES

Reza Mirzaei Nejad, COPL, Université Laval 1:45 pm

Mode division multiplexing (MDM) has interested increasing attention due to its ability to increase the capacity of fiber-optic networks scaled by the number of modes being transmitted. Using D linear polarized (LP) modes requires a D×D MIMO equalizer to undo the coupling between modes which occurs during propagation. Orbital angular momentum (OAM) modes are new alternative for MDM systems which have the advantage of no intermodal coupling and hence no need for MIMO equalizers in the receiver. But this modal basis can be only used for short fibers and short reach applications. After an already successful OAM-MDM data transmission, over 1.1 km of a specialty designed fiber [1], we have demonstrated OAM-MDM data transmission over longer length of 1.4 km over a specialty fiber designed by our group [2].

[1] N. Bozinovic et al., "Terabit-Scale Orbital Angular Momentum Mode Division Multiplexing in Fibers," Science vol. 340, pp. 1545 (2013).
[2] C. Brunet et al., "Design of a family of ring-core fibers for OAM transmission studies," Optics Express, vol. 23, no. 8 10553-10563 (2015).

ULTRA-FAST AMPLITUDE SHIFT KEYING USING ULTRA-LOW POWER SILICON MODULATOR

Raphaël Dubé-Demers, Université Laval 2:00 pm

Ultra-high-speed optical links are required for future generation of computing systems and data centers for the cloud. Further, additional augmentation of the data rate has been affected by power consumption and bandwidth resources. Key solutions have been identified, such as advances in integrated optical transceivers using complex modulation formats. To that extent, we use a complementary metal-oxide semiconductor (CMOS) compatible, silicon-on-insulator (SOI) process to fabricate microring based modulators (MRM). Leveraging their natural resonance to enhance light-matter interactions, we demonstrate record-breaking performance, i.e. 80 Gb/s using pulse-amplitude modulation (PAM), operating below 10 fJ/bit.

Saturday May 21st

Photonic Sensors and Biomedical Optics - Session 2

9:00 am to 10:15 am - Room 1334

ANALYZING NANOWIRE ALIGNMENT FOR NANOWIRE-BASED ENDOSCOPE DESIGN

Shuhao Wu, Columbia University 9:00 am

This paper analyzes the misalignment of nanowire to the fiber axis within a nanowire-based endoscope for intra-cellular level observation. The simulation result indicates that strict nanowire alignment may be necessary for those designs with very short nanowire length.

ANALYSIS OF TIME-CONTROLLED ELECTROLESS DEPOSITED GOLD FILMS ON TFBGS

Violeta Márquez-Cruz, Carleton University 9:15 am

A tilted fiber Bragg grating (TFBG) is a device built into the core of an optical fiber, which allows the coupling from the core guided light into multiple modes guided by the cladding. Once in the cladding, light can interact with an external medium of interest. Typically, label-free fiber optic sensors rely on the detection of small changes in the refractive index of the external medium. The sensitivity can be enhanced by the addition of thin metallic films on the fiber surface, which, depending on the procedure and the thickness, can lead to surface plasmon resonance. Thus, these devices represent a novel approach for biochemical or environmental sensing applications. In this work we present the analysis of gold films with various thicknesses built by electroless deposition on TFBGs. Particularly, we center our attention in the characterization of the sensitivity to changes in the refractive index of an external medium, as well as the topology of the films.

BRILLOUIN SCATTERING OF VECTOR MODES IN A FEW-MODE FIBER

Prabin Pradhan, École de technologie supérieure 9:30 am

Measurement of the Brillouin gain spectra of vector modes in a few-mode fiber is demonstrated for the first time using a simple heterodyne detection technique. The selective excitation of individual vector mode in few-mode fiber is performed using the tunable long period fiber grating. The effective indices of the vector modes as well as their corresponding effective index separations (Δneff) are retrieved from the Brillouin gain spectra of few-mode fiber. By utilizing the Brillouin frequency shifts corresponding to two or more vector modes, the proposed technique can be potentially applied in distributed fiber sensors with multi-parameter sensing capabilities [1, 2].

[1] Li, A., Wang, Y., Hu, Q., & Shieh, W., Opt. Express, 23(2), 1139-1150(2015).
[2] Weng, Y., Ip, E., Pan, Z., & Wang, T., Opt. Express, 23(7), 9024-9039(2015).

RAYLEIGH SCATTER BASED DISTRIBUTED SENSING ENHANCEMENT BY SIMPLE UV EXPOSURE OF FIBER

Sébastien Loranger, Polytechnique Montreal 9:45 am

Distributed sensing has become very attractive for various industrial and infrastructure monitoring applications. Distributed sensing utilize scattering mechanisms such as Raman, Brillouin or Rayleigh. Rayleigh scattering can theoretically offer the most cost effective solution with the highest sensitivity and spatial resolution, but it suffers from an important flaw: its very low return signal, therefore low signal to noise ratio. We demonstrate here that by exposing a photosensitive fiber to UV light, we can increase the Rayleigh signal by two orders of magnitude. This is demonstrated with 213 nm and 266 nm UV beams on H2 or D2 loaded silica fiber and photosensitive high Ge and/or B doped fiber. From this radical increase in Rayleigh, we show a decrease of over one order of magnitude in the noise level of distributed temperature measurement, giving rise to a <10 mK rms noise for a 1 cm gage length (spatial resolution) [1].

[1] S. Loranger, M. Gagné, V. Lambin-Iezzi, and R. Kashyap. Sci. Rep. 5 (2015).

COMBINED OPTICAL COHERENCE TOMOGRAPHY AND HYPER-SPECTRAL IMAGING USING A DOUBLE CLAD FIBER COUPLER

Xavier Attendu, École Polytechnique de Montréal 10:00 am

This work demonstrates the combination of Optical Coherence Tomography (OCT) and Hyper-Spectral Imaging (HSI) using a double-clad optical fiber coupler. In the optical fiber, the single mode core transmits OCT signals, while the inner cladding captures the reflectance spectrum of the sample. Combining both methods enables 3D acquisition of sample morphology with OCT, enhanced by complementary molecular information in the hyper-spectral images. Overlaying co-registered OCT and HSI data into the same images can provide clinicians with additional visual information and aid in improved tissue characterization and diagnosis. Such a system could easily be implemented in various current clinical endoscopic applications.

Semiconductors and Integrated photonics - Session 1

9:00 am to 10:15 am - Room 2415

FACILE OMNIDIRECTIONAL BLACK SILICON BASED ON POROUS AND NONPOROUS SILICON NANOWIRES FOR ENERGY APPLICATIONS

Abdelaziz M. Gouda, American University in Cairo 9:00 am

High reflection losses and low photon absorption combined with high velocity large area surface recombination are the main obstacles for boosting the efficiency of solar cell. We report a simple large-scale one step catalytic room temperature fabrication approach of black silicon (B-Si) in an aqueous solution of HF and AgNO3. B-Si based on porous and nonporous Silicon nanowires (SiNWs) shows a superior optical properties with low reflectance <0.1% and unprecedented absorption < 99.9% in the solar irradiance peak (wavelength range 400 to 800 nm). The black silicon reflects <2% at different incident angles up to ±60°. The black silicon consists of nonporous and porous SiNWs of tuned filing ratio from 130 to 750 nm, matching the wavelength of the incident light for improved light trapping inside the nanostructure.

TOWARDS A SILICON ELECTRO-OPTIC KERR EFFECT SWITCH

Deepak V. Simili, Dalhousie University 9:15 am

Optical structure design of the silicon electro-optic Kerr effect switch is presented. Such a type of device could lead to ultrafast, low voltage, CMOS compatible electro-optic switching for integrated optics. Majority of the previous efforts on electro-optic modulation in silicon utilize the free carrier plasma dispersion effect where the modulation bandwidth is limited to 10's of GHz due to inherent limitations of the excess carrier recombination lifetime or the carrier drift saturation velocity of silicon. An alternative idea is to utilize the ultrafast (sub pico second) nonlinear Kerr effect in silicon nanocrystals to achieve switching speeds beyond 100 GHz in a silicon-based electro-optic switch [1]. Experimental validation of the electro-optic or DC Kerr effect in silicon nanocrystals has also been reported [2].

[1] M. Cada, in International Symposium on Microwave and Optical Technology 2011, p. 445.
[2] L. Cao, A. Aboketaf, K. Narayanan, A. Elshaari, S. Kowsz, E. Freeman, S. McDermott, S. Preble, J. Bickford, N. Bambha, in FIO/LS Technical Digest 2012 (Optical Society of America, 2012).

GRAPHENE-INSULATOR-GRAPHENE ELECTRO-ABSOPRTION MODULATOR

Mohamed Y. Elsayed, American University in Cairo 9:30 am

Interconnect bottlenecks are endangering Moore's law and optical interconnects are a possible solution to this problem. Large optical components have hindered electro-optical integration. Plasmonic devices tackle this challenge by propagating waves in sub-wavelength structures. We designed a plasmonic electro-optical modulator operating in the mid infrared range. Graphene is interesting because of its tunable Fermi level[1]; the Fermi level can be located within the band gap for maximum absorption or far away from the band gap for minimum absorption[2]. Our modulator is composed Si3N4 between two graphene sheets on SiO2 substrate, with a footprint of 80 nm by 100 nm. Finite Difference Time Domain (FDTD) simulations gave an extinction ratio of 45 dB and insertion loss of 10 dB. We are exploring different substrate materials to reduce the insertion loss.

[1] Y. J. Yu, Y. Zhao, S. Ryu, L. E. Brus, K. S. Kim, and P. Kim, Nano Letters, vol. 9, pp. 3430-4, Oct 2009.
[2] Ming Liu et al, "A graphene-based broadband optical modulator" Nature 474, 64–67 (02 June 2011).

POLARIZATION INDEPENDENT FIBRE-TO-CHIP COUPLERS FOR RAPID PROTOTYPING OF SILICON PHOTONICS DEVICES

Philippe Jean, COPL, Université Laval 9:45 am

We compare various designs of edge couplers for rapid prototyping of silicon photonics chips fabricated using E-beam lithography. We have achieved 4.5 dB insertion loss for a 100nm wide band for both TE and TM polarizations using sub-wavelength grating tapers and an integrated transposer chip as a supplementary fibre-to-chip interface. This method allows for faster and automated testing, which is crucial in the development of silicon photonics devices and systems.

A RIGOROUS THEORETICAL ANALYSIS OF A SURFACE-PLASMON-ENHANCED MONOLAYER NANOLASER

Xiang Meng, Columbia University 10:00 am

Nanophotonic lasers based on monolayer crystals have recently been of major interest due to their compact gain medium[1,2]. Here a comprehensive theoretical model is developed to analyze the performance and operating physics of the laser. Specifically the laser is a direct bandgap optically pumped nanophotonic integrated laser consisting of a high-index nanowire and monolayer transition-metal dichacogenide semiconductor crystal mounted on a silver substrate. The optical field and materials medium are analyzed using a three dimensional finite-difference time-domain method and a first-principles calculation based on density functional theory respectively. The nanolaser is designed to have a threshold of ~0.6μW under quasi-continuous wave operation on an excitonic transition at room temperature.

[1] S. Wu, et al., Nature (London) 520, 69 (2015)
[2] Y. Ye, et al., Nathure Photon. 9, 733 (2015)

Semiconductors and Integrated photonics - Session 2

10:45 am to 12:00 pm - Room 1334

VO_2 FILMS FABRICATION BY RTAC

Cheikhou Ba, COPL, Université Laval 10:45 am

We propose rapid thermal annealing and cooling (RTAC) oxidation in air of sputtered vanadium-rich films to fabricate vanadium dioxide (VO2) with high thermochromic efficiency. In the RTAC oxidation process, the high heating rate allows a control of the film's microstructure and the high cooling rate allows texture control. Surface analysis show microstructure variation from small nanocrystals to elongated needles. X-ray diffraction patterns of oxidized vanadium thin film show very low intense VO2 peaks compared to traditional polycristalline samples. For new films, the optical switching contrast is more important in reflectance, unlike the polycrystalline VO2 thin samples, which show a more pronounced transmittance switching. There is good correlation between specific microstructure and their corresponding optical, electrical and crystallographic properties.

EPITAXIALLY-GROWN GALLIUM NITRIDE ON GALLIUM OXIDE SUBSTRATE FOR PHOTON PAIR GENERATION IN VISIBLE AND TELECOMM WAVELENGTHS

Kashif M. Awan, University of Ottawa 11:00 am

Gallium Nitride (GaN), along with other III-Nitrides, is attractive for optoelectronic and electronic applications due to its wide direct energy bandgap, as well as high thermal stability. It is suitable for integrated nonlinear photonic circuits for a wide range of applications from all-optical signal processing to quantum computing and on-chip wavelength conversion. Despite its abundant use in commercial devices, there is still need for suitable substrate materials to reduce high densities of threading dislocations (TDs) and other structural defects like stacking faults, and grain boundaries. All these defects degrade the optical quality of the epi-grown GaN layer as they act as non-radiative recombination centers. In this work, we propose GaN epitaxially grown on (-201) β-Ga2O3 [1, 2] as a suitable candidate for correlated photon pair generation, leading to on-chip quantum sources for both telecomm and visible spectrum. We also present designs for GaN waveguides to achieve efficient four-wave mixing (FWM) based on the experimental absorption and dispersion data of epitaxially grown GaN on Ga2O3.

[1] M. M. Muhammed, et al., Applied Physics Letters 105, 042112 (2014).
[2] K. Shimamura, et al., Japanese Journal of Applied Physics 44, L7–L8 (2005).

COLLOIDAL QUANTUM DOTS IN SCINTILLATION DOSIMETRY

Marie-Ève Delage, CHU de Québec & Université Laval 11:15 am

Although colloidal quantum dots (cQDs) have found their place in multiple fields, they are more recently being considered in medical fields. One of those is scintillation dosimetry where ionizing radiation doses are measured with visible light emitted by an irradiated material. The versatile material that constitutes the cQDs could offer multiple ways of incorporating this type of nanocrystals in scintillation dosimetry. Their tuneable emission wavelength, the smallness of the scintillating material and the various physical supports possible are interesting properties in considering the cQDs in dosimetric applications. The scope of the work presented is to characterize cQDs response to ionizing radiation and to show their usability in this scintillation dosimetry as well as in related fields like nanotheranostics (where the cQDs act both as the imaging and the therapeutic agent).

BOSE-EINSTEIN CONDENSATION OF EXCITON-POLARITONS

Pranai Vasudev, University of Toronto 11:30 am

Bose-Einstein condensation (BEC) is the phenomenon in which macroscopic quantum coherence emerges as a very large number of particles accumulate into a single state. Recently, researchers around the world have been investigating exciton-polaritons as a candidate for high-temperature BEC [1]. Exciton-polaritons are the “half-light, half-matter” quasiparticles that emerge when semiconductor structures are embedded in a high quality optical cavity. Our work focuses on obtaining room-temperature, equilibrium BEC of exciton-polaritons by using photonic crystals to form the optical cavity. Using slanted pore photonic crystals and InGaAs/InP quantum wells, our results suggest that equilibrium BEC is possible for temperatures up to 400K for emission wavelengths near the telecommunications band. The emitted light may exhibit photon antibunching which could be applied in a futuristic quantum communications network [2].

[1] H. Deng, H. Haug and Y. Yamamoto, Rev. Mod. Phys. 82, 1489-1537 (2010).
[2] S. Yang and S. John, Phys. Rev. B. 84, 024515 (2011).

MICRORESONATORS FOR QUANTUM OPTICS

Zachary Vernon, University of Toronto 11:45 am

Microresonators are developing as a promising platform for quantum optics. A number of exciting quantum applications of such resonators, especially microring resonators, have been demonstrated in recent years, including entangled photon pair generation and quantum frequency conversion. These devices can also be used as sources of heralded single photons. By studying the theoretical underpinnings of nonlinear optical processes in microresonators using fully quantum-mechanical models [1,2], we aim to better understand what is and what is not possible using these devices. We have investigated several intriguing features of these systems in various pumping regimes using different nonlinear interactions.

Laser Science and Ultrafast Optics - Session 2

10:45 am to 12:00 pm - Room 2415

DIRECT LASER WRITING OF WAVEGUIDES IN PHOTOSENSITIVE ZINC PHOSPHATE GLASS

Alain Abou Khalil, CELIA, Université of Bordeaux & COPL, Université Laval 10:45 am

Femtosecond laser direct writing in glasses is a growing research and development area. It presents many advantages compared to other techniques such as lithography, which is limited to 2D structuring. Indeed, femtosecond laser writing is widely used for photonics devices such as waveguides, couplers, Bragg gratings, etc. Structures in the sub wavelength scale has already been reported in photosensitive zinc phosphate glasses [1] as well as relatively high variation in the refractive index [2] $\Delta n \sim 5 \times 10^{-3}$. In this talk, I will present the way of writing structures below the diffraction limit, while on the other hand, exhibiting the evidence of laser writing waveguides in photosensitive zinc phosphate glass [2]. At last, variation of modes profile as a function of the laser parameters will be presented while comparing experimental results with simulations.

[1] M. Bellec, A. Royon, B. Bousquet, K. Bourhis, M. Treguer, T. Cardinal, M. Richardson, and L. Canioni, Opt. Express 17, 10304-10318 (2009).
[2] S. Danto, F. Désévédavy, Y. Petit, J.-C. Desmoulin, A. Abou Khalil, C. Strutynski, M. Dussauze, F. Smektala, T. Cardinal, and L. Canioni, Advanced Optical Materials 4, 162-168 (2016).

SYNCHRONOUS RAMAN AMPLIFICATION OF HIGH-ENERGY ULTRASHORT PULSES IN AN YTTERBIUM-DOPED GAIN FIBER

Maxime Hardy, COPL, Université Laval 11:00 am

The wide bandwidth of Yb-doped fibers is exploited to amplify ultrashort laser pulses to high energy. We propose a scheme where two pulses are propagated together in an Yb-doped fiber amplifier, while exchanging energy using stimulated Raman scattering. Simulations of the propagation of stretched ultrashort pulses at 1030 nm and 1078 nm in a gain fiber are presented. Energy is thus partly transferted from the pulse at 1030 nm to the pulse at 1078 nm by the Raman gain. We show that Raman amplification in a rod-type Yb-doped fiber could result in compressed pulses having durations slightly over 100 fs, energies over 5 mJ and peak powers close to 50 GW.

WATT-LEVEL LASER EMISSION AT 3.4 µm FROM A DUAL-WAVELENGTH PUMPED ALL-FIBER CAVITY

Frédéric Maes, COPL, Université Laval 11:15 am

Mid-infrared lasers have shown to be of particular interest in the development of various applications in spectroscopy, defense & security, biomedical and material processing fields. The $^4F_{9/2} \rightarrow {}^4I_{9/2}$ transition of erbium in fluoride fibers has proven to be efficient in generating such laser emission around 3.4 µm under dual-wavelength pumping [1]. This novel pumping scheme, involving pumps at 974 nm and 1976 nm, allows greater laser output powers and higher slope efficiency at 3.4 µm than conventional pumping at 655 nm. In this work, we report a maximum laser emission output power of 1.52 W at 3.4 µm from an erbium doped all-fiber cavity using dual wavelength pumping. Numerical modelling shows good agreement with experimental laser curves and will help us in finding the optimal laser cavity parameters.

[1] V. Fortin et al., Watt-level erbium-doped all-fiber laser at 3.44 µm, Opt. Lett. 41, 559-562 (2016).

LOW-LOSS FLUOROINDATE FIBER FOR MID-IR SUPERCONTINUUM GENERATION UP TO 5.4 MICRONS

Jean-Christophe Gauthier, COPL, Université Laval 11:30 am

In the last few years, mid-IR supercontinuum (SC) generation received a lot of attention due to its wide range of applications in medicine [1] or spectroscopy [2]. The 3-5 µm band is of particular interest since it overlaps with an atmospheric transparency window and the molecular “fingerprint” region, where most gaseous chemical species have fundamental absorption lines. This allows for applications like remote sensing (LIDAR) and monitoring of air pollutants. The advantage of InF3 fibers over traditional fluoride glasses (i.e. ZBLAN) for mid-IR SC comes from its extended transparency window (up to 5.5 µm), which is about 1 µm further than the standard ZBLAN composition. However, no previous demonstration was able to fully benefit from this transparency window. In this presentation, we report an octave-spanning SC ranging from 2.4 to 5.4 µm generated in an InF3 fiber pumped by a fusion spliced Er3+:ZrF4 fiber amplifier seeded by 400 ps pulses at 2.75 µm. Up to 82% of the SC energy is generated above 3 µm. This simple approach is interesting for many applications requiring 3-5 microns broadband light.

[1] A. Labruyre, A. Tonello, V. Couderc, G. Huss, P. Leproux, Opt. Fiber Technol. 18, 375–378 (2012).
[2] J. Mandon, G. Guelachvili, and N. Picqué, Nature Photonics 3, 99-102 (2009).

CASCADE LASING AT 2.8µm AND 1.6µm

Yigit Ozan Aydin, COPL, Université Laval 11:45 am

There are several techniques to achieve 2.8 µm laser action in erbium doped fluoride glass fibers. Cascade lasing at 2.8 µm (4I11/2 -> 4I13/2) and 1.6 µm (4I13/2 -> 4I15/2) under 980 nm pumping [1] is one of the most promising approaches, which effectively depopulates the lower laser level of the 2.8 µm transition (4I13/2). In this study, we developed a diode cladding pumped erbium fluoride fiber laser based on such cascade lasing scheme. In addition, the influence of the 1.6 µm lasing threshold on 2.8 µm transition efficiency was demonstrated and investigated by changing the length of the active medium and reflectivity of the output coupler at 1.6 µm.

[1] S. D. Jackson, M. Pollnau,J. Li, IEEE J. Quantum Electron., vol. 47, no. 4, pp. 471-478, (2011).

Photonic Sensors and Biomedical Optics - Session 3

3:30 pm to 5:00 pm - Room 1334

SLOW LIGHT ENHANCEMENT IN FABRICATED PHOTONIC CRYSTAL RING RESONATORS

Kathleen McGarvey-Lechable, Concordia University 3:30 pm

We present experimental results of photonic crystal ring resonators (PhCRRs) fabricated on the CMOS-compatible, silicon-on-insulator platform via optical lithography. The high accuracy of our dispersion-engineering design approach is demonstrated by reporting a mean photonic band-edge wavelength within 0.2% of our targeted band-edge wavelength of 1550 nm. Quality factors of PhCRRs and equivalently-sized ring resonators are compared, revealing slow-light enhancemen of PhCRR microcavity lifetimes. A record high PhCRR Q-factor of 31,200 is reported, indicating that highthroughput optical lithography is a very good candidate for PhCRR fabrication.

RAPID 3D CHEMICAL-SPECIFIC IMAGING OF MINERALS USING STIMULATED RAMAN SCATTERING MICROSCOPY

Marie-Andrée Houle, INRS-ÉMT & NRC 3:45 pm

We demonstrate the first application of Stimulated Raman Scattering (SRS) microscopy to geological samples. SRS microscopy provides both chemical specificity and excellent three-dimensional resolution. Unlike Raman microscopy, SRS microscopy is unaffected by fluorescence and can rapidly scan specific sections of the Raman spectrum within an overall tuning range of 400 – 4500 cm^{-1}. Our setup offers a multimodal tool by combining SRS microscopy with Second Harmonic Generation (SHG) and Two-Photon Fluorescence (TPF) microscopy. We use this technique to image various minerals as well as organic matters within geological samples to unveil their structure and chemical composition.

STUDY ON CELL OPTO-MECHANICS WITH OPTICAL TWEEZERS

Lingyao Yu, COPL, Université Laval 4:00 pm

We are the first to analyze a 3D biconcave cell's deformation in the dual-trap optical tweezers, where the highly focused laser beam scattering and the radiation stress distribution are balanced with the consequent deformation of the cell morphological shape at the equilibrium state. In time-sharing optical tweezers, our analysis indicates the omnipresence of the local stress and strain jumping in this regime, which is associated to viscoelastic hysteresis energy dissipation [1]. Our analysis also shows that in the creep testing the deformation of the object depends not only on the object viscoelasticity and the mechanical loading, but also on its 3D shape significantly, while the loss tangent in the dynamic testing is not sensitive to the 3D morphological shape [2].

[1] L. Yu, and Y. Sheng, Opt Express 22, (2014)
[2] L. Yu, and Y. Sheng, Opt Express 23, 6020 (2015)

THZ SPATIAL MAPPING OF PHOTOTHERMAL EFFECTS

Holger Breitenborn, INRS-EMT 4:15 pm

We have developed a novel temperature mapping technique exploiting the high sensitivity of terahertz (THz) waves to aqueous media. This method allowed us to investigate photothermal effects on a nano-scale, such as collective heating phenomena in a porcine skin. The correlation of the THz non-invasive imaging to temperature measurements enables us to develop a biological THz-based thermometer, so called “teramometer”.

ASSESSING CROWD DYNAMICS WITH THERMAL IMAGING

Sergio Mejia-Romero, Visual Psychophysics and Perception Laboratory, University of Montreal 4:30 pm

Thermal infrared imaging technology is relatively new in the study of human behavior, particularly in applications like pedestrian crowd movement. Recently there is a new concept to investigate human interactions in the real world known as living labs. We believed that photonic technology in general and specifically infrared imaging can help us to model complex human interactions present within a living lab. In this work we present a theoretical and experimental study of the natural movement of pedestrians when passed through a limited and known area, the experimental study conducted in a living lab using infrared cameras. We have modeled human pedestrian trajectories by using the principle of least-action, which we compared against experimental results obtained with thermal imaging technology.

Nonlinear Optics

3:30 pm to 5:00 pm - Room 2415

SILICON-BASED NANOSTRUCTURES AS SURFACE ENHANCED RAMAN SCATTERING SUBSTRATES

Abdelaziz M. Gouda, American University in Cairo 3:30 pm

We report surface enhanced Raman scattering substrates that are low cost and easy to fabricate using silver nanoparticles on silicon wafer and silicon nanowires decorated with the nanoparticles. Numerical simulations showed enhancement factors around 107 to 108 at the hot spots, enabling single molecule detection. We demonstrated experimentally the substrates using reduced Graphene oxide solution.

SCANNING NONLINEAR ABSORPTION IN LITHIUM NIOBATE OVER THE TIME REGIME OF SMALL POLARON FORMATION

Felix Freytag, University Osnabrueck 3:45 pm

Nonlinear absorption is studied in presence of small polaron formation in lithium niobate using the z-scan technique and ultrashort laser pulses with pulse durations of 70 - 1.000 fs. A model for the analysis of transmission loss as a function of pulse duration is introduced that considers (i) the individual contributions of two-photon and small polaron absorption, (ii) the small polaron formation time and (iii) an offset time between the optical excitation of free carriers by two-photon absorption and the appearance of small polarons. It is shown that the model allows for analysis of the experimentally determined z-scan data with high precision over the entire range of pulse durations. It can be concluded that the small polaron formation time is as short as (70 - 110) fs and the appearance of small polaron formation is delayed with respect to two-photon absorption by an offset of ~80 fs.

[1] Baddoreck et al., Opt. Mater. Express 5(12) 2729-2741 (2015).

TAILORING THE SPECTRUM OF BRIGHT SQUEEZED VACUUM

Samuel Lemieux, Max Planck Centre for Extreme and Quantum Photonics, University of Ottawa 4:00 pm

Two nonlinear crystals are used to study the frequency and angular spectra of squeezed vacuum generated in the high-gain regime, a macroscopic optical state exhibiting quantum features with a broad range of applications in quantum metrology [1,2]. In this work, the spectrum of high-gain parametric down-conversion is experimentally measured for different two-crystal configurations. Specifically, varying the distance and the dispersion between two nonlinear crystals can have a dramatic effect on the spectrum, the number of spatiotemporal modes, and the spectral dependence on the parametric gain.

[1] F. Hudelist, J. Kong, C. Liu, J. Jing, Z. Y. Ou, And W. Zhang, Nature communications 5 (2014).
[2] J. Aasi et al., Nature Photonics 7(8), 613-619 (2013).

ON-CHIP FREQUENCY COMB OF ENTANGLED PHOTON PAIRS

Piotr Roztocki, INRS-EMT 4:15 pm

Quantum-entangled photon pair sources are one of the key building blocks for applications in quantum information processing and computing, quantum communications, and metrology. To deliver the compactness, scalability, and efficiency required for future quantum optical circuit devices, photon source solutions focusing on an integrated (on-chip) approach have been recently studied and developed exploiting spontaneous four-wave mixing (SFWM) processes [1]. However, up till now the generation of entangled photon pairs has not been demonstrated for more than one signal-idler frequency pair. Here we report the generation of multiple frequency-channel, time-bin entangled photon pairs from a single integrated CMOS-compatible microring resonator [2].

[1] C. Reimer et al., Nature Communications 6, 8236 (2015)
[2] C. Reimer et al., Science 351, 1176-1180 (2016)

MULTI-PHOTON ENTANGLEMENT GENERATION ON A PHOTONIC CHIP

Christian Reimer, INRS-EMT 4:30 pm

The generation of entangled photon states is required for the realization of several quantum protocols, which can drastically increase computational speed or enable secure communication, amongst other applications. However, the generation of multi-partite entangled states is very challenging experimentally and has not yet been achieved on an integrated platform. A large variety of different integrated quantum sources has been demonstrated by exploiting different nonlinear optical interactions [1], however, until now, no integrated source has generated more than two entangled photons. Here we report the first generation of multiple, four-photon entangled states on a photonic chip, exploiting a new approach based on integrated quantum frequency comb sources [2].

[1] C. Reimer et al., Nature Communications 6, 8236 (2015)
[2] C. Reimer et al., Science 351, 1176-1180 (2016)

SCHMIDT DECOMPOSITION FOR SYSTEMS OF IDENTICAL PARTICLES

Stefania Sciara, INRS-EMT 3:45 pm

Schmidt decomposition (SD) is a key tool in quantum information theory for bipartite pure systems of distinguishable particles in pure states, playing a fundamental role in entanglement quantification. Nevertheless, it is considered inapplicable when particles are identical [1]. We demonstrate that, within a recently introduced particle-based approach [2], a SD also exists for systems of identical particles, and we exploit it to determine identical particle entanglement by the standard notion of the Von Neumann entropy of the reduced state. We apply the SD to situation of physical interests, such as Bell-like states, two particles in the same site, and so-called qutrits, demonstrating the efficiency of our approach. The SD provides a tool to measure entanglement in systems of particles in partially overlapping sites, which are relevant both theoretically and experimentally.

[1] M.C. Tichy et al., Essential entanglement for atomic and molecular physics, J.Phys.B: At. Mol. Opt. Phys. 44, 192001 (2011)
[2] R. Lo Franco and G. Compagno, Quantum entanglement of identical particles by standard information-theoretic notions, Sci. Rep. 6, 20603 (2016)

Posters

ADAPTIVE ENDOSCOPIC IMAGING OF THE BRAIN

Arutyun Bagramyan, Université Laval & Quebec Mental Health Institute

With the continued miniaturization of endoscopic imaging tools, the use of mechanical adaptation (focusing, etc.) becomes difficult. This is particularly true for the “mobile” or portable implants, including the freely behaving animals. In the current presentation we shall describe the concept of a motion less adaptive imaging on the example of a stationary (still large) system using liquid crystal micro lenses. Fixed gradient index and electrically tunable liquid crystal lenses (TLCL) were used to build the imaging optical probe. A focal shift of approximately 74 ± 3um was achieved by electrically controlling the lens TLCL. The potential of the system was tested by imaging neurons and spines in thick adult mouse brain sections and in vivo, in the adult mouse brain at different focal planes. Our results indicate that we can further modify our imaging system and obtain its miniaturized version for mobile applications.

FIBER-BASED TISSUE IDENTIFICATION FOR ELECTRODE PLACEMENT IN DEEP BRAIN STIMULATION NEUROSURGERY

Damon DePaoli, CRIUSMQ

We have designed a fiber optic device to be inserted within commercially available DBS electrodes, used for the treatment of Parkinson’s disease. The probes have the ability to sense biological information from the surrounding tissue to achieve much needed optical guidance for the intricate surgery. We are currently validating the accuracy of the guidance on in vivo primates undergoing electrode implantation. The optical method we use to acquire discriminatory information in vivo is currently diffuse reflectance; however, we have made significant strides ex vivo, using CARS spectroscopy.

THE EFFECT OF ORIENTATED-DEPOSITION GOLD COATINGS ON THE SURFACE PLASMON EXCITATION OF TILTED FIBER BRAGG GRATING

Dingyi Feng, Carleton University

Tilted fiber Bragg grating (TFBG) successfully modulates the TM-polarized cladding modes with suitable effective refractive index (ERI) by the surface plasmon polaritons (SPP) wave propagating along thin metal film coated on the TFBG surface [1]. Here, an unique SPR signature with much narrower line-width and large attenuation depth can be obtained as long as the orientation of TFBG plane placing in parallel with that of gold film, which provides a simple and reliable method for fiber-SPR refractometer, without the crucial film-constancy demand.

[1] Y. Shevchenko and Jacques Albert, Opt. Lett., 32, 211-213,2007.

FABRICATION OF FLUOROPHOSPHATE GLASS FIBER BY THE CRUCIBLE METHOD FOR TRANSMISSION IN THE UV

Gustavo Galleani, Sao Paulo State University & COPL, Université Laval

Novel fiber materials transmitting in the deep and vacuum ultraviolet (below 300 nm) are highly desirable for specific applications like in agriculture for elemental sensing (P and S with atomic absorption lines at 177 and 181 nm, respectively) and for excimer lasers radiation delivery in microlithography. To this end, fluorophosphate vitreous materials appear as excellent candidates thanks to their large glass-forming ability and transmission windows that can be extended to the deep-UV (down to ~160 nm) when their content of impurities are kept ultra-low. Here, we report on the development of highly-pure fluorophosphate step-index optical fibers by the crucible method. The potential of this material to be used as deep-UV transmitting optical fiber will be discussed.

OPTICAL WAVEGUIDE FOR SMARTPHONE APPLICATION

Jean-Sébastien Boisvert, Polytechnique Montréal

Smartphone companies are constantly trying to improve this high demand technology by creating new functionalities. However, new functionalities often require more hardware consuming space. What we propose is to integrate femtosecond laser written waveguides in the glass itself. We obtained low loss single-mode waveguides of 0.053 dB/cm in Gorilla® glass. Thus, we have made a Mach-Zehnder interferometer based temperature sensor [1] and a surface sensor which measures the refracted index of a liquid drop placed on the screen glass [2]. We are currently looking forward to improve those sensors by understanding the writing process and make novel devices.

[1] Jerome Lapointe, Mathieu Gagné, Ming-Jun Li and Raman Kashyap, Making smart phone smarter with photonics, OSA 2014, OPTICS EXPRESS 15483
[2] Jerome Lapointe, Francois Parent, Elton Soares De Lima Filho, Sebastien Loranger Raman Kashyap, Opt. Let. 23, 5657 2015

QUANTIFICATION OF PLASMONIC AND ENHANCED FLUORESCENCE PROPERTIES IN AG@SIO$_2$ SYSTEMS

Jérémie Asselin, Université Laval

Metal@silica concentric nanoparticles capable of metal-enhanced fluorescence (MEF) represent a powerful means to improve the brightness and stability of encapsulated organic fluorophores. The rational design of MEF-enabled analytical or biological sensors often involves comparing fluorescence enhancement factors (EF) between nanostructures having different structural properties (e.g., metal core diameter, silica shell thickness, extent of spectral overlap between plasmon band and fluorophore). In this work, Ag@SiO2@SiO2+x (where x is fluorescein, eosin or rhodamine B) nanostructures were synthesized with excellent control of core size, silica spacer shell thickness and fluorophore concentration, and investigated using UV-VIS spectrometry, spectrofluorimetry, time-resolved fluorometry and transmission electron microscopy.

[1] J. Asselin, P. Legros, A. Grégoire, and D. Boudreau, Plasmonics, doi : 10.1007/s11468-016-0186-5 (2016)

ADVANCE DEVELOPMENT OF AN ELECTROCHEMICAL SENSOR FOR QUANTIFICATION OF POTASSIUM IONS

Mathilde Loubier, Canada Excellence Research Chair in Photonic Innovations

Nowadays, an important need for the precise quantification of the soil's nutriments is a big interest for agriculture field. For this reason, there is an important analytic need for high spatial and temporal resolutions to improve management of agricultural production. Actual analytical techniques in laboratories cannot answer at the important demand. In this context, the development of a new technology to quantify ions in soil is very promising. Our approach is based on an electrochemical sensor using electrochemical impedance spectroscopy (EIS) to quantify specific ion. Previous work in our group research allowed us to develop a design sensor with a polymeric selective membrane [1-2]. Our study on this device showed a lack of selectivity. This presentation will report on progress of the development of different designs of sensor to achieve selectivity for the analytical device.

[1] Normandeau, C.-O.; Viens, J.-F.; Messaddeq, Y. (Université Laval). Electrochemical Sensor. US Patents WO 2014/078964 (PCT/CA2013/050893), Novembre 22, 2013
[2] Ghaffari, S.; Caron, W.; Loubier, M.; Normandeau, C.; Viens, J.; Lamhamedi, M.; Gosselin, B.; Messaddeq, Y. Electrochemical Impedance Sensors for Monitoring Trace Amounts of NO3 in Selected Growing Media, Sensors, 2015, 15, 17715–17727.

OPTICAL AND ELECTRICAL CHARACTERIZATIONS OF MULTIFUNCTIONAL AGI-AGPO$_3$-WO$_3$ BASED GLASSES AND FIBERS

Maxime Rioux, Département of chemistry, Université Laval & COPL, Université Laval

In this study, we report the first optically-transparent and electrically-conductive optical glasses and fibers based on AgI-AgPO3-WO3 glasses.1 The objective of this work was to fabricate and characterize different multifunctional fibers comprising AgI-AgPO3-WO3 glass and PC/PMMA polymers for concurrent electrical conduction and light transmission. By using the fusion/casting method we fabricated different compositions of AgI-AgPO3-WO3 glasses. The addition of tungsten oxide (WO3) into the phosphate glassy network allowed the adjustment of the glass transition temperature, refractive index and optical band edge. Furthermore, the addition of WO3 can improve considerably glass stability against water and humidity in the environment. AgI-AgPO3-WO3 glasses showed 10-3 S•cm-1 electrical conductivity at 1 MHz AC frequency.

[1] Rioux, M. et al. Optically-transparent and electrically-conductive AgI–AgPO3–WO3 glass fibers. RSC Adv. 5, 40236 (2015).

THEORETICAL AND EXPERIMENTAL STUDY OF ELECTROMAGNETIC FORCES IN PHOTONIC CRYSTALS WITH DEFECTS

Noemí Sánchez-Castro, BUAP & Amity School of Engineering and Technology

In this work we will study the possiblity of increasing the electromagnetic forces by adding a defect layer made of a lossy material (gold) to a porous silicon microcavity. The amplitude of the field is maximum at the defect layer and decreases towards the outer layers. We have experimentally characterized optical transmission of this new structure and compare with a theoretical model. The results show that we can use gold thickness up to 5 nm to have a good transmision of energy and therefore we should expect an electromagnetic force within the whole structure.

CALCIUM IMAGING OF ISOLATED NEURONAL NETWORKS

Pau Aleix Pagés, CRIUSMQ

Neuronal action potentials can be indirectly measured using fluorescent calcium sensors. Current calcium imaging techniques provide sufficient spatial resolution to track the evolution of thousands of cells simultaneously, yet such data are often limited to subsets of neurons that interact within much larger networks. In order to get a more complete description of how information is processed and exchanged between neurons, we imaged the calcium activity of small cultured neuronal networks, each of them being entirely contained within a circular area of 2 mm in diameter. We used the calcium indicator GCamp6f, which was genetically encoded into the neurons via virus infection. We stimulated the neurons by following chemical long-term potentiation plasticity protocols and studied their influence over the dynamics and functional connectivity of the networks.

THE SURFACE PLASMON RESONANCE OF SILVER NANOPARTICLES AS A SENSITIVE TOOL FOR PROTEIN ASSAY

Vasyl Syrvatka, Institute of Animal Biology NAAS

Nanotechnologies are considered to be integrated into protein quantitation techniques as a powerful approach in proteomics. The goal of the research was to build a new sensitive tool for a fast protein quantitation method based on surface plasmon resonance of silver nanoparticles. This new method is based on changing physical properties by transforming nanoparticles into suitable reagent for protein concentration determination. In the core of the surface plasmon resonance lies the quantum phenomenon, as a very sensitive tool for determination of structural changes of nanoparticles in samples. UV-vis spectroscopy was used to study optical properties of silver nanoparticles at different stages when using the new assay. A transmission electron microscopy analysis was performed to visualize structure transformation of silver nanoparticles in the samples. As a result, we developed a new highly sensitive and quick protein quantification method based on surface plasmon resonance of silver nanoparticles that can be use in research and medicine.

PHOTO-INDUCED PHENOMENA IN AS-BASED THIN FILMS GLASSY DOPED WITH COPPER

Aouatif Qasmi, COPL, Université Laval

It is well known that one of the photoinduced changes in As-based chalcogenide materials by exposure to near-bandgap light result in the red shift of the absorption edge i.e. photodarkening (PD). However since the observation of Liu et al. [1] showing that the presence of 1% Cu in bulk As2S3, eliminates the PD, there remains a lack of detailed study concerning the influence of different experimental conditions on the composition, structure, optical properties of As- based glassy doped with copper. In the present work we have studied the effect of copper on the optical and structural photoinduced changes of chalcogenide glassy system Cu10(As20S80)90.

[1] J. Z. Liu, and P. C. Taylor. "Absence of photodarkening in bulk, glassy As2S3 and As2 Se3 alloyed with copper." Physical review letters 59.17 (1987)

INTENSITY ENHANCEMENT OF SELF-ACCELERATING BEAMS

Domenico Bongiovanni, INRS-EMT

We study analytically and experimentally the dynamics of two-dimensional (2D) self-accelerating beams generated from the Fourier-space phase modulation of light. We demonstrate that the trajectory of a 2D self-accelerating beam can be designed through a direct mapping between the spatial spectrum and the propagation distance. In addition, the main lobe of the beam can be approximately described by an analytical solution in a generalized way. Moreover, we also propose a method to optimize the beam generation, aiming at obtaining enhanced peak intensities. Our theoretical analyses are in good agreement with the experimental results. Our findings may be relevant to many physical applications.

SPATIOTEMPORAL BESSEL-GAUSS BEAMS: RECONSTRUCTION USING FOURIER TRANSFORM SPECTRAL INTERFEROMETRY

Laurent Dusablon, COPL, Université Laval

Spatiotemporal Bessel-Gauss beams have non-diffracting and non-dispersive field distributions. As a result, theses beams propagate with no temporal nor spatial spread over a long distance in a material with properly chosen anomalous dispersion. Such beams were introduced in 2007 by M. Dallaire in Spatiotemporal Bessel beams: theory and experiments [1]. In this paper, we developed and used a Fourier transform spectral interferometry method to reconstruct their spatiotemporal profile. Reconstruction was realized with different values of the dispersion parameter. Experimental results are consistent with theoretical predictions.

[1] Michaël Dallaire, Nathalie McCarthy, and Michel Piché, "Spatiotemporal bessel beams: theory and experiments," Opt. Express 17, 18148-18164 (2009)

MAOT CALCULATIONS ENERGIES AND WIDTHS FOR THE 3s3p6 ($2S_{1/2}$) np (n=4-30) RYDBERG SERIES OF THE ARGON ATOM

Malick SOW, Université Cheikh Anta Diop

It is important to arrange digital data of the resonance parameters useful for the understanding of the astrophysical observations. The profusion of the Argon element in the X-spectral of young supernovae is revealed by the satellite Chandra. These stellar observations testify of the interest that takes on the calculation of the resonances parameters in the atom of argon and its ions for the modelling of astrophysical plasmas. In this presentation, the Modified Atomic Orbital Theory (MAOT) [1] is applied to the study of the resonant photoionization of the Argon. We present our results of the energies and widths of the 3s3p6 (2S1/2) np(n =4-30)Rydberg series of the Argon atom. Our MAOT results are in very good agreement with the most recent results obtained by Carette and al., [2] who applied the approach R-matrix that is the most widely used photoionization method.

[1]: Sow, M et al., Chin. J. Phys. Vol 52, N°5, 1459 (2014).
[2]: T. Carette, J. M. Dahlström, L. Argenti, and E. Lindroth, Phys. Rev A 87, 023420 (2013)

CHALCOGENIDE GLASSES DOPED WITH IRON FOR MID-IR LASER SOURCES

Matthieu Chazot, Université Laval

There is a strong interest for generating new mid–infrared laser sources operating in the range of 3-5 microns. ZnSe crystals doped with ferrous ions are currently the most efficient materials used as optical cavities. Ferrous ions absorb from 2.5 up to 3.8 µm and fluorescence between 3 and 5 µm [1], [2]. However their high cost and their need to be cooled at low temperature to be functional limit their use [2]. There is a need then to research new materials able to replace ZnSe crystals. To achieve this purpose, we decided to focus our work on glasses doped with iron ions. For that, materials having low phonon energy are required. Chalcogenide glasses are a good candidates for such application.

[1] V. F. S Mirov, "New Regimes of Excitation and Mid-IR Lasing of Transition Metal Doped II–VI Crystals," Springer, pp. 261–314, 2008.
[2] V. V. Fedorov, S. B. Mirov, A. Gallian, D. V. Badikov, M. P. Frolov, Y. V. Korostelin, V. I. Kozlovsky, A. I. Landman, Y. P. Podmar'Kov, V. a. Akimov, and A. a. Voronov, "3.77-5.05-µm tunable solid-state lasers based on Fe2+-doped ZnSe crystals operating at low and room temperatures," IEEE J. Quantum Electron. vol. 42, 2006.

STUDY OF OPTICAL AND SPECTROSCOPIC PROPERTIES OF ERBIUM DOPED TELLURIUM/GERMANIUM OXIDE GLASSES FOR APPLICATIONS IN NANOPLASMONICS

Otavio B. Silva, Grupo de Óptica, Instituto de Física de São Carlos & COPL, Université Laval

Tellurium and Germanium oxide based glasses present attractive optical/mechanical properties, like high refractive index (n≥2), extended transmission in the infrared region (up to 5-6 µm), low phonon energy compared to silicate glasses (650-900 cm-1) and good mechanical resistance [1]. Furthermore, their high solubility for rare earths has made them excellent candidates for optical fibers and optical amplifiers on the last two decades. The goal of this work is to analyze the optical and structural properties of erbium doped Tellurium/Germanium oxide glasses with a fixed content of rare earth and varying the TeO2/GeO2 relative concentrations, in order to use them as substrates for nanostructures.

[1]A.Jha, et al. « Rare-earth ion doped TeO2 and GeO2 glasses as laser materials ». Prog. Mater. Sci, p.1426 (2012)

ON THE OPTIMIZATION OF TAPERED NANOANTENNAS RESONATING IN THE TERAHERTZ RANGE

Diego Caraffini, INRS-EMT

In recent years, resonant nanoantennas (NAs) have been extensively investigated due to their capability of concentrating incident light in sub-wavelength volumes, thus leading to a local field enhancement (FE) [1]. This phenomenon has been effectively employed in the terahertz (THz) region to sense elementary excitations and fingerprints of ensembles of molecules [2]. However, it is commonly assumed that dipolar NAs represent the best solution to maximize the FE in proximity of their tips [1]. Here, we prove, through extensive numerical simulations performed with COMSOL and through the development of a quasi-analytical model, that small taper angles (0.4°÷0.5°) can significantly improve the FE of such nanostructures in the THz region.

[1] K. B. Crozier et al., J. Appl. Phys. 94, 4632 (2003).

[2] A. Toma et al., Nano Lett. 15, 386 (2015).

EXPLORE THE ULTIMATE LIMIT OF QUALITY FACTOR FOR MIM OPTICAL FILTER DESIGN WITH TRANSMISSION LINE MODEL

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Optical properties of MIM filter are analyzed with transmission line model, which calculated spectrum matches the numerical results well when electric field is confined within the cavities. We further propose that the model can be utilized to explore the upper limit of quality factor for MIM optical filter design.

SENSITIVITY ANALYSIS OF ELLIPSOMETRY APPLIED TO A THIN FILM ON A CURVED SUBSTRATE

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Ellipsometry is a non-invasive optical method mainly used to investigate the thickness and refractive index of thin films on a substrate. It directly measures the polarization state change before and after light reflection upon a sample. Conventional ellipsometry is limited to thin films on flat surfaces, even though the speed and accuracy have been greatly improved over the years. This study aims to extend the scope of ellipsometry to curved surfaces. We theoretically analyze the sensitivity of a general ellipsometric system to measure thin film on a curved surface, and to lay the foundation for our design and further experimental setup.

[1] Tompkins, Harland, and Eugene A. Irene. Handbook of ellipsometry. William Andrew, 2005.

[2] Azzam, R. M. A. "Ellipsometry Handbook of Optics 2nd edn, vol 2, ed M Bass." (1995).

DEVELOPMENT OF AN EVALUATION BOARD FOR THE CONTROL OF LED LIGHT BROADENING USING A LIQUID CRYSTAL ELEMENT IN A CLOSED LOOP

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Since the massive invasion of LED lighting over the illumination market, a clear trend of need appeared for a more efficient and targeted lighting. The project leads this trend by developing an evaluation board to test smart lighting applications with a new liquid crystal light modulator recently developed for broadening LED light beams. These modulator are controlled by electricals signals and they are characterised by a very linear working zone. This feature allows the implementation of a closed loop control with a sensor feedback. We show that the use of computer vision is a promising opportunity for closed loop control. The developed evaluation board integrates the liquid crystal modulator, a camera, a LED light source and all the required electronics to implement a closed loop control with a computer vision algorithm.

INVESTIGATION ON SUPPRESSION OF LASER SPECKLE NOISE IN MULTIMODE FIBER

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We experimentally demonstrate a simple technique to reduce speckle contrast in a multimode fiber (MMF) that is set into vibration using a piezoelectric cylindrical transducer (PZT). Speckle is the random modulation of light intensity that occurs when a rough surface, such as a projection screen, is illuminated with coherent or partially coherent light resulting in projected images with a granular appearance1. The speckle patterns obtained at the output of a MMF stem from the coupling between the numerous propagation modes in the fiber whose relative weights can be somewhat controlled through external vibration of the MMF. In this experiment, a part of a MMF was fixed on the radial direction of PZT and high frequency oscillation applied to the PZT. The far field speckle images obtained on the screen was captured using a camera. The experimental results show a significant reduction (>41%) of speckle contrast with the PZT and are due to time averaged smoothing. Factors that affect speckle contrast like exposure time of camera, roughness of screen and laser diode current modulation are also investigated and reported.

[1] Jeffrey G. Manni1, and Joseph W. Goodman, Optics Express, 20, 10 (2012)

EXPLORING THE POTENTIAL OF USING MESOPOROUS SILICA NANOPARTICLES FOR OPTICAL ANTIREFLECTIVE COATINGS

E.Vahanian, COPL, Université Laval

High concentrating photovoltaic (HCPV) systems use optical components in order to focus the sunlight on a small sized photovoltaic cell. In many HCPV systems, primary and secondary optical elements are used (POE and SOE) to focus and homogenize the sun light, respectively [1]. However, adding multiple surfaces increases the number of interfaces where wavelength dependent reflections can occur generating thus optical losses and degrading the efficiency of HCPV system. This study was aimed to find a cost effective antireflective coating for the POE and SOE specific surfaces. In the present work, we use mesoporous silica nanoparticles to coat glass or plastic surfaces (plane or grooved) by a layer-by-layer assembly, where opposite charged particles are deposited successively [2].

[1] A.Luque, Solar Cells and Optics for Photovoltaic Concentration, The Adam Higler series on Optics and Optoelectronics, 1989.
[2] X.Li, X.Du and J.He, "Self-Cleaning Antireflective Coatings Assembled from Pecular Mesoporous Silica Nanoparticles," Langmuir-American Chemical Society, vol. 26, no. 16, pp. 13528-13534, 2010.

PSEUDO-CIRCULATOR IMPLEMENTED AS A MULTIMODE FIBER COUPLER

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We present a linear all-fibre device exhibiting the functionality of a circulator, albeit for multimode fibres. We define a pseudo-circulator as a linear three-port component that transfers most of a multimode light signal from Port 1 to Port 2, and from Port 2 to Port 3. Unlike a traditional circulator which depends on a nonlinear phenomenon to achieve a non-reciprocal behavior, our device is a linear component that seemingly breaks the principle of reciprocity by exploiting the variations of etendue of the multimode fibres in the coupler. The pseudo-circulator is implemented as a 2x2 asymmetric multimode fibre coupler, fabricated using the fusion-tapering technique. The coupler is asymmetric in its transverse fused section. The two multimode fibres differ in area, thus favoring the transfer of light from the smaller to the bigger fibre. The desired difference of area is obtained by tapering one of the fibre before the fusion process. Using this technique, we have successfully fabricated a pseudo-circulator surpassing in efficiency a 50/50 beam-splitter. In all the visible and near-IR spectrum, the transmission ratio exceeds 77% from Port 1 to Port 2, and 80% from Port 2 to Port 3. The excess loss is less than 0.5 dB, regardless of the entry port.

INVESTIGATIONS OF SPREAD FUNCTION OF THE OPTICAL SPECTRAL DEVICE BASED ON ACOUSTO-OPTIC TUNABLE FILTER

Georgy Korol, St. Petersburg State University of Aerospace Instrumentation

The analysis of the spectra of the dynamic signals in optical range by techniques of acousto-optics at light diffraction on a traveling acoustic wave excited by a periodic sequence of radio pulses with a rectangular envelope and linear variation of the instantaneous frequency is considered. The expression of the spread function of the spectral device based on acousto-optical tunable filter that allows to investigate in detail the advantages of this optical spectrometer is obtained. Mathematical modeling of the spread functions for different values of speed of change of the instantaneous control frequency is performed. The results of experimental research are provided.

RESOLUTION ENHANCEMENT IN CONFOCAL MICROSCOPY USING BESSEL-GAUSS BEAMS

Louis Thibon, COPL, Université Laval & CRIUSMQ

Laser scanning microscopy is limited in lateral resolution by the diffraction of light. We show that the use of Bessel-Gauss beams leads to a resolution enhancement of 20% in confocal microscopy. Advantages of this technique include simplicity of installation and use, polarization independence, compatibility with other resolution enhancement and superresolution techniques. We have demonstrated the resolution enhancement capabilities of Bessel-Gauss beams both theoretically and experimentally on nano-spheres and tissue samples. Because of the polarization independence of the technique we can focus Bessel-Gauss beams of different orders and further improve an existing resolution enhancement technique (SLAM: Switching LAser Modes). We also show that using Bessel-Gauss beams for a statistical colocalization analysis leads to less false positive results than using Gaussian beam.

ORTHONORMAL GRADIENT POLYNOMIALS FOR HIGH-RESOLUTION DATA PROCESSING IN RECTANGULAR DOMAIN

Maham Aftab, College of Optical Sciences, University of Arizona

To analyze surfaces or wavefronts, especially for high-resolution or freeform optics, often the gradients of the surface are measured, over a rectangular aperture. Common examples of this include Shack-Hartmann sensors and deflectometry. It is important to be able to reconstruct the wavefront or surface reliably from the gradient data. We have derived a new set of vector polynomials, based on the gradients of the 2D Chebyshev polynomials that are orthonormal over a rectangular pupil, and can be used to reconstruct the scalar data. Using simulated and real data, we show how our approach is more precise and more robust to noise compared to other reconstruction techniques. To credibly represent mid-to-high spatial frequencies, our recursive polynomials can easily and accurately be generated for up to hundreds of terms. Additionally, a simple conversion between the scalar and vector polynomial coefficients makes this process fast and efficient.

DETERMINATION OF THE GEOMETRIC RAY CONTENTS OF LIGHT PROPAGATING IN HIGHLY-MULTIMODE OPTICAL FIBER

Philippe Décoste, École Polytechnique de Montréal

A technique is proposed to characterize the power distribution of guided light in a highly multimode fiber. In the geometric propagation point of view, rays of light have two invariants related to axial and orbital momentum respectively. A measurement setup is presented that enables the measurement of power density with respect to these two invariants. The results yield a simple representation of the multimode guided light properties.

3D PRINTED LONG PERIOD GRATINGS FOR OPTICAL FIBERS

Victor Iambin Iezzi, The Fabulas laboratory, Polytechnique Montréal

We have demonstrated a simple technique for implementing long period grating (LPG) structures in optical fibers by the use of a 3D printer. By applying stress through an external 3D printed periodic structure, we are able to manipulate the mode coupling within an optical fiber. Different LPG lengths and periods have been studied as well as the effect of the applied stress on the coupling efficiency from the fundamental mode to cladding modes. This simple technique is highly flexible, affordable and easy to implement without the need of altering the optical fiber compared to other conventional LPG methods. This work is part of a growing line of interest in the use of 3D printers for optical applications.

NONLINEARITY IN SILICON OPTICAL MODULATORS

Sasan Zhalehpour, Université Laval

The plasma dispersion effect is commonly used in silicon electro-optical modulators by means of varying the free-carriers' densities in a doped silicon waveguide. The electro-optic mechanism achieved in silicon modulators unlike LiNbO3 comes with a nonlinear effect. In addition, the transfer function of Mach–Zehnder Interferometer (MZI) structure produces a nonlinear behaviour. Thus, the nonlinearity in Silicon modulators is modeled based on the plasma dispersion effect, operating bias point of the modulator nonlinear transfer function and combination of both effects. The nonlinearity in silicon modulators creates distortions which limit the performance of the system.

EMISSIVE PERFORMANCE OF WEARABLE RF TEXTILES MADE FROM MULTI-MATERIAL FIBERS

Stepan Gorgutsa, COPL, Université Laval

In this work, we present novel textile antenna, featuring miniaturized multi-material fiber structures, dedicated to body area network applications in the WLAN (2.4 GHz) band. The multi-material fibers are fabricated by incorporating a conductive layer of silver within a silica capillary and are integrated in textile to form of a dipole antenna. Sub-millimeter-size fibers have the same mechanical flexibility as traditional textile threads and the imbedded elements within the fibers can be shielded from water, detergent, chemical exposure, physical stress, and high temperatures. Performance of the fiber dipole antenna is studied in off- and on-body scenarios, in terms of return loss, gain and radiation patterns. Direct comparison with wide-spread commercially available solutions confirms the good performance of the textile fiber-antenna (measured gain equals 3.34 dBi). Numerical simulations and experimental measurements confirm compliance with the SAR requirements and safety of the presented textile antennas for the end user.

SOLID-STATE BROADBAND DETECTION OF THZ PULSES

Alessandro Tomasino, INRS-EMT

Terahertz (THz) area is still affected by a lack a reliable solid state ultra-broadband detection scheme. We propose a silica based device operating in a similar manner to the Air Biased Coherent Detection (ABCD) technique [1], but exploiting the very high nonlinearity and breakdown voltage of silica. The device is featured by few micron-wide gaps of very high quality fused silica sandwiched between gold contacts. Very strong electric fields can be set up by applying bias voltage of few hundreds volts. With only 200 V, we achieved comparable performance in terms of SNR and bandwidth for the ABCD case, which instead requires several kV. Our results pave the way to a novel integrated ultra-broadband detector for THz pulses.

[1] X. Lu and X. C. Zhang, Appl. Phys. Lett. 98, 151111 (2011)

CONICAL NANOANTENNA ARRAYS FOR TERAHERTZ LIGHT

Andrea Rovere, INRS-EMT

In the last years, plasmonic nanoantennas have been demonstrated to be an effective solution for localizing free-space light well beyond the diffraction limit, leading to a local field enhancement that can be exploited, e.g., for enhanced spectroscopy [1]. In this work, we report a preliminary investigation on the frequency response of 3D gold nanocone arrays resonating at terahertz (THz) frequencies. First, we numerically investigated them, to optimize their near- and far-field frequency response. Then, the fabricated sample have been characterized using broadband synchrotron THz radiation. Experimental results are in good agreement with simulations and show the potential for nanomaterial spectroscopy.

[1] Toma A. et al., Nano Letters 15, 386–391 (2015).

MID-INFRARED DBR RAMAN LASER IN CHALCOGENIDE MICROWIRE

Nurmemet Abdukerim, McGill University

In this presentation, we demonstrate the design and operation of an ultra-compact fiber laser operating at a wavelength of 2.04 μm based on the Raman effect in a chalcogenide microwire. The resonant cavity is made out of the chalcogenide microwire with integrated side-written fiber Bragg gratings (FBGs). This laser is expected to provide an enhanced slope efficiency with respect to previous works, since it operates outside the TPA wavelength range [1]. Finally, because the resonant cavity is made out of the chalcogenide microwire with integrated FBGs, this laser architecture could as well operate at any wavelength of the mid-infrared transmission window of As2Se3. Coupled differential equations are numerically solved using collocation method, and give good predictions in terms of threshold pump power and laser slope efficiency in just 10 cm long microwires. Raman lasing using cascaded Raman effect in the chalcogenide microwire is also possible.

[1] R. Ahmad and M. Rochette, IEEE J. Sel. Topics Quantum Electron. 20, 299 (2014).

THERMAL NONLINEARITY EFFECT IN A SURFACE NANOSCALE AXIAL PHOTONICS RESONATOR

Tabassom Hamidfar, Concordia University

Micro-scale whispering gallery modes (WGM) resonators have been extensively studied over the last years and they have been successfully applied for trapping, slowing down, and intensifying the light in optoelectronics applications. Of the many available silica-based devices, surface nanoscale axial photonics (SNAP) resonators have become favored because of their flexibility and ultra-low loss, which lead to ultra-high quality factors. They have great potential applications as photonic micro devices in switching, slowing light, filtering, lasing and sensing with high precision. Here, we present a new fabrication method of SNAPs using a regular hydrogen-oxygen torch, requiring less equipment than current ones. We characterize our SNAP with evanescent spectroscopy where the excitation source is a tapered fiber. The transmission spectroscopy results show ultra-high Q-factors (Q≈107) resonant modes. Due to the very low losses, optical non-linear thermal processes are significantly enhanced.

ALL FIBER NONLINEAR MICROSCOPY AT 1550nm USING A DOUBLE-CLAD FIBER COUPLER

Thomas Perrillat-Bottonet, École Polytechnique de Montréal

Typically, nonlinear microscopes operate under free space propagation, using a dichroic mirror to separate the nonlinear signals from the excitation laser. We propose a robust all-fiber nonlinear microscopy system at 1550nm. The system would allow multiplexing second harmonic generation (SHG) and two-photon excitation fluorescence, collected from the inner cladding using a double-clad fiber coupler; and confocal microscopy, detected from the core using a circulator. The counterpart consists in carefully managing the transmission of the femtosecond pulse in the fiber. Chromatic dispersion and self-phase modulation (SPM) are the main effects to consider during the propagation of the pulse in fiber as we show through numerical simulations. Indeed, dispersion and SPM broaden the pulse both temporally and spectrally, thus drastically reducing generation of nonlinear signals.

LASER AMPLIFICATION OF 10 MICRONS SHORT PULSES

Yacine Kassimi, Université Laval

We have developed a concept of an optically pumped CO2 amplifier. We use 2 - 2.2 µm radiation to directly excite the 2001, 1201 and 0401 vibration levels of CO2. The energy will be transferred via collisions to the 0002 sequence band. The laser transitions (0002 -> 1001 (9 µm) and 0002 -> 0101 (10.6 µm)) will take place between overtones of the conventional laser action in CO2. In a first step we have built an OPO/OPA system used to pump the CO2 laser with 2-µm radiation [1]. We show simulation of basic parameters of the OPO/OPA system (energy/pulse, pulse to pulse stability, tunability, etc.) and compare them with our experiment. Ultrashort 10 micron pulses of high power are essential for the generation of high-order harmonics in a multi-keV regime. In order to produce short pulses at 10 microns we use pressure broadening and have built a high pressure CO2 cell. We show our concept and present CO2 absorption spectra until 40 bar.

[1] O. Nordseth, "Master oscillator/power amplifer system for optical parametric conversion of high energy pulses from 1 to 2 µm," FFI/RAPPORT-2004/02159. Norwegian Defence Research Establishment (2004)