MWP 2018

International Topical Meeting on Microwave Photonics

Toulouse, France, October 22-25, 2018

Welcome to MWP 2018 Toulouse

The IEEE Topical Meeting on Microwave Photonics is the major event of this cross-disciplinary field of research. It receives the technical sponsorship of IEEE Photonics Society and IEEE Microwave Theory and Techniques Society. It welcomes the greatest specialists in the field to share their latest results through invited talks, regular talks and poster presentations during three days.

This year, a workshop will also take place just before the conference on the topic: “Microwave photonics for embedded systems”. Toulouse is indeed the European capital of aeronautics and space thanks to the main plants of Airbus, Thales Alenia Space and CNES. This topic fits perfectly with the economical and educational interests of the town and the region.

We hope you will appreciate not only the conference but also Toulouse town and the Occitanie region. Toulouse has lot to offer to the visitor, with its old streets, monuments and museums. Gastronomy is everywhere in France, but this is particularly true in the south-west where you can taste local specialties and wines. The neighboring cities of Carcassonne and Albi are worth a day trip if you are interested in history.

We would like to thank here particularly all the people involved in the conference organization, which includes the local committee and the technical program committee. If this conference is a success, it is thanks to the strong involvement of each one of them.

We wish you a pleasant stay in Toulouse and we hope that this conference will help you for your research or development in the field of microwave optical systems.

Olivier Llopis Angélique Rissons

MWP 2018 General Chairs

Local committee

General Chairs

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Chris Roeloffzen, LioniX International, the Netherlands
Eszter Udvary, Budapest University of Technology and Economics, Hungary
Kerry Vahala, California Institute of Technology, USA
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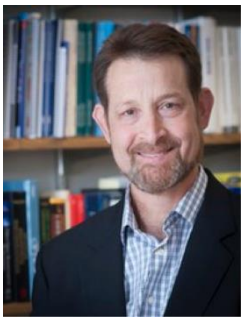
Lilin Yi, University of Shanghai, China
Li Zhang, Synergy Microwave Corporation, USA
Leimeng Zhuang, Monash University, Australia

Plenary sessions speakers

Andrew Weiner, Purdue University, USA

Ultrabroadband Radio-Frequency Photonics



One of the outstanding attributes that optics brings to radio-frequency photonics is the ability to coherently manipulate very wide bandwidth. Ultrabroadband RF photonics approaches enable programmable arbitrary waveform generation at frequencies up to the RF W-band, reconfigurable filtering at deep submicrosecond rates, and hardware spread spectrum pulse compression over multi-GHz bandwidths. Conversely, RF controlled processes such as phase modulation enable exotic optical configurations such as temporal cloaks. This talk surveys the field of ultrabroadband radio-frequency photonics, drawing heavily on research at Purdue University, and illustrating the application both of established devices such as mode-locked lasers and pulse shapers and newer components such as microresonator frequency combs.

Yann Le Coq, Syrte, Paris, France

Ultra low phase noise microwave generation with stabilized optical combs

Microwave signals generated by photonics means have demonstrated their high potential compared to purely electronics technologies. Among such techniques, a femtosecond laser in the optical frequency comb configuration has the potential to generate extremely low phase noise microwave signals by photodetection of the pulse train. This technology has now demonstrated the generation of microwave signal with phase noise as low as -173dBc/Hz at >10kHz and -100dBc/Hz at 1Hz from a 12GHz carrier. To achieve this low phase noise, the optical frequency comb is phase locked to a high performance Fabry-perot-stabilized CW laser. The microwave signal is therefore phase coherent with the optical radiation of CW laser and the optical comb effectively acts as a frequency divider from the optical to the microwave range. The corresponding large division ratio, combined with the high spectral purity achievable for CW laser, explains the extremely low phase noise that is achieved. This communication will present the technique in more detail and, in particular, address the various parasitic effects that can limit the performance, as well as the ways to circumvent them. A noise metrology technique is also developed, based on a home-made fully digital heterodyne cross-correlator. Last, on-going work aiming at reducing the footprint of the apparatus for in-field applications, at the cost of a slightly reduced performance, is presented.

Juerg Leuthold, ETHZ, Switzerland,

Plasmonic for microwave photonics

Plasmonics is emerging as a solution that may complement photonics for applications where highest speed and a most compact footprint is needed. So for instance, plasmonic phase-shifters, modulators and novel plasmonic photodetectors offering bandwidths exceeding 300 GHz have been introduced. These components have already been tested for use in highest-speed optical communications. Yet, such components may also play an important role in the development of next generation sub-THz millimeter links or become pivotal in ultrafast beam-steering schemes. In this talk, we will review the advantages and challenges offered by microwave plasmonics. We will review the state-of-the art of current components and comment future trends in the field.

Benjamin Eggleton, University of Sydney, Australia,

Advanced Brillouin signal processing using integrated approaches

Stimulated Brillouin scattering (SBS) is a phase matched nonlinear process between photons and optically driven acoustic phonons. In this paper I provide a detailed overview of Brillouin scattering in integrated waveguides in the context of recent results from the literature, highlighting the emergence of applications in microwave photonics and signal processing and will provide perspectives for future platforms and opportunities for further research and translation.

Invited speakers

Each session of the conference will start with a 30 mn invited talk

Andreas Beling, University of Virginia, USA, High Power Integrated 100 GHz Photodetectors

The talk reviews recent results from waveguide photodetectors, integrated photodiode-antenna emitters, and flip-chip bonded photodiodes with bandwidths up to 120 GHz. Recent results from heterogeneous III-V photodiodes on silicon for analog applications will be discussed.

Daniel Blumenthal, University of California Santa Barbara (UCSB), USA, Photonic integration beyond silicon

Microwave photonics demands on photonic circuits go beyond what can be delivered with silicon photonics alone. The potential for next generation integration platforms, including silicon nitride and tantalum pentoxide, to handle high power, deliver low phase noise, and realize photonic microwave functional circuits will be described.

Mona Jarrahi, University of California Los Angeles (UCLA), USA, Plasmonic enhanced THz devices

I will describe some of our recent work on developing plasmonics-enhanced terahertz optoelectronic devices to achieve record-high terahertz radiation powers, detection sensitivities, and signal-to-noise ratios in various imaging, spectrometry, and spectroscopy systems for medical diagnosis, space explorations, industrial quality control, and environmental sustainability applications.

Thomas Kürner, University of Braunschweig, Germany, THz communication challenges and applications beyond 100 G

Apart from research in academia THz communications has also triggered projects heading to develop appropriate technological solutions to enable the set-up of hardware demonstrators. In parallel discussions and activities in standardization and regulation already took off. This talk will discuss all three aspects of future THz communication systems.

Lute Maleki, GM, USA, Advances in LiDAR

LiDAR is now recognized as an important enabling sensor for many applications in remote sensing, robotics, and autonomous vehicles. In this talk recent advances in LiDAR will be discussed, and future directions identified. Particular emphasis will be placed on LiDAR for self-driving vehicles.

Loïc Morvan, Thales Research & Technology, France, RF spectrum analyzer for ultra-wide instantaneous bandwidth

We present an ultra-wideband RF spectrum analyzer based on spectral hole burning in a rare-earth ion-doped crystal. It monitors and records spectrums of complex signals over an instantaneous bandwidth above 20 GHz, with a time resolution below 10 µs, and a 100% probability of intercept.

Scott Papp, National Institute of Standards and Technology (NIST), USA, Photonic-chip frequency combs for optical synthesis and metrology

Optical-frequency combs are versatile tools for measuring time, identifying chemicals, and generating quantum states. A new direction is to produce frequency combs through intriguing nonlinear behaviors of light in Kerr microresonators. I will discuss experiments that probe Kerr soliton comb formation and demonstrate ultra-precision measurements.

Hiroyuki Otsuka, Kogakuin University, Tokyo, Japan, 5G trials toward 2020 and the application of RoF in mobile systems

This talk reviews recent 5G trial results by NTT DOCOMO, e.g., high data transmission in 300 km/h mobility conditions, technical collaborations with industry partners. This talk also introduces fiber-optic relaying with simultaneous transmission and reception on the same carrier frequency using RoF technology.

Sébastien Tanzilli, University Côte d'Azur, France, Quantum photonics at telecom wavelengths

Guided-wave optics is often employed for producing telecom photonic entanglement. I will show how this resource has been exploited as an enabling technology for implementing fundamental tests of entanglement, establishing a QKD protocol over 150 km, and for sensing fiber dispersion with unprecedented precision.

Sponsors

The Centre National d'Etudes Spatiales (CNES) is the French space agency. It is deeply involved in research and development of new approaches for space systems.

Discovery Semiconductors, Inc. is an industry leader in manufacturing ultrafast, high optical power handling InGaAs photodetectors, RF over fiber optical receivers, balanced optical receivers, 2 micron extended wavelength photodetectors, and several custom products for applications ranging from analog RF links to ultrafast digital communications. Discovery began operations in 1993 and has grown into a global enterprise by leading the market with high-technology products for 10, 25, 40, and 100 Gb applications. Discovery's instrumentation and systems include the Lab Buddy and Optical Coherent Receiver System. Since 1998, Discovery Semiconductors maintains a world class clean room facility for manufacturing high reliability products for telecom, datacom, avionics and aerospace applications.

The other sponsors are the local academic laboratories, Toulouse University, CNRS, Thales, Thales Alenia Space and Region Occitanie.

Exhibitors

iXBlue Photonics helps photonics engineers all around the world to get the most out of the light by providing high performance, innovative and reliable photonic solutions. We offer specialty fibers, Bragg gratings and optical modulation solutions based on the company integrated modulators for a variety of applications including: optical communications, fiber lasers and amplifiers, fiber optics sensors, space and sciences.
iXBlue Photonics results from the acquisition and merging of the former companies iXFiber and Photline. The expanded team, fully dedicated to photonics, masters key technologies including fiber preform processing, fiber drawing, waveguide wafer processing, RF design and components packaging. Gathered in a single organization, this team is in a strong position to leverage its synergies and offer new and more complete fiber optics solutions to its customers.

Anritsu solutions for Signal Integrity are used in the different steps of the development of electrical or optical components/systems.They are providing physical measurements, not simulation, where generators & detectors are needed. They enable you to perform tests on high speed rate up to 64 GBauds or high frequency up to 145 GHz.Vector Network Analysers - Large Frequency Range, S-parameters, Time Domain, Network Extraction and De-embedding, Eye Diagrams in VNAs, Crosstalk, Noise Figure, E/O & O/E … Signal Quality Analysers (SQA) NRZ & PAM4 up to 64 GBauds – including specific functions: Pre-emphasis, ISI, CTLE, Jitter, Noise amplitude, O/E & E/O – supporting several protocols like PCI-E, USB, TBT… E/O Sampling Oscilloscopes for digital signals NRZ & PAM4 up to 56 GBauds.

LUMIBIRD is one of the world's leading specialists in lasers. With 50 years of experience and expertise in 3 key technologies - solid-state lasers, laser diodes and fiber lasers - the group designs, manufactures and markets high performance lasers for scientific (laboratories and universities), industrial (manufacturing, defense, Lidar sensors) and medical (ophthalmology) markets. Resulting from the October 2017 merger between Keopsys and Quantel groups, LUMIBIRD, is listed on the stock exchange. With its 400 employees, LUMIBIRD is present in France, USA, Japan and China.

Nano-Giga is a value-added distributor and consultant of components and systems focused on Photonics and microwaves. We provide solutions that range from components to complete solutions. Our clients are research institutes, public or private laboratories, SMEs or major international groups involved in the fields of Optics, Optoelectronics, Laser, Lighting, Space, Avionics , Medical, Defense, Instrumentation, Semiconductors, etc… Our Suppliers are European, North American or Southeast Asian. They all have recognized names in their field of expertise. In addition, they are keen to evolve in the technologies of the future and devote a significant part of their know-how in the development of new technologies. Nano-Giga not only provides products that meet the customer’s specifications, but proactively suggest solutions that may still be radically different from those requested by the customer. We work with customers, suppliers and partners who believe in long-term business relationships for mutual benefits.

APEX Technologies offers a range of high performance optical test devices for use in the telecommunication industries and research laboratories, including Ultra High Resolution Optical Spectrum Analyzers (down to 5 MHz/0.04 pm resolution), Optical Modulation Analyzers and Optical Multi-Test Platforms (Polarimeters, Grating OSAs, Tunable Laser Sources, DFB Lasers, Optical Power Meters, Optical Amplifiers, Variable Attenuators, Tunable filters, Switches). APEX Technologies propose une large gamme d'appareil de test optique à haute performance destinés aux industries de télécommunication et aux laboratoires de recherche. On propose notamment les analyseurs de spectre optique à ultra-haute résolution (jusqu'à 5 MHz / 0.04 pm), les analyseurs de modulation optique et les plateformes multi-tests optiques (Polarimètres, Analyseur de spectre optique à réseaux, Laser accordables, Lasers DFB, Puissance mètres optiques, Amplificateurs optiques, Atténuateurs variables, Filtres accordables, switches).

The company Sercalo Microtechnology Ltd was founded in 1999 and is a leader in MEMS products for fiber-optic telecommunication. Sercalo designs, manufactures, and sells fiber optic components based on MEMS technology since more than 15 years.The production site in Neuchâtel, Switzerland maintains a fully equipped state of the art MEMS fabrication facility. Main products are switches and variable optical attenuators for applications in fiber optic, telecommunication networks, test & measurement equipment's, sensing equipment´s, medical and aerospace sector with a proven track record of 100'000s of fiber-optic MOEMS products shipped and installed since 1999. Currently Sercalo offers a broad range of approximately 40 different switching and attenuator products. Ranging from simple 1x2 switches up to 1x36 switches in single and multimode configurations, to integrated 4x4 and 8x8 switch matrices and 1x4 PM switches. The newest product line is the magnetically actuated large aperture MEMS 2D scanning system for LIDAR applications.

MorePhotonics supplies European engineers with cutting edge photonics solutions so they get the most out of their photons, and, in turn, can conduct successful research projects, develop innovative solutions and produce top quality products. With the support of its selected principals and thanks to a 30-year experience in photonics and high-technology, MorePhotonics is the partner of choice for research teams, development and production groups who demand the best of the available photonics technology.

Amonics is the international leading specialist in the design and production of optical amplifiers and light sources.
Our optical amplifier product line includes Erbium-Doped Fiber Amplifiers (EDFAs), Ytterbium-Doped Fiber Amplifiers (YDFAs), Raman Amplifiers and Hybrid Raman-EDFA Amplifiers, for transmission over metropolitan and long haul fiber optic communication networks. Our broadband light sources encompass Amplified Spontaneous Emission (ASE), 1050nm ASE, and Superluminescent Diode (SLED) broadband sources for optical component characterization and fiber-optic sensing applications.

Workshop, Monday, Oct. 22, 2018

	Session 1 - Microwave photonics for space systems
09:00 - 09:30	Microwave Photonics for Space Missions - François Deborgies, ESA,The Netherlands
09:30 - 10:00	Microwave photonic applications for the Next Generation of Telecom Payloads - Miguel A. Piqueras, DAS Photonics, Spain
10:00 - 10:30	*Coffee break*
10:30 - 11:00	Photonics-based radar enabling ultra-high resolution detection of space debris - Shilong Pan and Fangzheng Zhang, Nanjing Univ. of Aeronautics and Astronautics, China
11:00 - 11:30	Photonic RF Payloads for Telecom Satellites: Achievements and Prospects - Muriel Aveline, Thales Alenia Space, France
11:30 - 12:00	Photonics in Next Generation Telecom Satellites Payloads - Javad Anzalchi, Airbus Defence and Space, UK
12:00 - 13:30	*Lunch*
	Session 2 - Integrated microwave photonics
13:30 - 14:00	European Network for High Performance Integrated Microwave Photonics - José Capmany, VLC Photonics, Spain
14:00 - 14:30	Hybrid integrated microwave photonics platform - Caterina Taddei, LioniX International, the Netherlands
14:30 - 15:00	Direct implementation of RF payloads using photonics – Miguel V. Drummond, Aveiro University
15:00 - 15:30	Silicon photonic integrated microwave generator and signal processors - Jianping Yao, University of Ottawa, Canada
15:30 - 16:00	*Coffee break*
	Session 3 - Microwave photonics for defense and aerospace
16:00 - 16:30	Photonics in Land and Naval Defence Systems - Massimiliano Dispenza, Leonardo, Italy
16:30 - 17:00	Satellite Communications using Microwave Photonics - Charles Middleton, Harris Corporation, USA
17:00 - 17:30	Photonics for Electronic Support Measures - Antonella Bogoni, CNIT, Italy
17:30 - 18:00	New trends in photonics for radar, E.W and lidar systems - Daniel Dolfi, Thales R&T, France

Workshop: microwave photonics for embedded systems

Abstracts

Microwave Photonics for Space Missions

F. Deborgies, European Space Agency, Noordwijk, The Netherlands

Potential space applications of MWP range from few tens of MHz to several hundreds of GHz covering today mostly Earth Observation and Telecommunications. The space environment being very demanding, new technologies are not easily taken on-board satellites thus MWP will only be accepted if unique features or capabilities are offered. This presentation will give some highlights of Microwave Photonics "enabled" past and future Earth Observation missions and cover some of the most recent developments.

Microwave photonic applications for the Next Generation of Telecom Payloads

Miguel A. Piqueras, DAS Photonics, Spain

State of the art High Throughput Satellites offers capacities in the range of Gbps by using current RF and microwave technology. The multiplication factor required to achieve the multi Tbps capacity paradigm demanded from the forecasted double-digit growth in the coming decade pushes the limits of the payloads and platforms cost, volume and complexity well beyond the nowadays affordable solutions with traditional technology. Microwave photonic technologies could be key enablers to overcome the challenges required to provide the capacity and flexibility to dynamically manage future Terabit/s communication satellites payloads. The ability of photonics to handle high data rates and RF bandwidth and its potential for large integration and mass reduction in advance applications like antenna beamforming or multi-frequency conversion at very high frequencies is critical in this scenario, especially when the optical fiber is included in the payload design substituting waveguides or coaxial cables.

Photonics-based radar enabling ultra-high resolution detection of space debris

Shilong Pan and Fangzheng Zhang, Nanjing University of Aeronautics and Astronautics, Nanjing, China

The increasing number of small-size debris in space has put forward urgent requirements for high-resolution target detection and imaging. Traditional microwave radars face difficulties in achieving this goal due to their limited operation bandwidth. Recently, ultra-wideband signal generation and ultra-fast analog signal processing in the optical domain enabled the possibility of ultra-high resolution and real-time radar imaging. In this talk, recent advancement on the photonics-based radar for real-time and ultra-high resolution target detection and imaging is reviewed. The established photonics-based radar prototype can achieve inverse synthetic aperture radar (ISAR) imaging with a 2D resolution as high as 2 cm × 2 cm. Therefore, it has good potential for detection and identification of small-size space debris, and this property has been soundly verified by successful tracking and imaging of a small unmanned aerial vehicle in a field trial experiment.

Photonic RF Payloads for Telecom Satellites: Achievements and Prospects

Muriel Aveline, Thales Alenia Space, Toulouse, France

Thales Alenia Space elaborated innovative concepts of photonic RF payloads with the objective to provide telecom satellites with enhanced functionality, higher performance and lower cost. This went through assessment of enabling technology as well as design of new architectures for the repeater and antenna sub-systems. In particular, major steps were achieved with the demonstration of representative photonic RF repeater models, based on optical distribution of local oscillators (LOs), photonic frequency-conversion and routing of RF signals. The benefits of these new solutions were thoroughly assessed. Among other advantages, they significantly improve the repeater architectures, and payload mass and power budgets compared to conventional RF solutions. The challenge is now to increase their maturity and to offer the best solutions in a constantly evolving and demanding telecom payload market. In this context, photonic RF solutions will also need to be increasingly innovative and efficient.

Photonics in Next Generation Telecom Satellites Payloads

Javad Anzalchi, Airbus Defence and Space, UK

The main challenge of the next generation of High Throughput Satellites (HTS) is to provide a ten-fold increase in capacity together with enhanced flexibility whilst maintaining the overall satellite within the current volume and mass envelope. With telecom satellite payloads based on traditional RF equipment any increase in capacity and/or flexibility generally translates into a more or less linear increase in equipment count, mass, power consumption and power dissipation. Photonics is a very promising technology which can help to overcome the above challenges. The ability of Photonics to handle high data rates and high frequencies as well as enabling reduced size, mass, immunity to EMI and ease of harness routing (by the use of fibre-optic cables) is significant.

European Network for High Performance Integrated Microwave Photonics

José Capmany, VLC Photonics, Spain

The European Network for High Performance Integrated Microwave Photonics (EUIMWP) COST 16220 Action aims to shape and bring the relevant Integrated Microwave Photonics (IMWP) community supporting coordination and networking actions to consolidate this new ecosystem, providing exchange of knowledge, ideas and delivering a portfolio of technological benchmarkings to establish performance indicators defining future technological requirements in high performance scenarios such as 5G, automotive and aerospace technologies. The action brings together groups from academia, industry and transnational organizations with complementary competences and on a global scale including PIC and MWP experts, microwave system application designers and end-users to fully develop the synergies required by this new paradigm. This talk will introduce the basic structure, instruments and objectives of the project and also publicize its different working groups.

Hybrid integrated microwave photonics platform

Caterina Taddei, Chris Roeloffzen, LioniX International, the Netherlands

LioniX International manufactured and characterized the world's first fully hybrid integrated microwave photonics system. Such system is obtained using the indium phosphide-TriPleX platform which combines the low-loss silicon nitride waveguide technology with indium phosphide chip-based active components, such as gain diodes, modulators, and detectors in order to have a compact and robust multi-chip module. The combination of InP and TripleX allows the implementation of several functionalities on-chip, e.g. filtering, beamforming, taking advantage of the strength of each material. To our knowledge, this is the first fully hybrid integrated microwave photonics module that provides full RF-to-RF functionality. These modules will be used as processing core for array antennas, i.e. as beamforming networks, for broadband satellite communication at Ka band (19-22 GHz), and are an essential step towards the development for future 5G mm Wave wireless applications at even higher frequencies (28 GHz and 60 GHz). The use of hybrid integrated microwave photonics systems can be exploited to address the extremely challenging requirements for the next generation of wireless and satellite communications.

Direct implementation of RF payloads using photonics

Miguel Drummond, Instituto de Telecomunicações, Aveiro, Portugal

The results and lessons learned in FP7 project BEACON will be presented. Project BEACON aimed at using photonics to implement a standard RF payload receiver with no changes to the main architecture, which meant using self-heterodyne coherent detection. The first part of the presentation will report the successful results of such a simple and yet challenging approach, also including photonic true-time delay beamforming. Even though the system is coherent, it needs not to be implemented in a single chip, thus being modular. Such is a mandatory requisite in large-scale photonic payloads. The second part of the approach builds on the successful demonstration results for dimensioning a complete payload supporting 260 beams. The scalability of the proposed approach in terms of size, weight and power consumption is quantified. The presentation ends with the lessons learned in the project.

Silicon photonic integrated microwave generator and signal processors

Jianping Yao, University of Ottawa, Canada

A silicon photonic integrated circuit (PIC) that can be reconfigured to operate as a microwave photonic filter and an optoelectronic oscillator for microwave signal processing and generation will be discussed. The design, the fabrication, and the experimental evaluation of the PIC will be elaborated.

Photonics in Land and Naval Defence Systems

Massimiliano Dispenza, Leonardo SpA, Roma, Italy

Development of photonic technologies for Land & Naval Defence Systems aims at the implementation of building blocks that realize specific functions (Signal distribution with high Signal Integrity and low EMI, Local Oscillator Generation and Waveform, AD conversion, etc …) with advantages for the system in terms of performance (wide bandwidth, low phase noise, high ENOB, etc …) or SWaP. Results for these building blocks, achieved so far, have shown increased performances compared to conventional technologies. Furthermore such technological achievements are currently aimed also to intersect new system paradigms, such as Software Defined Radar, offering solutions for challenges of next generation products (e.g. Fully Digital AESA systems). At the same time new approaches in integration, exploiting PICs (Photonic Integrated Circuits) based on different platforms (Silicon, SiN, InP), are envisaged to offer new routes for a more pervasive and effective presence of photonic components in the system.

Satellite Communications using Microwave Photonics

Charles Middleton, Harris Corporation, Melbourne, USA

The need for higher data rates in satellite communication systems can be met by using higher frequency bands and higher-order modulation formats, but each of these places more difficult requirements on system performance. Microwave signal processing becomes more difficult at higher frequencies, and higher-order modulation formats require improved signal-to-noise ratio and linearity. To address these challenges, microwave photonics provides several unique capabilities. In this talk we describe an experiment comparing the performance of a traditional satellite communications system and a microwave photonics-based equivalent system, in which many of the signal processing functions are performed using photonic techniques. We demonstrate significant performance improvements that enable the use of higher-order modulation formats, and show operation over a wide range of frequencies.

Photonics for electronic support measures

Antonella Bogoni, Interuniversity National Consortium for Telecommunications (CNIT), Pisa, Italy

The potential of photonics for electronic support measures will be overviewed. In particular the first photonics-based 0-40 GHz RF scanner module prototype will be presented that provides state of the art performance with reduced size, weight and power consumption. Moreover preliminary results of a photonics-based jammer with an extended frequency flexibility in the whole 0-40 GHz range will be introduced and discussed.

New trends in photonics for radar, E.W and lidar systems

D. Dolfi, L. Morvan, V. Crozatier, O. Lelièvre, G. Baili, P. Berger, J. Bourderionnet, A. de Rossi, S. Combrié, I. Ghorbel, P. Feneyrou, A. Martin, L. Leviandier, P. Nouchi, A. Brignon, Thales Research &Technology, Palaiseau, France

Photonics appears as a disruptive technology for multifunction radar systems, electronic warfare systems and for electro-optic systems. All of these systems benefit from the wide frequency bandwidth offered by photonic architectures providing functions such as waveform generation, adaptive filtering, high speed sampling, coherent mixing, spectrum analysis,…We will review, through examples of implementation, these advanced capabilities and the impact of integrated photonic circuits on improved performances.

MWP 2018 Conference

Tuesday, October 23, 2018

08:30 - 08:40		Welcome – General chairs
08:40 - 09:20	**Plenary 1**	***Advanced Brillouin signal processing using integrated approaches*** – Benjamin Eggleton, University of Sydney, Australia Chair: José Capmany
09:20 - 10:00	**Plenary 2**	***Plasmonic for microwave photonics*** – Juerg Leuthold, ETHZ, Switzerland Chair: José Capmany
10:00 - 10:30		***Coffee break***
10:30 - 12:00	**Session**	***5G and beyond*** – Chair: Cyril Renaud
10:30 - 11:00	**Invited**	***THz communication challenges and applications beyond 100 GHz*** – Thomas Kürner, University of Braunschweig, Germany
11:00 - 11:15		***Multi-service Digital Radio over Fibre System with Millimetre Wave Bridging*** – Tongyun Li, Richard Penty, Ian White, University of Cambridge, UK – Haymen Shams, Cyril C. Renaud, Alwyn J. Seeds, Martyn Fice, University College of London, UK This paper demonstrates a novel digital radio over fibre (DRoF) architecture that is able to transport multiple compressed digitised RF services using both optical fibre and wireless millimetre wave (mmW) links. This solution has advantages as a cost effective indoor wireless infrastructure where flexible transmission schemes are required. Experimental results indicate wide RF dynamic range for two LTE services transmitted simultaneously, showing its capability for creating a neutral-host radio access network (RAN) with good spectral efficiency and cost effectiveness.
11:15 - 11:30		***A photonic QPSK modulation in 2 GHz with an RF signal from a microwave optoelectronic oscillator*** – Jognes Panasiewicz, Larissa Britto, Gefeson Pacheco, Instituto Tecnológico de Aeronáutica (ITA), Sao José dos Campos, Brazil - Angelique Rissons, Fabien Destic Institut Supérieur de l'Aéronautique et de l'Espace (ISAE), Toulouse, France This article presents a photonic circuit that achieves direct carrier QPSK modulation of an RF signal from an optoelectronic oscillator (OEO) suitable for satellite data transmitter. The circuit was implemented with three Mach-Zehnder optical modulators. One modulator was used to construct an OEO to generate a carrier with a frequency equal to 2.019 GHz. The others two modulators were used to compose the microwave photonic I/Q modulator. The setup initially achieved a data rate of 50 Mbps in a QPSK scheme with an EVM of 7.5%. Using a root-raised-cosine filter, it was possible to reduce the EVM to 5%. The diagrams of the optoelectronic circuit and the modulation measurements are displayed. After the EVM analysis, the modulated signal was demodulated through an actual satellite receiver. Using the demodulator, it was possible to measure the BER and consequently the degradation analysis. The degradation for a bit rate of 100 Mbps was 0.07 dB using the OEO as RF generator. In this case, the values of Eb/N0 and BER were 11.37 dB and 10^{-7}, respectively.

11:30 - 11:45		***A six-channel mmWave/IFoF link with 24Gb/s Capacity for 5G Fronthaul Networks*** – C. Vagionas, S. Papaioannou, G. Kalfas and N. Pleros, Aristotle University of Thessaloniki, Greece - N. Argyris, K. Kanta, N. Iliadis, G. Giannoulis, D. Apostolopoulos, H. Avramopoulos School of Electrical and Computer Engineering, National Technical University of Athens, Greece A 24 Gb/s analog Intermediate Frequency over Fiber Wireless V-band link is experimentally demonstrated over a 7km fiber length and 5m wireless distance, employing a digital 6-IF-carrier stream, each with a variable advanced modulation format, achieving record capacity for multi-band 5G Fronthaul networks.
11:45 - 12:00		***Comparison of performance between OFDM and GFDM in a 3.5GHz band 5G hybrid Fiber-Wireless link using SDR*** – Monica Rico-Martinez, Christian Camilo Cano Vasquez, Santiago Isaac Rodriguez, Gloria Margarita Varon Duran, Universidad Nacional de Colombia, Bogota, Colombia - Idelfonso Tafur Monroy, Technische Universiteit Eindhoven, Eindhoven, Netherlands This work presents a comparison between Orthogonal Frequency Division Multiplexing OFDM and Generalized Frequency Division Multiplexing GFDM to evaluate the latency and bit error rate in a Fiber-wireless link in 3.5 GHz band using Software Defined Radio SDR, taking into account its feasibility for the 5G networks in the future.
12:00 - 13:30		***Lunch***
13:30 – 15:30	**Session**	**Microwave signal processing** – Chair: Dalma Novak
13:30 - 14:00	**Invited**	***RF spectrum analyzer for ultra-wide instantaneous bandwidth*** – Loïc Morvan, Thales Research & Technology, France
14:00 - 14:15		***Single-Shot Sub-Nyquist RF Signal Reconstruction Based on Deep Learning Network*** – Shun Liu, Chaitanya K. Mididoddi, Chao Wang, University of Kent, UK - Baojun Li, Weichao Xu, Guangdong University of Technology, Guangzhou, China - Huiyu Zhou, University of Leicester, Leicester, United Kingdom Real-time detection of high-frequency RF signals requires sophisticated hardware with large bandwidth and high sampling rates. Existing microwave photonic methods have enabled sub-Nyquist sampling for bandwidth-efficient RF signal detection but fall short in single-shot reconstruction. Here we report a novel single-shot sub-Nyquist RF signal detection method based on a trained deep neural network. In a proof-of-concept demonstration, our system successfully reconstructs high frequency multi-toned RF signals from 5x down-sampled single-shot measurements by utilizing a deep convolutional neural network. The presented approach is a powerful digital accelerator to existing hardware detectors to significantly enhance the detection capability.
14:15 - 14:30		***Simple all-fiber optical-microwave phase detector for subfemtosecond synchronization*** – Chan-Gi Jeon, Yongjin Na, Jungwon Kim, Bong-Wan Lee, Korea Advanced Institute of Science and Technology (KAIST), Korea We demonstrate a passively phase-biased simple all-fiber optical-microwave phase detector based on intrinsic phase shift of multiport fiber coupler. It is composed of fiber coupler, phase modulator and balanced photodetector, hence free of additional phase bias and magneto-optic components. As a result of optical-microwave synchronization between mode-locked laser and voltage controlled microwave oscillator, 875-as integrated jitter [1 Hz-1 MHz] and 860-as rms timing drift over 1 hour is achieved.

14:30 - 14:45	***A band-limited, intermodulation-based band-folding frequency translation link using a single modulator*** – Bryan Haas, Jason McKinney, Naval Research Laboratory, Washington DC, USA We present, characterize, and demonstrate a simple, and novel, continuous-time band-folding microwave photonic link. Implemented with a single dual-drive Mach-Zehnder modulator (DDMZM) acting as 2 parallel phase modulators, the link effects an 8:1 bandwidth folding to enable direct sampling and digitization of an entire band. Two microwave tones modulated on one arm along with their 3rd order intermodulation (IMD) products serve as the spectral comb that exists only in the desired band, and the microwave spectrum of interest (SOI) is modulated onto the other arm. Parallel implementation adds, rather than multiplies, the tone and signal together, eliminating many cross-modulation products and spurs that would otherwise complicate and limit the foldable bandwidth. The link can operate with no optical filters if biased or with no bias if an optical bandpass filter is used.
14:45 - 15:00	***Analog time-reversal of optically-carried RF signals with a rare earth ion-doped processor with broadband potential*** – Anne Louchet-Chauvet, Laboratoire Aimé Cotton (LAC), Université Paris-Saclay, Orsay, France We propose a novel analog architecture for time-reversing optically carried RF signals, based on a rare-earth atomic processor. Our scheme combines long processed signals duration (>10us), potentially GHz bandwidth, direct access to the signal field amplitude, and compatibility with phase-modulated signals. The combination of these features makes this architecture ideal for refocusing RF signals distorted by their propagation in a reverberating environment.
15:00 - 15:15	***Tunable Multimode Optical Delay Line for Single-Wavelength Microwave Photonic Transversal Filter*** – Xiaojuan Liu, Chaitanya K. Mididoddi, Guoqing Wang, Chao Wang, University of Kent, UK - Shandong University of Technology, China - Zhongwei Tan, Institute of Lightwave Technology, Beijing, China - Liyang Shao, Southern University of Science and Technology, Shenzhen, China Most existing microwave photonic transversal filters are implemented in the incoherent regime using multiple optical carrier wavelengths to avoid optical interference. The system therefore becomes complicated and expensive. In this work, we present a novel single-wavelength microwave photonics transversal filter design in the coherent regime using a single multimode fibre. Filter taps are generated from spatial modes excited by multiple narrow optical beams with different incident angles. Therefore, optical interference is eliminated due to space demultiplexing. Time delays between filter taps are obtained due to large modal dispersion and can be simply tuned using spatial slots. In a proof-of-concept experiment, a modal dispersion enabled optical delay line module for a two-tap microwave photonic transversal filter has been demonstrated with avoided optical interference.
15:15 - 15:30	***Nitrogen-vacancy centers in diamond for instantaneous spectral analysis in the radiofrequency domain up to 18 GHz*** – Ludovic Mayer, Thierry Debuisschert, Thales Research & Technology, Palaiseau, France Detection and spectroscopy of microwave (>GHz) signals is of pivotal importance for key areas of modern technology, including wireless communication, radar, navigation and medical imaging. Here we demonstrate a real-time spectrum analysis of microwave signals using nitrogen-vacancy (NV) centers in diamond. By monitoring electron spin dependent fluorescence of NV centers under a continuous illumination, we managed to detect microwave signal with a 1 MHz resolution spatial resolution, a upper frequency limit of 18 GHz and a 1 ms temporal resolution.
15:30 - 16:00	***Break***

16:00 - 18:00	**Session**	***Sensing and radar*** – Chair: Mehdi Alouini
16:00 - 16:30	**Invited**	***Advances in LiDAR*** – Lute Maleki, GM Cruise, Pasadena, CA, USA
16:30 - 16:45		***A Microwave Photonic Tunable Receiver with Digital Feed Forward Phase Noise Cancellation for Electronic Support Measures and Antenna Remoting*** – Daniel Onori, J. Azaña, Institut National de la Recherche Scientifique - Energy, Materials and Telecommunications center (INRS-EMT), Quebec, Canada A high performance photonics-based RF tunable receiver that exploits a novel digital feed-forward phase noise cancellation technique is proposed and experimentally demonstrated. In the scheme, a signal receiver exploits an optical I/Q architecture fed by two free-running lasers to filter and down-convert to baseband the incoming RF signal. At the same time, a reference receiver acquires the phase-noise of the two free-running lasers by heterodyning them with an optical frequency comb. Then, a digital feed-forward algorithm utilizes the heterodyning signal to extract the differential phase noise between the two free-running lasers so that to cancel the phase noise that the lasers sources introduce to the baseband signal. Moreover, the scheme is effectively divided in a central unit and a remote-antenna module in order to provide improved remoting capability through fiber optic links. An experiment demonstrates low phase noise operation in an RF input range of 0-50 GHz, only limited by the available laboratory equipment. Photonic integration of the scheme will reach high environmental stability and chip-scale footprint, targeting the challenging requirements of next-generation electronic support measures systems.
16:45 - 17:00		***Reconfigurable photonic arbitrary waveform generation based on a single CW laser and low frequency electronics*** – Hugues Guillet De Chatellus, Côme Schnebelin, LiPhy, Grenoble, France We propose and demonstrate a new and simple concept of reconfigurable photonic generation of arbitrary RF waveforms, based on a recirculating frequency shifting loop seeded with a CW laser. We report arbitrary RF waveforms with specifications beyond state of the art photonic AWG techniques.
17:00 - 17:15		***All Photonic Radar System based on Laser Frequency Sweeping and Leaky-Wave Antennas*** – Matthias Steeg, Asmaa Al Assad, Andreas Stöhr, University of Duisburg-Essen, Germany In this paper, we report on a novel all photonic FMCW radar system for detection and localization of multiple objects. This is achieved by utilizing the self-sweeping functionality of tunable external cavity lasers (ECL) in combination with optical heterodyning for generating a millimeter-wave FMCW radar signal. In order to also localize the objects, frequency scanning mm-wave leaky-wave antennas (LWAs) are used. The LWAs enable beam steering via the FMCW signal for estimating the direction of arrival (DoA) of the radar echos. Overall, this approach yields very compact all photonic radar systems that do not require electrical oscillators or optical modulators. In addition, thanks to the LWAs, multiple objects can be localized within a single sweep and without any clock or control signals. Experimentally, the performance of a developed all photonic 60 GHz radar with a 10 GHz bandwidth is demonstrated for multiple object detection and localization. It is shown that the developed radar provides a range and DoA angle estimation error of <1 cm and ~3°, respectively. This is achieved without using any dedicated radar signal post-processing algorithms.
17:15 - 17:30		***Steering and Shaping of Multiple Beams with a Spatial Light Modulator based Beamformer*** – R. Bonjour, S. Welschen, J. Leuthold, ETH Zurich, Switzerland - J. F. Johansson, RUAG Space AB, Göteborg, Sweden We introduce and demonstrate an optical beamformer concept based on a spatial light modulator that enables independent steering and shaping of a large number of beams. In addition, our microwave photonic based system has a relatively small volume and provides additional capabilities when compared to other concepts for next generation high throughput satellites.

Photonics-based Radar Transceiver For Full-Polarimetric Inverse Synthetic Aperture Imaging – Xingwei Ye, Fangzheng Zhang, Yue Yang, Shilong Pan, Key Laboratory of Radar Imaging and Microwave Photonics, Ministry of Education, Nanjing University of Aeronautics and Astronautics, China

17:30 - 18:00

A compact photonics-based radar transceiver for simultaneous measurement of all the four elements in target polarization scatting matrix is proposed. In the transmitter, two wideband linear frequency modulated (LFM) signals with complementary chirp slopes are generated as the excitations in different polarizations. In the receiver, de-chirping and decoupling of radar echoes with different polarizations are implemented based on photonic frequency mixing. A proof-of-concept experiment of full-polarimetric inverse synthetic aperture radar (ISAR) imaging is carried out with a bandwidth of 6 GHz (9~15 GHz). Polarization-dependent ISAR images are successfully recovered, which can verify the feasibility of the proposed radar transceiver.

Photonics-based Microwave Radiometer for Hyperspectral Earth Remote Sensing – Todd Pett, Jennifer H. Lee, Ball Aerospace and Technologies Corp., Boulder - Yossef Ehrlichman, University of Colorado, Boulder - Hayk Gevorgyan, Anatol Khilo, Milos Popovic, Boston University, Boston, USA

17:45 - 18:00

Space-based microwave radiometers (MRs) have a long history of providing critical inputs for retrieval algorithms that generate accurate estimates of geophysical properties of the Earth's surface and atmosphere. Mission cost reduction pressure has led to increased use of small spacecraft (e.g. CubeSats and SmallSats) for scientific and operational Earth observation applications. The need for miniaturized MR electronics that fit into SmallSats and maintain performance poses a challenge for conventional MR technologies. Channel filters are one driver of MR size and weight. Microwave photonics (MWP) fabricated on silicon photonic integrated circuits (PICs) is one means to dramatically reduce the size of these filters enabling SmallSat platform integration and enhanced measurement capability. In this paper, we address the performance requirements for PICs to provide a viable path for low cost, size, weight and power (c-SWaP) MRs. We present experimental results of a silicon PIC filter development and a new electro-optic modulator (EOM) design that will integrate monolithically with these filters. The performance of an integrated MWP-based MR is modeled and compared to an operational MR. It is shown that the MWP design using the new EOM can provide radiometric performance comparable to conventional MRs but within a dramatically smaller sensor volume and in a purely silicon platform enabling low cost.

Wednesday, October 24, 2018

08:30 - 10:00 **Session** ***Radio Frequency signal generation*** – Chair: Andrey Matsko

08:30 - 09:00 **Invited** ***Photonic-chip frequency combs for optical synthesis and metrology*** – Scott Papp, National Institute of Standards and Technology (NIST), Boulder, Colorado, USA

Minituarized Ka-band Photonic Oscillators – David Seidel, Anatoliy Savchenkov, Danny Eliyahu, Skip Williams, Andrey Matsko, OEwaves Inc., Pasadena, USA

09:00 - 09:15

We report on recent experiments involving tight packaging of Ka-band photonic oscillators based on Kerr frequency combs generated in nonlinear microresonators. The devices with volume not exceeding 1 cc characterized with phase noise approaching -120 dBc/Hz at 10 kHz frequency offset are demonstrated at both 28 GHz and 35 GHz.

09:15 - 09:30		***Ultra-low Noise Microwave Generation based on a Free-Running Optical Frequency Comb*** – Pierre Brochard, Stéphane Schilt, Thomas Südmeyer, Laboratoire temps-fréquence, Neuchatel, Switzerland We present ultra-low noise microwave (ULNM) signal generation based on a transfer oscillator method using an optical reference and a free-running or only weakly-locked optical frequency comb (OFC). This proof-of-principle demonstration circumvents the requirement for an optical lock of the OFC to the optical reference and the related need of high-bandwidth OFC actuators. By electrically removing the phase noise contribution of the OFC from a beat-note signal between the comb and the optical reference, we are able to divide the phase noise of the optical frequency down to a radio-frequency signal without limitation by a locking bandwidth or added servo noise bumps. The measured phase noise of the generated signal at 15 GHz is mainly limited by the phase noise analyzer used in this initial evaluation and by the shot-noise of the photo-detection, leading to a noise floor lower than -150 dBc/Hz at high Fourier frequencies and -60 dBc/Hz at 1-Hz offset frequency obtained with 1,100 cross-correlations. The reported method offers many attractive possibilities, such as the use of OFCs with GHz repetition rates to make the system more compact, of potentially lower cost and even more easily transportable. In addition, a single OFC can be used for the generation of different ULNM signals from distinct optical sources as no optical lock is involved.
09:30 - 09:45		***Integrated Optics DFB Lasers On Glass For High Radio-Frequency Generation -*** Nisrine Arab, Lionel Bastard, Davide Bucci, Elise Ghibaudo, Jean-Emmanuel Broquin, Julien Poëtte, IMEP-LAHC, Grenoble, France In this paper, we study the capacity of glass integrated optics DFB lasers to generate millimeter wave and terahertz frequencies. We present the different technological parameters that can be adjusted to generate frequencies up to 8.8THz by photomixing two free running DFB lasers on glass. The impact of each parameter is explicitly demonstrated using simulations and experimental measurements.
09:45 - 10:00		***Photonic THz Generation Using Optoelectronic Oscillator driven Optical Frequency Comb Generator*** – G.K.M. Hasanuzzaman, Stavros Iezekiel, University of Cyprus, Cyprus - Haymen Shams, Cyril Renaud, John Mitchell, University College of London, UK We propose and experimentally demonstrate a photonic THz signal generation technique combining a discrete optoelectronic oscillator (OEO) and optical frequency comb (OFC) generator. Using a microwave photonic filter (MPF), we generate an electrical oscillation up to 18.36 GHz with a phase noise of -103 dBc/Hz at 10 kHz offset frequency. The OEO frequency tunability is obtained by changing the bandwidth of a tunable optical band pass filter (TOBF). This can produce an electrical RF carrier from 6.58 GHz to 18.36 GHz. The OEO driven optical comb generates 21 optical comb lines with a frequency spacing of 18.36 GHz, covering a bandwidth of 360 GHz. By selecting two optical comb lines with a wavelength selective switch (WSS) and beating them in a uni-travelling carrier photodiode (UTC-PD), a THz wave is generated at 238.68 GHz with phase noise of -76.79 dBc/Hz at 10 kHz offset frequency. This technique has potential for use in THz signal generation, where it is possible to tune the THz carrier frequency by tuning the RF carrier generated from the OEO.
10:00 - 10:30		***Coffee break***
10:30 - 12:00	**Session**	***Integrated photonics and Brillouin signal processing*** – Chair: Antonella Bogoni
10:30 - 11:00	**Invited**	***Photonic integration beyond silicon*** – Daniel Blumenthal, University of California Santa Barbara (UCSB), USA

11:00 - 11:15	***Frequency Agnostic RF-Photonic Limiter with GeAsSe Tapered Fiber Brillouin Laser*** – Daniel Yap, Tsung L. Yang, David Persechini, Gabriel Virbila, HRL Laboratories, LLC, USA - Johann Trolés – Université de Rennes, France - Laurent Brilland, SelenOptics, Rennes, France A RF-photonic limiter capable of frequency agnostic suppression of strong RF interferers was demonstrated. By using stimulated Brillouin scattering in a Brillouin laser comprising polarization maintaining GeAsSe micro-structured optical fiber tapers, limiting of multiple simultaneous in-band interferers can be achieved with minimal degradation of wideband signals.
11:15 - 11:30	***Integrating Brillouin processing with functional circuits for enhanced RF photonic processing*** – Yang Liu, Amol Choudhary, Guanghui Ren, KhuVu, Blair Morrison, Alvaro Casas-Bedoya, Thach G.Nguyen, Duk-Yong Choi, Arnan Mitchell, Stephen J. Madden, David Marpaung, Benjamin J. Eggleton, University of Sydney, Australia - University, Melbourne, Australia - Australian National University, Canberra, Australia On-chip linear and nonlinear optical effects have shown tremendous potentials for applications in RF photonic signal processing. Combining their complementary optical properties in the same integrated platform is expected to satisfy the future increasing demands of high-performance integrated microwave photonic systems. However, the integration of linear circuits with high-performance optical nonlinearity elements remains challenging. Here, we report the first proof-of-concept demonstration of a microwave photonic notch filter based on the simultaneous integration of active Brillouin circuits and passive ring resonators on the same photonic chip, merging advanced filtering functionality, optimized performance and compactness.
11:30 - 11:45	***Intracavity Brillouin Gain Characterization*** – Ananthu sebastian, Stéphane Trebaol, Pascal Besnard, Foton, Université de Rennes, France Brillouin gain coefficient is usually evaluated using well-established pump-probe technique. We report a technique based upon the cavity ringdown method that enables to characterize this fundamental parameter directly in a Brillouin laser cavity. Indeed, within a unique experimental setup, material gain, optical cavity parameters and laser properties can be extracted. This method would be particularly suitable for micro-resonator lasers intracavity material Brillouin gain determination.
11:45 - 12:00	***Broad-band phase-shifter based on stimulated Brillouin scattering and RF interference*** – Luke McKay, Moritz Merklein, Amol Choudhary, Yang Liu, Benjamin Eggleton, The University of Sydney, Australia - Micah Jenkins, Charles Middleton, Alex Cramer, Joseph Devenport, Anthony Klee, Richard DeSalvo, Harris Co, USA - Khu Vu, Duk-Yong Choi, Pan Ma, Stephen Madden, Australian National University, Canberra, Australia Phase shifters are an important building block of modern RF communications and RADAR systems, with an ever-increasing demand to improve the operating bandwidth and to reduce power consumption and footprint. Microwave photonic phase shifters based on stimulated Brillion scattering (SBS) offer tunable and broadband phase shifts, however, their performance has been constrained by the requirement of high Brillouin gain to achieve 360° of phase shift. Here, we demonstrate a 360° broadband phase shifter by combining SBS and RF interference which greatly reduces the required Brillouin gain and thus the required optical power. Using this technique, we are able to enhance the phase shift by more than an order of magnitude, showing bandwidth tunability from 0.1-65 GHz while also being optimized to minimize amplitude variations.
12:00 - 13:30	***Lunch***

13:30 – 15 :00	**Session**	***High-speed devices*** – Chair: Frederic Van Dijk
13:30 - 14:00	**Invited**	***High Power Integrated 100 GHz Photodetectors*** – Andreas Beling, University of Virginia, USA
14:00 - 14:15		***60 GHz Wireless Link Implementing an Electronic Mixer Driven by a Photonically Integrated Uni-Traveling Carrier Photodiode at the Receiver*** Ahmad W. Mohammad, Katarzyna Balakier, Haymen Shams, Chin-Pang Liu, Chris Graham, Michele Natrella, Xiaoli Lin, Alwyn J. Seeds, Cyril C. Renaud, University College of London, UK - Frédéric van Dijk, III-V Lab, Palaiseau, France We report the first 60 GHz wireless link implementing a uni-traveling carrier photodiode (UTC-PD) at the transmitter and a photonic integrated chip incorporating a UTC-PD at the receiver. In this demonstration, a 64.5 GHz signal carrying 1 Gbps on-off keying (OOK) data was generated by heterodyning two optical tones into the transmitter UTC-PD. The signal was transmitted using a 24 dBi gain parabolic antenna over a wireless distance of three meters before reaching an identical receiver antenna. At the receiver, an electronic mixer was used to down-convert the received signal into an intermediate frequency of 12.5 GHz. The local oscillator to the electronic mixer was provided by heterodyne mixing of two optical tones generated using a UTC-PD that is monolithically integrated with semiconductor lasers. The down-converted signal was acquired by a real-time oscilloscope for offline processing, which showed zero error bits in a 105 bit-long transmission.
14:15 - 14:30		***Directly modulated high power semiconductor optical amplifier*** – François Duport, Cécil Pham, Romain Brenot, Carmen Gomez, Jean-François Paret, Alexandre Garreau, Catherine Fortin, Karim Mekhazni, Frédéric van Dijk, Alcatel-Thales III-V Lab, Palaiseau, France High power Semiconductor Optical Amplifiers (SOA) are used in optical systems such as Mode Locked Lasers (MLL) as gain medium, or in Master Oscillator Power Amplifiers (MOPA) when they are monolithically integrated with a DFB Laser. In both applications, the optical power at the input of the SOA is rather large (from 1 to few 10th of mW) leading to gain saturation in the device. We present here an experimental study of the harmonic regime for a saturated high power SOA. The electro-optic parameters are measured and a model is proposed in two configurations: when the modulation is applied at the input or at the output of a two section high power SOA.
14:30 - 14:45		***Large Active Area, High-Speed Photoreceiver for Optical Wireless Communications*** – T. Umezawa, K. Kusakata, A. Kanno, A. Matsumoto, N. Yamamoto, T. Kawanishi, National Institute of Information and Communications Technology (NICT), Tokyo, Japan We report a newly developed 45-Gbuad, 32-pixel two-dimensional photodetector array (2D-PDA) and the photodetector's performance in free space optical (FSO) communication. With the selected 4 X 4 pixels in 32 pixels to preserve large active area, the direct coupling between high data rate FSO beam and the 2D-PDA was demonstrated to improve optical alignment tolerances. The eye diagram, bit error rate (BER), and photo-current characteristics in the range 10-45 Gbaud were evaluated for 4 X 4 pixels in plane.
14:45 - 15:00		***High-Power Waveguide Integrated Modified Uni-Travelling Carrier Photodiode Arrays*** – Patrick Runge, Felix Ganzer, Tobias Beckerwerth, Sharam Keyvanimia, Sven Mutschall, Angela Seeger, Martin Schell, Fraunhofer Institute for Telecommunications, Heinrich Hertz Institute, Berlin, Germany We demonstrate high-speed and high-power evanescently-coupled waveguide modified uni-traveling-carrier photodiode arrays. The arrays are an optically parallel connection of different

numbers of photodiodes. A responsivity of 0.46A/W at 1550nm, 3dB-bandwidth of 28GHz and 12dBm RF output power at 40GHz was achieved with such a device. Furthermore, the linearity was measured at different temperatures and frequencies in order to determine the limiting factor of the performance.

15:00 - 16:30	**Session**	***Posters - Signal generation and processing***
15:00 - 16:30		***All photonic-gain Optoelectronic Oscillator at 10 GHz*** – O. Lelièvre, V. Crozatier, G. Baili, P. Berger, P. Nouchi, D. Dolfi, L. Morvan, Thales Research & Technology, Palaiseau – F. Goldfarb, F. Bretenaker, LAC, Orsay – O. Llopis, LAAS, CNRS, Toulouse – K. Mezkhani, R. Brenot, J-F. Paret, A. Garreau, P. Charbonnier, F. Duport, F. Van Dijk, III-V Lab, Palaiseau, France We present a 10 GHz optoelectronic oscillator (OEO) based on optical amplification. The setup uses a 1-km of standard optical fiber at 1.5 µm and a semiconductor optical amplifier (SOA). The phase noise is -90 dBc/Hz at 100 Hz and 132 dBc/Hz at 10 kHz, currently limited by the oscillator noise floor.
15:00 - 16:30		***Chromatic Dispersion measurement of short optical fibers by sinusoidal phase modulation of a monochromatic light*** – Aliou Ly, Gilles Bailly, Arnaud Fernandez, Olivier Llopis, LAAS, CNRS, Univ. de Toulouse, Toulouse, France We report a simple method to measure the chromatic dispersion of short length optical fibers using phase modulation of a continuous-wave light. The results obtained were exploited to design an optimized coupled optoelectronic oscillator with optimization of its intracavity dispersion.
15:00 - 16:30		***Comparison of two photonic sampling mixer architectures based on SOA-MZI for all-optical frequency up-conversion*** – Dimitrios Kastritsis, Kyriakos Zoiros, Democritus University of Thrace (DUTH), Greece - Thierry Rampone, Ammar Sharaiha, Lab-STICC, Brest, France An experimental comparison of the conversion gain and harmonic distortion performance between Switching and Modulation architectures of an all-optical photonic sampler mixer up-converter using a Semiconductor Optical Amplifier-based Mach-Zehnder Interferometer (SOA-MZI) is presented. The process of frequency up-conversion from 1 GHz to 9 GHz is evaluated. Because of their different principle of operation, the Switching architecture demonstrates higher positive conversion gain by approximately 6 dB and 8 dB for standard and differential configuration, respectively, while the Modulation architecture achieves lower harmonic distortion up to 8 dB, depending on the modulation index of the 1 GHz signal.
15:00 - 16:30		***Configurable Photonic True-Time Delay Line Based On Cascaded Linearly Chirped Fiber Bragg Grating*** – Jiejun Zhao, Zhidan Ding, Fei Yang, Haiwen Cai, Key Laboratory of Space Laser Communication and Detection Technology, Shanghai Institute of Optics and Fine Mechanics University of Chinese Academy of Sciences, Shanghai, China We propose and demonstrate a configurable and flexible photonic true-time delay (PTTD) line for integrated transmitting/receiving optically controlled phased array antenna (PAA) based on combinations of cascaded linear chirped fiber Bragg grating (LCFBG). A large-scale beam steering angle close to the limit and high angle resolution can be obtained by precisely configuring the parameters including dispersion coefficient and the numbers of cascaded LCFBG; Multi-beams for different beam steering angles are acquired synchronously.

15:00 - 16:30

Double-Loop All-Optical Gain Optoelectronic Oscillator with Low Phase Noise and Spurs Level – Kiryl Mikitchuk, A. Chizh, S. Malyshev, SSPA "Optics, Optoelectronics and Laser Technology" of National Academy of Sciences of Belarus, Minsk, Belarus

In this paper, the optoelectronic oscillator module with double-loop configuration and all-optical gain is presented. The oscillator module simultaneously provides ultra-low phase noise of -142 dBc/Hz at 10 kHz offset from 10 GHz oscillation frequency and low spurs level of â-91 dBc. Additionally, the close-in phase noise behavior at low offset frequencies is studied with respect to the influence of flicker noise.

15:00 - 16:30

Dual-band Microwave Photonic Radar based on a Photonic-Assisted Stretch Processing Receiver – Jiming Cao,Wen Jiang, Ruoming Li, Jiyao Yang, Zhenwei Mo, Xiangpeng Zhang, Wangzhe Li, National Key Laboratory of Microwave Imaging Technology, Institute of Electronics, Chinese Academy of Sciences, Beijing, China - School of Electronics, Electrical and Communication Engineering, University of Chinese Academy of Sciences, Beijing, China

A dual-band linear frequency-modulated continuous-wave (LFMCW) microwave photonic radar is proposed and demonstrated. The system is capable of operating at different bands independently and simultaneously based on a photonic-assisted stretch processing receiver. An experimental demonstration is conducted, operating at C-band and Ku-band with a bandwidth of 700MHz and 3600MHz respectively. A series of tests in a microwave anechoic chamber are performed. The results verify the concept of the dual-band microwave photonic radar, which provides a photonic solution to multi-band radar based on a unified system.

15:00 - 16:30

Experimental and Small-signal Analysis of Microwave Photonic Phase Shifter based on Slow and Fast Light using Linear and Nonlinear Semiconductor Optical Amplifiers – Noor Hamdash, Ammar Sharaiha, Thierry Rampone, Pascal Morel, Denis Le Berre, Noham Martin, Cédric Quendo, Lab-STICC, Brest, France

This paper investigates the performance differences obtained by using four different SOAs as microwave phase shifters. All performances are evaluated in terms of measured phase shift, radiofrequency gain penalty and 3 dB bandwidth. A microwave phase shift as high as 89.3° is achieved by slow and fast light effects in a high gain extra-nonlinear SOA. In the same SOA a different response of the phase from usual CPO is observed experimentally at low frequencies for particular operating points in saturated regime. This phenomenon is theoretically analyzed by means of a small-signal analysis.

15:00 - 16:30

High Performance, Low Noise Figure Brillouin-based Tunable Microwave Photonic Bandpass Filter – Andri Mahendra, Eric Magi, Amol Choudhary, Yang Liu, David Marpaung, Benjamin J. Eggleton, The University of Sydney Nano Institute, Institute of Photonic and Optical Science (IPOS), School of Physics, University of Sydney, Sydney, Australia

We present a high-performance, low-noise figure tunable microwave photonic bandpass filter based on stimulated Brillouin scattering (SBS) loss responses. The bandpass filter response is formed by suppressing the out-of-band signal using multiple broadened SBS loss responses on a high-performance MWP link without introducing additional noise in the passband. A noise figure of 20 dB and -17 dB link gain of 100 MHz passband bandwidth at 14 GHz with spurious-free dynamic range of 105 dB.Hz2/3 are obtained. Multi-bandpass response, bandwidth reconfigurability from 100 MHz to 1 GHz and center frequency tunability up to 16 GHz are also demonstrated.

Incoherent optical frequency domain reflectometry using balanced frequency-shifted interferometry in a downconverted phase-modulated link – Juan Clement, Haroldo Maestre, Germán Torregrosa, Carlos R. Fernández-Pousa, Universidad Miguel Hernández de Elche, Spain

15:00 - 16:30

An incoherent optical frequency domain reflectometer (I-OFDR) has been implemented using frequency-shifted interferometry in a 9-GHz bandwidth. The system is based on low-bandwidth direct detection and balanced bidirectional phase modulation, which provides negligible amplitude and phase imbalance in frequency up and down-conversion. The setup is fed with dithered laser light to reduce coherent effects, and the intensity detected after the slope of a fiber Bragg grating. The reflectometer shows a dynamic range of 25 dB, a sensitivity <-55 dB, and a resolution of 2.3 cm in fiber. These results indicate the feasibility of this type of I-OFDR systems for the interrogation of quasi-distributed, high-density optical fiber sensors.

Investigation of the Dispersion Effect on Stimulated Brillouin Scattering based Microwave Photonic Notch Filters – Cheng Feng, Stefan Preussler, Thomas Schneider, Institut für Hochfrequenztechnik, Technische Universität Braunschweig, Germany

15:00 - 16:30

In this paper, distortion effects due to the dispersion of microwave photonic notch filters (MPNF) based on stimulated Brillouin scattering (SBS) with sideband-amplitude and phase control are investigated. Up to 8.3 MHz MPNF center frequency shift and 21 dB degradation of the stopband rejection are experimentally demonstrated. With a theoretical model, the dispersion effect is investigated in detail. The theory and simulation results show good agreement with the experimental data. On one side, the results help to ensure the excellent performance of MPNF on the other side, they can be used as a novel way for dispersion measurement.

Investigation of the dynamic regime in operation of spin-wave optoelectronic oscillators – Alexadr V. Kondrashov, Alexey B. Ustinov, Vladimir A. Sokolov, Boris A. Kalinikos, St. Petersburg Electrotechnical University, Russia

15:00 - 16:30

Influence of an optical fiber length on nonlinear dynamics of a spin-wave optoelectronic oscillator is investigated. An increase of the signal power level leads to transition from a stable monochromatic oscillation to a chaotic signal generation through a number of bifurcations. Generation of the rectangular pulses, periodic nonlinear pulses, chaotic pulses, and dynamic chaos are observed for the different fiber lengths. Numerical characterization demonstrates increase of the fractal dimension with increasing of the optical fiber length.

Low-Power RF Signal Detection Using a Tunable OEO based on DP-MZM and PS-FBG – Shao Yuchen, Mingshan Zhao, Han Xiuyou, Dalian University of Technology, China – Yitang Dai, Beijing University of Post and Telecom., China – Ming Li, Chinese Academy of Sciences, Beijing, China – Chao Wang, University of Kent, UK

15:00 - 16:30

A novel photonic method for low-power RF signal detection by a tunable optoelectronic oscillator (OEO) based on a dual-parallel Mach-Zehnder modulator (DP-MZM) and a phase-shifted fiber Bragg grating (PS-FBG) is proposed and experimentally demonstrated. The DP-MZM is utilized to generate the equivalent phase modulation (EPM) signal with a partially suppressed optical carrier. The EPM is helpful to enhance the gain to the RF signal in the OEO loop. The RF signals from 2 to 18 GHz as low as -87 dBm are detected with a gain of 10 dB.

Microwave Photonic Analog-to-Digital Converter Based on Optical Filtering in Frequency Domain – Sergey Kontorov, V. Cherepenin, V. Kulagin, D. Prokhorov, A. Shulunov, N. Kargin, V. Valuev, The National Research Nuclear University MEPhI, Moscow Engineering Physics Institute, Moscow, Russia

15:00 - 16:30

Traditional approach for microwave photonic ADC is based on processing in time domain, where every time-neighbor sample of input signal is handled by its own channel. However, this method typically requires high precision and expensive photonic components: femtosecond pulse source (mode-locked laser) with ultra-low timing jitter, optical fibers with high precision lengths, balanced photodetectors and others, which form together very unstable and bulky device. For the input signals with limited bandwidth, another approach can be used, in which the incoming broadband microwave signal is divided into several channels where optical filtering and down conversion are implemented in frequency domain for further processing by low speed electrical ADCs. Performance capabilities for such microwave photonic ADC are derived with numerical simulations and compared with experimental results. It is shown that, for modern photonic components, 8-10 effective bits can be achieved in the digitized signal.

Noise reduction in a dual-frequency VECSEL at telecom wavelength using fully correlated pumping – Hui LIU, Grégory Gredat, Syamsundar De, Ihsan Fsaifes, Aliou Ly, Rémy Vatré, Fabienne Goldfarb, Fabien Bretenaker, Laboratoire Aimé Cotton (LAC), Orsay, France - Ghaya Baili, Thales R&T, Palaiseau, France - Sophie Bouchoule, C2N, Univ. Paris Saclay, France

15:00 - 16:30

We demonstrate the noise reduction in a dual-frequency vertical-external-cavity surface-emitting laser at tele-com wavelength using fully correlated pumping. A fully in-phase correlated pumping is obtained by polarization combining two single-mode fibered laser diodes in a single-mode fiber. With this pumping, ultra-low noises are observed, i. e. relative intensity noise lower than -140 dB/Hz, and beatnote phase noise suppression by 30 dB, getting close to the spontaneous emission limit. The generalized noise reduction is shown by modeling the beatnote phase noise spectra and relative intensity noise transfer gain depending on the in-phase correlation amplitude.

Output power enhancement in photonic-based RF generation by optical pulse compression with a dispersion managed highly-nonlinear fiber – Reinhard Karembera, Takashi Yamaguchi, Hiroyuki Toda, Doshisha University, Kyoto, Japan

15:00 - 16:30

In this manuscript, we propose to use optical pulse compression in a dispersion managed fiber (DMF) with highly nonlinear fiber to enhance the output power in photonic-based 100-GHz RF generation. Even though the average dispersion is zero, RF gain of more than 5.0 dB can be obtained with moderate optical power to the DMF. Using four-sectioned DMF with zero average dispersion, we found the possibility of near octave-band operation in RF frequency.

Programmable Fiber-Optics Microwave Photonic Filter based on Temporal Talbot Effects – Reza Maram, Lawrence Chen, McGill University, Canada – Daniel Onori, Jose Azana, INRS, Canada

15:00 - 16:30

We introduce and experimentally demonstrate a reconfigurable microwave photonic filter based on temporal Talbot effects. An optical pulse source is employed to sample the microwave signal through intensity modulation. The sampled signal is then propagated through the Talbot-based microwave photonic filter, involving temporal phase modulation and chromatic dispersion. The microwave photonic filter exhibits a periodic transfer function whose passband frequency and frequency periodicity (free spectral range) can be programmed electrically by adjusting the phase-modulation profile, e.g., using an arbitrary waveform generator, without the need for manual adjustment of the optical components and with the potential for fast tuning of the filter's response. The bandwidth of the filter passband can also be easily customized by adjusting the sampling pulse width using an optical bandpass filter.

15:00 - 16:30		***Regenerative Talbot Laser*** – V. Billault, V. Crozatier, M.Schwarz, G. Feugnet, G. Baili, Thales Research and Technology, Palaiseau, France - H. Guillet de Chatellus, LIPhy, Grenoble, France We report on the generation of GHz pulse trains with a regenerative frequency shifting cavity at 780 nm using a semiconductor optical amplifier. This configuration improves the sidemode rejection, and delivers pulse train with mW power.
15:00 - 16:30		***Two Dimensional Radar Imaging Algorithm of Bistatic Millimeter Wave Radar for FOD Detection on Runways*** – Naruto Yonemoto, Akiko Kohmura, Shunichi Futatsumori, Kazuyuki Morioka, Naoki Kanada, Electronic Navigation Research Institute, National Institute of Maritime, Port and Aviation Technology, Japan We are investigating the millimeter wave radar system to cover the vast space with high range resolution. These challenges are owing to the combination of 90GHz millimeter wave and Radio over Fiber (RoF) technologies. This paper introduces the background of system development, the architecture of the system, and preliminary result of a field test in Narita International Airport. We also discuss the improvement of the two-dimensional positioning of the object using the data from plural remote radar heads.
15:00 - 16:30		***Ultralow Noise Microwave Generation based on All-Fiber Michelson Interferometer and Sagnac Loop*** – Dohyeon Kwon, Juan Wei, Shilong Pan, Jungwon Kim, Korea Advanced Institute of Science and Technology (KAIST), Daejeon, Korea We present an all-fiber Michelson interferometer based repetition-rate stabilization for ultralow noise pulse trains and fiber-loop based optical-microwave phase detector for ultralow noise microwave extraction. The absolute rms timing jitter of pulse trains is suppressed down to 1.4 fs over 0.1 s when 10-km fiber interferometer is employed. The absolute timing jitter of generated 10 GHz microwave is 7.6 fs over 0.1 s when 1-km fiber interferometer is used.
15:00 - 16:30		***VCSEL Based Optoelectronic Oscillator (VBO) for 1.25 Gbit/s RZ Pulse Optical Data Generation*** – Christian Daniel Muñoz, Angélique Rissons, Fabien Destic, Institut Supérieur de l'Aéronautique et de l'Espace ISAE – SUPAERO, France - Margarita Varón, Universidad nacional de Colombia, Colombia - Juan Coronel Rico, Facultad de Ingenieria - Universidad El Bosque Bogotá, Colombia We present the implementation results of a VCSEL based optoelectronic oscillator (VBO) in terms of phase noise and time jitter in the electrical and optical domain. The electrical signal at 1.25 GHz is used as a clock for Non-Return-to-Zero (NRZ) data generation. A system for optical pulse data generation to obtain duty cycles (DC) lower than 30% is proposed and simulated.
16:30 – 18 :00	**Session**	***Millimeter waves and THz generation and devices*** – Chair: Tetsuya Kawanishi
16:30 - 17:00	**Invited**	***Plasmonic enhanced THz devices*** – Mona Jarrahi, University of California Los Angeles (UCLA), USA
17:00 - 17:15		***Nonlinear Distortions in Plasmonic Mach-Zehnder Modulators*** – M. Burla, W. Heni, C. Hoessbacher, D. Werner, Y. Fedoryshyn, J. Leuthold, Institute of Electromagnetic Fields (IEF), ETH Zurich, Switzerland - D. L. Elder, L. R. Dalton, University of Washington, Seattle, USA We report the first experimental characterization of intermodulation distortions in ultrafast (>325 GHz) plasmonic-organic hybrid Mach-Zehnder modulators. The third-order input intercept point (IIP3) measured for a 25 μm-long plasmonic modulator reaches 18.9 dBm, very close to the

value of 19 dBm obtained for a commercial high-performance GaAs modulator. The plasmonic approach may provide ultrafast (hundreds GHz speeds), ultracompact and highly linear modulators for novel microwave photonics applications.

17:15 - 17:30

Millimeter-Wave Band Optical Single-Sideband Modulator Utilizing Antenna-Coupled Electrode with Polarization-Reversed Structures and Asymmetric Mach-Zehnder Waveguide – Hiroshi Murata, Graduate School of Engineering, Mie University, Japan - Yuuki Matsukawa, Osaka University, Japan

We have proposed and developed an optical single-sideband (SSB) modulator using an antenna-coupled electrode with polarization-reversed structures and an asymmetric Mach-Zehnder waveguide for millimeter-wave (MMW) band radio-over-fiber (RoF) systems. This device can convert MMW wireless signals to optical SSB modulation signals directly without an external power supply. In this paper, a newly-designed device using a fluorine-based resign substrate is reported. The conversion efficiency from 60 GHz wireless to optical SSB modulation signals was improved by 2.5 dB in modulation index compared to our proto-type device.

17:30 - 17:45

High bandwidth photoswitch for heterodyne detection of optically generated mmW signals using 1.5 µm integrated glass lasers – Róbert Horváth, N. Arab, J. Poëtte, J.F. Roux, L. Bastard, B. Cabon, Institut de Microélectronique, Electromagnétisme et Photonique - Laboratoire d'Hyperfréquences et Caractérisation, IMEP-LAHC, Grenoble, France

We demonstrate the performance of an InGaAs photoconductor as a heterodyne detector of optically generated mmW signals. Two continuous wave DFB lasers integrated on glass emitting in the 1.5 µm range are used to generate radio frequency through optical heterodyning by illuminating the ultra-fast nitrogen ion implanted InGaAs photoconductive switch. The beating signal corresponding to the mmW signal is downconverted by mixing with electrical RF frequencies up to 65 GHz. This low cost and robust device as ultrafast optoelectronic mixer shows uniform performance over a wide range of detected optical beating frequencies up to 164 GHz, limited by our equipment.

17:45 - 18:00

Generation of Coherent Terahertz Carriers in the 3 THz Range Using Optical-Comb-Based THz Source for Terahertz Communications – Isao Morohashi, Yoshihisa Irimajiri, Atsushi Kannno, Akira Kawakami, Naokatsu Yamamoto, Norihiko Sekine, Akifumi Kasamatsu, Iwao Hosako, National Institute of Information and Communications Technology, Tokyo, Japan

We proposed a terahertz (THz) communication system operating in the 3 THz range using an optical-comb-based THz source and a heterodyne receiver system using a hot electron bolometer mixer (HEBM) along with a quantum cascade laser (QCL) operating at 3 THz for a local oscillator. The THz source is composed of a Mach-Zehnder-modulator-based flat comb generator (MZ-FCG), and a uni-traveling-carrier photodiode (UTC-PD). By using a phase-locked loop (PLL) system, the oscillation frequency of the QCL was highly stabilized. By using this system, generation and detection of coherent THz carriers in the 3 THz range have been demonstrated, which had a phase noise of -70 dBc/Hz at an offset frequency of 100 kHz.

19:30 – 23:00 ***Gala dinner at Hotel Dieu St Jacques***

Thursday, October 25, 2018

08:30 - 09:10	**Plenary 3**	***Ultra low phase noise microwave generation with stabilized optical combs*** – Yann Le Coq, Syrte, Paris, France Chair: Daniel Dolfi
09:10 - 09:50	**Plenary 4**	***Ultrabroadband Radio-Frequency Photonics*** – Andrew Weiner, Purdue University, USA Chair: Daniel Dolfi
09:50 - 10:15		***Coffee break***
10:15 - 12:00	**Session**	***Integrated photonics and applications*** – Chair: David Marpaung
10:15 - 10:45	**Invited**	***Quantum photonics at telecom wavelengths*** – Sébastien Tanzilli, University Côte d'Azur, France
10:45 - 11:00		***Fast Photonics-Assisted Beamforming Network for Wide-Band, High Bit Rate 5G Communications*** – Bilal Hussain, Paolo Ghelfi,, Consorzio Nazionale Interuniversitario per le Telecomunicazioni (CNIT) – Giovanni Serafino, Francesco Amato, Claudio Porzi, Antonella Bogoni, Scuola Universitaria Superiore SantÁnna, Pisa, Italy We present a fast reconfigurable beamforming network with switching time < 5 ns, based on photonic integrated circuits. It allows for a complete antenna beam steering, controlling the signal phase over > 360°. The proposed beamforming network is tested by transmitting and steering a 2 Gb/s signal, without introducing any signal degradation, demonstrating its suitability to wideband, high bit-rate future 5G communications.
11:00 - 11:15		***Reflective Microring Sensing Probe based on Narrowband Microwave Photonic Notch Filter*** – Liwei Li, Suen Xin Chew, Shijie Song, Keith Powell, Xiaoke Yi, Linh Nguyen, Robert Minasian, School of Electrical and Information Engineering, The University of Sydney, Australia A novel, reflective, high performance microring sensing probe based on narrowband microwave photonic notch filtering is proposed and experimentally demonstrated. The system employs an integrated silicon-on-insulator microring resonator with a reflective loop as a sensing probe, which allows the sensed light to be reflected back and measured from a point source, thus enabling the capability to perform remote measurements at locations with limited accessibility. To enhance the beating cancellation of the optically filtered sideband, a programmable wideband optical equalization filter is used to create an amplitude equalization profile of the sidebands, thus achieving a desirable narrowband microwave photonic notch filter, which is a key feature for implementing sensor interrogation systems with high resolution. As an application example, a highly sensitive temperature sensor which monitors the temperature dependent notch locations of the narrowband microwave photonic notch filters has been experimentally verified. It achieves a high sensitivity of 11.6 GHz/°C, which provides the capability to detect and convert a small temperature change into a large variation in the radio frequency domain with clear notch frequency shifts in the order of several hundred MHz.

Programmable On-Chip Photonic Signal Processor Based on a Microdisk Resonator Array – Jianping Yao, Weifeng Zhang, University of Ottawa, Canada

11:15 - 11:30

A programmable on-chip photonic signal processor based on a silicon photonic microdisk array is proposed and experimentally demonstrated. The processor has a two-dimensional mesh network structure with multiple input and multiple output ports. In each mesh cell, two identical thermally-tunable high-Q microdisk resonators (MDRs) are used for routing and processing the optical signal, and a low-loss waveguide crossing is employed at the waveguide intersection to enable low-crosstalk optical transmission. By programming the DC voltages applied to the MDRs, the processor can be reconfigured with diverse circuit topologies to perform multiple array signal processing functions. An 8 X 8 programmable signal processor is designed, fabricated and characterized. By controlling the DC voltages, an on-chip tunable optical delay line based on 8 MDRs cascaded in an all-pass filter configuration is experimentally demonstrated. Thanks to scalable mesh structure of the proposed processor, the entire device holds a promising potential for strong reconfigurability and parallel computing with low power consumption.

Widely Tunable Silicon Photonics Narrow-Linewidth Passband Filter Based on Phase-Shifted Waveguide Bragg Grating – Fabio Falconi, Photonic Networks & Technologies National Laboratory, CNIT, Pisa, Italy – Claudio Porzi, Antonella Bogoni, TeCIP Institute, Scuola Superiore Sant'Anna, Pisa, Italy – Marc Sorel, Grahm Sharp, University of Glasgow, UK

11:30 - 11:45

A new approach for broad and efficient tuning of the narrow resonant transmission window in integrated phase-shifted Bragg gratings realized in silicon waveguides, suitable for the photonic processing of microwave signals, is proposed and demonstrated. The method exploits local micro-heaters (MHs) for the tuning of the resonant cavity formed by the insertion of a phase-shift section within a uniform Bragg grating structure. Two different MHs geometries have been investigated. Wide tuning ranges of the passband filter with a narrow linewidth of ~30 pm up to 7 nm, only limited by the BG stopband region width, for maximum MH absorbed power of ~11 mW are observed.

Silicon-Photonic Dense 8-Channel Multiplexer Using Auto-Regressive Moving-Average Filters – Dvir Munk, Moshe Katzman, Mirit Hen, Maayan Priel, Arik Bergman, Avi Zadok, Yuri Kaganovskii, Michael Rosenbluh, Bar-Ilan University, Ramat-Gan, Israel - Naor Inbar, Menachem Vofsy, TowerJazz, Migdal Haemek, Israel

11:45 - 12:00

We propose and demonstrate an integrated 8-channel dense wavelength division multiplexer in silicon-on-insulator platform. The device layout comprises of 7 stages in a tree topology. Each stage is based on an unbalanced Mach-Zehnder interferometer with a nested ring resonator. The transfer function of each stage is that of an auto-regressive moving-average filter, characterized by a uniform passband, strong out-of-band rejection and sharp spectral transitions. The passband of each channel is extremely narrow: only 0.135 nm (16 GHz), and the worst-case crosstalk among channels is -22 dB. Individual phase delays within the device are trimmed through selective photo-removal of an upper cladding layer of photo-sensitive chalcogenide glass. The devices are suitable for integrated-photonic processing of radio-over-fiber and mm-wave communication.

12:00 - 13:30 ***Lunch***

13:30 - 14:45 **Session** ***Posters - High speed devices and Telecom applications***

13:30 - 14:45

16-Wavelength DWDM A-RoF with Stimulated Brillouin Scattering Suppression, for Antenna Remoting in Wireless Front-haul – Hadi Bahramiabarghouei, Robert Leroux, Chunshu Zhang, Sai Kilambi, Dominic J. Goodwill, David Wessel, Eric Bernier, Huawei Technologies, Canada

A DWDM analog radio over fiber (ARoF) system connected a base band unit (BBU) to a radio remote unit (RRU). It is capable of carrying massive-MIMO, sub-6 GHz and mmWave signals. It was tested using live mmWave traffic. Uplink and downlink each comprised 16 wavelengths, with directly-modulated lasers. Each wavelength capable of carrying a 2 GHz RF-bandwidth signal on a 1.5 GHz IF carrier, at RF ACLR of 40 dBc at 12 km fiber, including 3 dB ACLR improvement by offsetting the wavelength from the optical mux grid by 22 GHz. Using ARoF, no DSP is needed at the RRU. This reduces weight and power consumption on the tower compared to eCPRI, and allows the RF format to be modified as new standards emerge, without replacing or reprogramming the RRU.

13:30 - 14:45

A Multi-antenna GNSS-over-fiber System with High Vertical Precision – Xin Jiang, Xiangchuan Wang, Shilong Pan, Key Laboratory of Radar Imaging and Microwave Photonics, Ministry of Education, Nanjing University of Aeronautics and Astronautics, China

A novel multi-antenna global navigation satellite system over fiber (GNSS-over-fiber) system with real-time microwave-photonics-based fiber-length-difference monitoring is proposed. In the architecture, GNSS signal transmission from two or more remote antennas to the local processing center is realized based on radio-over-fiber techniques. A novel microwave-photonics-based fiber length measurement scheme is applied to compensate the line bias delay between different GNSS channels due to the fiber-length variation. Then the carrier phase single difference (SD) algorithm, instead of the carrier phase double difference (DD) algorithm, can be used to improve the vertical precision of multi-antenna GNSS system. Experimental results show that the vertical positioning precision with SD algorithm is about 1.3 mm which is 3.15 times better than that with DD algorithm. Meanwhile, the horizontal positioning precision is about 1.5 mm which is on the same level compared with the system with DD algorithm.

13:30 - 14:45

An Integrated Adjustable-Bandwidth Rectangular Filter Based on Cascading Ring-Assisted Mach–Zehnder Interferometers – Jiachen Li, Yu Li, Minghua Chen, Tsinghua University, Beijing National Research Center for Information Science and Technology, Beijing, China

We propose a narrowband rectangular optical filter based on cascading ring-assisted Mach-Zehnder interferometers with spectrum tailoring. Just by reasonably arranging the temperatures of different micro heaters on each stage, the center wavelength and bandwidth of filter can be tuned simply. We fabricated the device and measured the performance to prove that the bandwidth could be adjusted from 14 GHz to 4 GHz maintaining rectangular response. The filter shows potential in practical applications due to its flexibility and reconfigurability.

13:30 - 14:45

Band pass & low-voltage symmetrical electro-optic modulator for absolute distance metrology – Henri Porte, Alexandre Mottet, iXBlue, Besançon, France

We report here the description and performances of a novel type of low voltage and band-pass optical modulator dedicated to high precision metrology instruments allowing absolute distance measurement.

13:30 - 14:45	***Broadband and Sensitive Lateral Optical Phase Modulators using 1D-PhC for Integrated Si-Photonics*** – Kai Wei, Afshin Daryoush, Drexel University, Philadelphia, USA Design of broadband optical phase modulators (PM) with improved sensitivity is presented in this paper using lateral coupled micro-strip (CMS) driving electrodes and a photonic crystal (PhC). The 1D PhC structure consists of alternating sub-micrometer layers of PMMI and Air materials. This 1D PhC is placed as a superstrate to the optical core and contributes to a slow-lightwave structure for a 200 fs optical pulse at the center wavelength of 1550 nm. Both optical BPM and FTDT along with HFSS simulation results demonstrate a 3 dB bandwidth of 54 GHz and about 100% improvement of the figure of merit of $V\pi$ x L of the PM over optical bandwidth 1530 to 1570 nm wavelength.
13:30 - 14:45	***Broadband Optical Phase Modulator Based on Electro-Optic Polymer*** – Yuya Yamaguchi, Atsushi Kanno, Naokatsu Yamamoto, Akira Otomo, National Institute of Information and Communications Technology, Tokyo, Japan – Shingo Takano, Satoshi Oikawa, New Technology Research Laboratory, Chiba, Japan - Tetsuya Kawanishi, Faculty of Science and Engineering, Waseda University & National Institute of Information and Communications Technology, Tokyo, Japan We devised a broadband optical phase modulator using an electro-optic polymer material, which is lucrative for its potential for application as the material used in high-speed modulator. It has the possibility to achieve low half-wave voltage and large bandwidth simultaneously. The measured 3-dBo bandwidth of the fabricated modulator reached 50 GHz.
13:30 - 14:45	***Distortion mitigation in IFoF system employing frequency-separated DPD*** – Hyoung Joon Park, In Ho Ha, Sang-Kook Han, Yonsei University, Seoul, Korea We propose and experimentally demonstrate a frequency-separated model based digital pre-distortion (DPD) technique in intermediate frequency over fiber system. Frequency-separated model based DPD could mitigate distortion caused by optical and electrical components in the transmission system. To employ the proposed DPD technique, least-mean-square (LMS) algorithm is used to derive the coefficients of pre-distorting equalizer. By the proposed DPD, error vector magnitude was decreased and adjacent carrier leakage ratio was increased.
13:30 - 14:45	***Experimental evaluation of digital predistortion for VCSEL-SSMF-based Radio-over-Fiber link*** – Muhammad Usman Hadi, Jacopo Nanni, Pier Andrea Traverso, Giovanni Tartarini, University of Bologna, Italy - Olivier Venard, Geneviève Baudoin, Jean-Luc Polleux, Université Paris Est, ESIEE Paris, UPEM, Le Cnam, Noisy-leGrand, France This article proposes a Digital Predistortion (DPD) technique in order to enhance the linearity of short and limited range Mobile Front Haul (MFH) links for the present Long-Term Evolution (LTE) and future (5G) cellular networks. The proposed technique is applied to 850 nm Single Mode Vertical Cavity Surface Emitting Lasers (VCSELs) and Standard Single-Mode Fibers (SSMFs) low cost and low consumption Radio-over-Fiber (RoF) link. Memory Polynomial is employed using Indirect Learning Architecture (ILA). Moreover, the resilience of the DPD approach to changes in input power levels is investigated. The improvements in the quality of the received signal due to the proposed solution are illustrated with reference to scenarios of applicative interest. The performance of proposed technique is evaluated in terms of Adjacent Channel Power Ratio (ACPR) and Normalized Mean Square Error (NMSE) for entire LTE frame of 10ms for 5 MHz band signal having 64 QAM modulation format.

Experimental Investigation of Millimeter Wave Communication on Railway Environment – Ryosuke Nakamura, Yusuke Dohi, Daiki Shibahara, Fumitoshi Abe, Tetsunori Hattori, Research and Development Center of JR East Group, East Japan Railway Company, Saitama, Japan

13:30 - 14:45

On railway environments, the millimeter wave communications have potential to achieve huge communication capacity and so that is expected to be utilized in new communication services. However, the radio propagation performances of millimeter wave communications on railway environments are not fully analyzed to install millimeter wave communication systems. In this paper, we introduce how to use the millimeter wave communications on railway environments and also show the results of the field test on Shinkansen environment with the prototype millimeter wave transceivers. As results of the test, we mention the possibility of the millimeter wave systems for railway.

Fully reconfigurable signal processor with silicon photonic chip – Yuhe Zhao, Xu Whang, Dingshan Gao, Jianji Dong, Xinliang Zhang, Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology, China

13:30 - 14:45

A fully reconfigurable signal processor based on photonic integrated circuit is proposed in this paper. The device is a spectral shaper utilizing cascaded microrings. With 32 voltages applied to the chip, a variety of applications are realized using this signal processor. Here we show the experimental results for three functions: microwave arbitrary waveform generation, optical differentiator and tunable optical filter.

High frequency characterization of a vertical electro-absorption modulator for data communications – L. Marigo-Lombart, C. Viallon, A. Rumeau, O. Gauthier-Lafaye, A. Monmayrant, G. Almuneau, LAAS-CNRS, Toulouse, France
K. Panajotov, H. Thienpont, Vrije Universiteit, Brussel, Belgium

13:30 - 14:45

This paper describes the high-frequency characterizations of a vertical electro-absorption modulator (EAM) to ensure its monolithic integration onto a VCSEL for data communications. Splitting the emitting and the modulating part in such devices is an attractive approach compared to directly current modulated VCSEL since it releases the intrinsic limitations due to carriers dynamics in such VCSEL device. It is, in this aim, utmost to thoroughly characterize and understand the properties and performances of the vertically integrated EAM under high frequency operation, as it will be decisive for the application of EAM-VCSEL to very high data-rate communications. EAM measurements, presented up to 40 GHz, require a precise control of the optical fiber coupling and a precise evaluation of the injection losses over the full frequency range.

High-Power InGaAs/InAlAs Schottky Photodiode with Low Amplitude-to-Phase Noise Conversion – Alexander Chizh, S. Malyshev, K. Mikitchuk, SSPA “Optics, Optoelectronics and Laser Technology” of National Academy of Sciences of Belarus, Minsk, Belarus – K. Zhuravlev, I. Chistokhin, D. Dmitriev, A. Toropov, M. Aksenov, N. Valisheva, A. Gilinsky, Russian Academy of Sciences, Novosibirsk, Russia

13:30 - 14:45

In the paper, high-power InGaAs/InAlAs Schottky photodiode with low amplitude-to-phase noise conversion is presented. It is shown that photodiode cutoff frequency is 28 GHz and maximal output microwave power is 58 mW at the frequency of 20 GHz. Amplitude-to-phase noise conversion coefficient of the proposed photodiode is demonstrated to be less than 1.5 rad/W at the frequency of 20 GHz.

Indoor Optical/Radio Wireless Communication – Demonstration of High-Def Video Streaming using Steerable Infrared Beams – Ton Koonen, Fausto Gomez-Agis, Jiun-Yu Sung, Zizheng Cao, Ketemaw Mekonnen, Frans Huijskens, Eduward Tangdiongga, Institute for Photonic Integration, Eindhoven University of Technology, The Netherlands

13:30 - 14:45

A hybrid wireless indoor system has been designed and validated which realizes ultrahigh-capacity transmission downstream by directing narrow infrared beams to mobile devices individually, using an AWGR-based module for wavelength-controlled 2D beam steering. For upstream, 60GHz radio techniques are employed which are also used to localize the devices and enable automatic infrared beam steering by a remotely located central communication controller. In a laboratory demonstrator, automatic mobile device localization and IR beam steering is demonstrated, and the transmission performance of conveying two high-def video streams optical-wirelessly to two users individually is demonstrated.

Microwave image rejection mixing using a Mach-Zehnder electrooptic modulator – Steven T. Lipkowitz, Timothy U. Horton, Vincent R. Pagan, Thomas E. Murphy, University of Maryland, Department of Electrical and Computer Engineering, Laboratory for Physical Sciences, College Park, MD, USA

13:30 - 14:45

Here we present a technique for realizing an image rejecting radio-over-fiber downconverting link. The system uses one arm of a dual-drive Mach-Zehnder modulator (DD-MZM) to modulate an optical carrier with an RF signal, and the other arm to modulate the carrier with a local oscillator (LO). The resulting output is then sent into an asymmetric Mach-Zehnder interferometer (AMZI) which separates the frequency components above and below the LO into separate output ports. By separately detecting these two outputs and applying the appropriate DC bias to the DD-MZM, we are able to obtain in-phase and quadrature photocurrents. By combining these I and Q photocurrents with a 90-degree electrical hybrid, we obtain over 40 dB of image rejection.

Optical RF Self-Interference Cancellation Using Polarization Multiplexed Dual-MZMs – Shuo Wang, Xiuyou Han, Hanqiao Wang, Xinxin Su, Zhenlin Wu, Mingshan Zhao, Yuchen Shao, Dalian University of Technology, Dalian, China - Bofan Huo, China Electronics Technology Group Corporation, Shanghai, China

13:30 - 14:45

An optical approach to cancel the RF self-interference using polarization multiplexed Mach-Zehnder modulators (MZMs) is presented with theoretical analysis and experimental demonstration. By using the dual-MZMs biased at inverted quadrature points, the out of phase relationship between the received interference signal and the reference signal is obtained. Through adjusting the delay time and amplitude of the reference signal in optical domain, the matching conditions for the RF self-interference cancellation are implemented. Only one laser source is utilized and the coherent beat noise between the optical carriers from the same laser source is prevented by the polarization multiplexing. The cancellation experiments of RF signals at 5 GHz and 8 GHz are conducted. The self-interference cancellation performance for single frequency and bandwidth of 5 MHz and 10 MHz are investigated.

Photonics-Assisted Radio-Frequency Self-Interference Cancellation and Fiber Transmission Using a DP-QPSK modulator – Yang Chen, East China Normal University, Shanghai, China - Shilong Pan, Key Laboratory of Radar Imaging and Microwave Photonics, Nanjing University of Aeronautics and Astronautics, Nanjing, China

13:30 - 14:45

A photonic approach for radio-frequency (RF) self-interference cancellation and fiber transmission using a dual-polarization quadrature phase-shift keying (DP-QPSK) modulator is proposed in this paper. One dual-parallel Mach-Zehnder modulator (DP-MZM) in the DP-QPSK modulator is used to cancel the interference signal directly in the optical domain via optical carrier-suppressed double-sideband modulation, whereas the other DP-MZM in the DP-QPSK modulator provides a phase-tunable optical carrier. The two interference-free optical sidebands and the phase-tunable optical

carrier at the two orthogonal polarization states are combined for the recovery of the desired RF signal. Since the interference is directly cancelled in the optical domain, the fiber dispersion will not lead to the reappearance of the interference signal, which makes it suitable for long-distance fiber transmission. An experiment is performed. RF self-interference cancellation is demonstrated both in single-carrier and wideband operations at 9 and 15 GHz, and the compensation of the fading effect is also studied.

13:30 - 14:45

Strategies for noise reduction of a dual-frequency VECSEL dedicated to cesium CPT clocks – Grégory Gredat, Hui Liu, Fabienne Goldfarb, Fabien Bretenaker, Laboratoire Aimé Cotton, Orsay, France - Ghaya Baili, François Gutty, Thales R&T, Palaiseau, France - Isabelle Sagnes, C2N, Université Paris-Saclay, France

We investigate the strategies to reduce the noise of a class-A dual-frequency vertical external cavity surface emitting laser (VECSEL) operating at Cesium clock wavelength. We focus mainly on the beatnote phase noise of the two orthogonally polarized modes emitted. Within the framework of coupled rate equations, we show that the phase noise spectrum of the beatnote is well described by considering both the phase-amplitude coupling and the thermal effects. The spearhead of this study consists in first theoretically evidencing reduction strategies for the phase noise beatnote by optimizing the physical parameters of the model and then experimentally demonstrating its feasibility by using two in-phase fully-correlated beams pumping each mode separately. Possible ways to decrease the intensity noises are also identified.

13:30 - 14:45

Time-Resolved spectroscopy for laser chirp characterization and self-heterodyne generation of apodized-NLFM microwave pulses – Pedro Tovar, Luis Ynoquio, Jean Pierre von der Weid, Pontifical Catholic University of Rio de Janeiro, Brasil - Vladimir Jabulka, Ricardo Ribeiro, Universidade Federal Fluminense, Niterói, Brasil

This paper reports the photonic generation of apodized non-linear frequency modulation (NLFM) microwave pulses by using a self-heterodyne scheme. Time-resolved optical spectroscopy was developed for the characterization of the laser diode chirp. By using a step-shaped current stimulus the laser chirp transfer function H(s) was obtained. With knowledge of H(s), a numerical model produced the suitable current stimulus i(t) needed to generate apodized-shaped radio frequency chirped pulses through self-heterodyning. Experiment results agreed with the numerical simulations.

13:30 - 14:45

Ultrafast User Localization and Beam Steering in Optical Wireless Communication Using an In-Fibre Diffraction Grating – Chaitanya Mididoddi, Guoqing Wang, Usman Habib, Chao Wang, University of Kent, Canterbury, UK - Hongxia Zhang, Tianjin University, Tianjin, China

Wavelength-controlled laser beam steering has been successfully demonstrated for indoor optical wireless communications (OWC). Here we demonstrate ultrafast user localization (50 million scans per second) in OWC based on real-time wavelength monitoring. A separate time stretched pulsed laser source is introduced to implement ultrafast optical wavelength (hence optical beam) scanning. A dispersion unbalanced Mach-Zehnder interferometric configuration creates chirped encoding in stretch optical pulses. The reflected optical wavelength from a remote user carrying the location information of the user is detected by real-time instantaneous microwave frequency detection. This new approach facilitates simultaneous ultrafast user localization and data transmission at communication C-band. A proof-of-concept experiment is carried out to verify the proposed approach.

13:30 - 14:45		***Use of SiGe Photo-Transistor in RoF links based on VCSEL and standard single mode fiber for low cost LTE applications*** – Jacopo Nanni , Zerihun Gedeb Tegegne, Catherine Algani, Jean-Luc Polleux, Electronique, Systèmes de communication et Microsystèmes, ESYCOM, ESIEE, Université Paris-Est, Marne la Vallée, France - Giovanni Tartarini, Department of Electrical, Electronic and Information Engineering "Guglielmo Marconi", University of Bologna, Italy This paper presents for the first time the transmission of LTE signal based-on Radio-over-Fiber (RoF) scheme by using SiGe Hetero-junction Photo-Transistor as photo-receiver. The photo-transistor is fabricated based-on the commercial bipolar transistor technology. An 850 nm single mode Vertical Cavity Surface Emitting Lasers (VCSELs) and Standard Single Mode Fiber (SSMF) are used to complete the link so that makes the total cost of the system very low. The transmission of 20 MHz bandwidth LTE signal with high modulation format is achieved. The performance of the system is evaluated through the measurement of EVM under different operation conditions of the photo-transistor (in photo-diode mode, photo-transistor mode and two terminals mode). We reach an Error Vector Magnitude (EVM) below 8% for the input power of -25 dBm to -2 dBm when the photo-transistor operates under two terminals condition. This EVM value fulfills the requirements of the LTE standard for 64-QAM modulation. The stability of the system with regard temperature variation and modal noise is also presented.
14:45 - 16:15	**Session**	***Radio over fiber*** – Chair: Anne-Laure Billabert
14:45 - 15:15	**Invited**	***5G trials toward 2020 and the application of RoF in mobile systems*****,** Hiroyuki Otsuka, Kogakuin University, Tokyo, Japan
15:15 - 15:30		***Photonic RF Repeaters for Broadband Telecom Satellites: System Demonstration and Test Results*** – Michel Sotom, Sophie Roux, Muriel Aveline, Mathieu Picq, Benoit Benazet, Thomas Colombo, Thales Alenia Space, Toulouse, France This paper presents the main achievements in the development of photonic RF payload solutions for telecommunication satellites based on Optical Multi-LO frequency Conversion (OMC), and the related experimental results. Down-scaled models of these solutions were developed and experimentally assessed in a representative temperature environment. The end-to-end RF performance as achieved in test campaigns are reported.
15:30 - 16:00		***256/64-QAM Multicarrier Analog Radio-over-Fiber Modulation using a Linear Differential Drive Silicon Mach-Zehnder Modulator*** – Colm Browning, Liam P. Barry, Dublin City University, Ireland - Alexander Gazman, Nathan Abrams, Keren Bergman, Department of Electrical Engineering, Columbia University, New York, USA Highly linear integrated optical modulators are required in order to provide a distribution platform for analog Radio-over-Fiber (RoF) signals. The work outlined examines the performance of multiple bands of Generalized Frequency Division Multiplexed (GFDM) signals in a photonic link employing a linear differential drive silicon Mach-Zehnder Modulator (MZM). Performance is evaluated in terms of received Bit Error Rate (BER) and Error Vector Magnitude (EVM). In an optical back-to-back scenario, 3.3% EVM is achieved in the case where three GFDM bands modulated with 256 Quadrature Amplitude Modulation (QAM) are transmitted.

15:45 - 16:00		***Spatial Diversity Gain of Micrometer-scale MIMO FSO Transceivers utilizing Multicore Fiber and 2-D Photodetector Array*** – Yuki Yoshida, Toshimasa Umezawa, Naokatsu Yamamoto, National Institute of Information and Communications Technology (NICT), Japan Feasibility of a high-capacity spatially-multiplexed free-space optical (FSO) communications system utilizing small-footprint spatial diversity transceivers based on multicore fiber and 2-D photodetector array is investigated. With the aid of MIMO-DSP, the micrometer-scale spatial diversity transceivers enable 37-Gbps 2x4 MIMO-FSO transmission over strongly-correlated optical MIMO channels.
16:00 - 16:15		***Radio-over-Fiber-supported Millimeter-wave Multiuser Transmission with Low-Complexity Antenna Units*** – Usman Habib, Nathan J Gomes, Communications Research Group, University of Kent, UK - Matthias Steeg, Andreas Stöhr, University of Duisburg-Essen, Duisburg, Germany A system for serving a large number of users at millimeter-wave (mmW) frequencies using a single Radio Frequency (RF) chain is presented. A single Remote Antenna Unit (RAU) supported by Radio-over-Fiber transport is used to transmit multiple 60GHz band signals to various users located at different spatial locations using the beamsteering characteristics of a Leaky Wave Antenna (LWA). Error Vector Magnitude analysis has been performed for each user signal up to a maximum of seven users per RF chain with wireless transmission over 2 m. A performance comparison for different user-signal frequency spacings has been provided to understand the limitations of the system and results show that the proposed system design with the LWA performs better than systems using waveguide and horn antenna transmitters. A realization to double the number of served users is also presented which shows that up to 10 users can be served using half region of the LWA, with each user transmitting 1 Gb/s data rate, delivering an aggregate data rate of 10 Gb/s.
16:15 - 16:20		***Closing session***
16:30 - 18:30	**Tour**	***Airbus visit*** – Visit of the Airbus assembly lines
16:30 - 18:15	**Tour**	***Thales Alenia Space visit*** – Visit of the satellite assembly line and test room of Thales Alenia Space

MWP 2018 Gala Dinner

The Gala dinner will be held on Wednesday 24th evening at Hotel Dieu Saint Jacques, in the historic columns room.

The best student paper prize will be delivered during the dinner.

At the end of the dinner, the music group Cuarteto Tafi will give a private concert for the attendees in the columns room.

For those staying at Palladia Hotel, two buses will leave Palladia Hotel at 7 pm to the gala.

Hotel Dieu can also be reached by metro line 1, station "St Cyprien" or "Esquirol"

MWP 2018 Visits

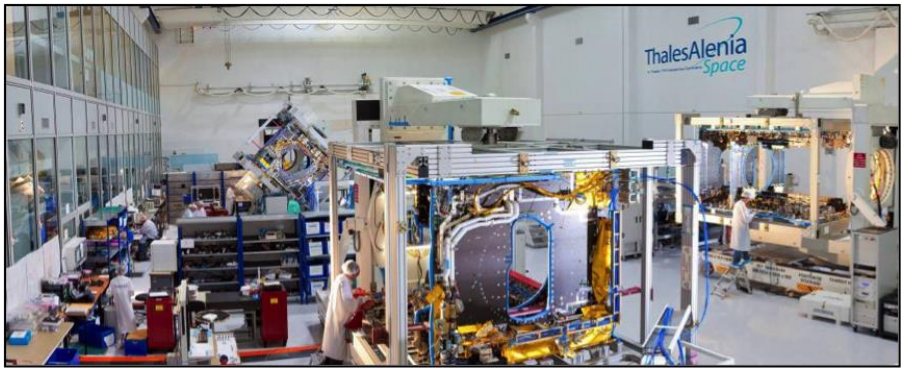
Visit of AIRBUS or THALES ALENIA SPACE

Thursday October 25, 16h30-18h

Registration and passport data required 15 days before the visit

Buses leaving from Palladia hotel at 16h30 (return to the hotel or to a tram station closer from the airport)

Airbus assembly line



Thales Alenia Space satellite integration room