Program for *2026 IEEE MTT-S International Microwave Workshop Series on Advanced Materials and Processes for RF and THz Applications (IMWS-AMP)*

Time (Brisbane)	Michaelmus A	Michaelmus B	Reef	Urchins 2
Wednesday, July 22				
08:50 am-09:05 am	*Opening Ceremony*			
09:05 am-09:55 am	**K1**: *Keynote: MHz to THz Technologies Addressing Fundamental Science Questions - Goutam Chattopadhyay*			
10:00 am-11:00 am	**P1**: *Semi-Plenary 1*	**P2**: *Semi-Plenary 2*		
11:00 am-11:30 am	*Break*			
11:30 am-12:45 pm	**W1**: *Workshop: Recent Advancement in Emerging Materials and Processing Technologies*	**S1**: *CMOS and BiCMOS Power Amplifiers I*	**S10**: *Metamaterials and Metasurfaces I*	**S19**: *Biomedical and Wearable Sensing II*
12:45 pm-02:00 pm	**L1**: *Lunch*			
02:00 pm-03:15 pm	**W2**: *Workshop: Recent Advancement in Emerging Materials and Processing Technologies*	**S2**: *CMOS and BiCMOS Power Amplifiers II*	**S11**: *Terahertz Technologies and Systems IV*	**S20**: *Metamaterials and Metasurfaces III*
03:15 pm-03:45 pm	*Break*			
03:45 pm-05:00 pm	**W3**: *Workshop: Recent Advancement in Emerging Materials and Processing Technologies*	**S3**: *Terahertz Technologies and Systems I*	**S12**: *Biomedical and Wearable Sensing I*	**S21**: *Antenna Arrays and Beamforming II*
05:00 pm-06:30 pm	*Welcome Reception @ Roof Top Pool Deck*			
Thursday, July 23				
09:00 am-09:45 am	**K2**: *Keynote: Reconfigurable Microwave and Millimeter-Wave Devices Enabled by Phase-Change Materials, BST and Liquid Crystal Technologies - Raafat Mansour*			
09:45 am-10:45 am	**P3**: *Semi-Plenary 3*	**P4**: *Semi-Plenary 4*		

Time (Brisbane)	Michaelmus A	Michaelmus B	Reef	Urchins 2
10:45 am-11:15 am	Break			
11:15 am-12:30 pm	BPC: Ask Us Anything	**S4**: Terahertz Technologies and Systems II	**S13**: Metamaterials and Metasurfaces II	**S22**: Antenna Arrays and Beamforming I
12:30 pm-01:45 pm	**L2**: Lunch			
01:45 pm-03:00 pm	ISTP: Meet the Editors	**S5**: CMOS and BiCMOS Power Amplifiers III	**S14**: Machine Learning in RF and Microwave Applications	**S23**: Terahertz Technologies and Systems V
03:00 pm-03:30 pm	Break			
03:30 pm-05:00 pm	Panel Discussion	**S6**: GaN and Compound Semiconductor Devices	**S15**: Dielectric and Magnetic Materials	**S24**: Antenna Arrays and Beamforming III
06:00 pm-10:30 pm	Awards Ceremony and Banquet @ Urchins 4			

Friday, July 24

09:00 am-09:45 am	**K3**: Keynote: The Evolution of Guided-Wave Technologies: Driving the Future of Integrated Circuits and Systems - Ke Wu			
09:45 am-10:45 am	**P5**: Semi-Plenary 5	**P6**: Semi-Plenary 6		
10:45 am-11:15 am	Break			
11:15 am-12:30 pm	YP Session	**S7**: Low Noise Amplifiers and Receivers	**S16**: Millimeter-Wave and Terahertz Passives II	**S25**: Antenna Arrays and Beamforming IV
12:30 pm-01:45 pm	**L3**: Lunch			
01:45 pm-03:00 pm	WIM Session	**S8**: Terahertz Technologies and Systems III	**S17**: CMOS and BiCMOS Power Amplifiers IV	**S26**: Microwave Filters and Resonators I
03:00 pm-03:30 pm	Break			
03:30 pm-04:45 pm	**S27**: Online (TBC)	**S9**: Microwave Filters and Devices	**S18**: Dielectric Characterisation	BPC (Debabani-Mentoring Session)

Time (Brisbane)	Michaelmus A	Michaelmus B	Reef	Urchins 2
04:45 pm-05:00 pm	*Awards & Closing Ceremony*			

Wednesday, July 22 8:50 - 9:05

Opening Ceremony

Room: Michaelmus A, Michaelmus B

Wednesday, July 22 9:05 - 9:55

K1: Keynote: MHz to THz Technologies Addressing Fundamental Science Questions - Goutam Chattopadhyay

Goutam Chattopadhyay, Senior Research Scientist

Room: Michaelmus A, Michaelmus B

Chair: Yang Yang (University of Technology Sydney, Australia)

Space exploration has long served as a powerful catalyst for inspiring the imagination of the next generation. The sight of rovers on Mars, images from distant galaxies, and the dream of humans returning to the Moon or reaching Mars ignite curiosity and a spirit of discovery in young minds. These missions are not just feats of engineering - they are stories that capture the human desire to explore the unknown and push beyond boundaries. By engaging students, educators, and the public in the wonders of space, exploration fosters STEM education, fuels innovation, and builds a generation that dreams bigger and reaches further.

Beyond its inspirational value, space exploration offers a unique lens through which we can better understand ourselves and our place in the cosmos. As we study other planets and moons, we gain valuable insight into planetary evolution, atmospheric behavior, and the potential for life beyond Earth. Observing Earth from space also provides critical data on climate change, environmental degradation, and the fragile systems that sustain life. In this way, space science not only fuels our search for extraterrestrial life but also deepens our understanding of Earth's past, present, and future. Ultimately, exploring the universe is a journey inward as much as outward - it challenges us to think about our shared humanity, our responsibility to protect our planet, and our collective future among the stars.

In this lecture, we will explore the technological innovations in the MHz to THz frequency domain driving the next generation of instruments and highlight specific instrument developments along with the fundamental science questions they aim to address.

This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with National Aeronautics and Space Administration (NASA).

Goutam Chattopadhyay Biography

Goutam Chattopadhyay is a Senior Scientist at NASA's Jet Propulsion Laboratory (JPL), California Institute of Technology (Caltech), and a Visiting Professor at Caltech in Pasadena, USA. He previously served as the BEL Distinguished Visiting Chair Professor at the Indian Institute of Science, Bangalore, and as an Adjunct Professor at the Indian Institute of Technology, Kharagpur. Dr. Chattopadhyay received his Ph.D. in Electrical Engineering from Caltech in 2000. He is a Fellow of the IEEE (USA), National Academy of Inventors (NAI), and the IETE (India); an Associate Fellow of the AIAA, the 2025 President of the IEEE Microwave Theory and Technology Society (MTT-S), a Track Editor for the IEEE Transactions on Antennas and Propagation, and an IEEE Distinguished Lecturer. His research focuses on microwave, millimeter-wave, and terahertz receiver systems and radars, as well as space instrumentation for the search for life beyond Earth.

Dr. Chattopadhyay has authored over 450 publications in international journals and conferences and holds more than 25 patents. He has received over 35 NASA Technical Achievement and New Technology Invention Awards. In 2026, he received NASA's Group Achievement Medal. In 2025, he received the NASA-JPL North Star Award, the highest honor bestowed upon a NASA-JPL scientist. In 2024, he was awarded the prestigious Armstrong Medal by the Radio Club of America (RCA) in recognition of his outstanding contributions to radio science. He also received the NASA-JPL People Leadership Award in 2023. Among other honors, he was named IEEE Region 6 Engineer of the Year in 2018 and received the Distinguished Alumni Award from the Indian Institute of Engineering Science and Technology (IIEST), India, in 2017. He is a two-time recipient of the Best Journal Paper Award from IEEE Transactions on Terahertz Science and Technology (2020 and 2013), and also received the Best Paper Award for Antenna Design and Applications at EuCAP in 2017. Additional accolades include the IETE Biman Bihari Sen Memorial Award (2022) and the IETE Prof. S. N. Mitra Memorial Award (2014).

Wednesday, July 22 10:00 - 11:00

P1: Semi-Plenary 1

Room: Michaelmus A

Chair: Konstanty S Bialkowski (The University of Queensland, Australia)

Printed VO_2 Tiles for Tunable Holographic Metasurface

Kamran Ghorbani (RMIT University, Australia)

Metasurfaces, as two-dimensional arrays of subwavelength engineered meta-atoms, provide powerful control over electromagnetic waves through spatial modulation of amplitude, phase, polarisation, and surface impedance. Compared with conventional bulk metamaterials, metasurfaces offer a lower-profile, more fabrication-friendly platform while retaining strong wavefront-engineering capabilities, enabling applications such as beam steering, focusing, polarisation control, holography, and antenna miniaturisation. In antenna applications, metasurfaces have progressed from reflectarray or lens structures to radiating apertures, forming metasurface antennas capable of guiding, modulating, and radiating electromagnetic waves with high design flexibility. However, passive metasurfaces are inherently limited to fixed responses after fabrication, motivating extensive research into tunable and reconfigurable metasurfaces based on electrical, optical, mechanical, liquidcrystal, semiconductor, and phase-change-material tuning mechanisms. Although these approaches have enabled dynamic electromagnetic control, scalable implementation remains constrained by biasing complexity, fabrication cost, power consumption, and the need to individually address large numbers of unit cells.

Novel Design Strategies for Wideband Millimeter-Wave Switched-Type MMIC Phase Shifters with Low Amplitude and Phase Errors

Wenquan Che (South China University of Technology, China)

In 5G and beyond 5G era, the growing demands for high data transmission rates in communication systems and high resolution in radar imaging pose strict requirements on millimeter-wave phase shifters. Specifically, wide bandwidth, precise phase control, and high amplitude consistency are essential for ensuring excellent beamforming quality and scanning accuracy. In this way, passive switched-type MMIC phase shifters have emerged as a promising solution, featuring zero DC power consumption and low-cost calibration. However, in the conventional direct-cascading architecture for multi-bit designs, inter-stage mismatch and load-pulling effects severely restrict the operational bandwidth and degrade the phase and amplitude accuracy. In this talk, some recent research on new phase-control theories and path-switching mechanisms for mmW switched-type phase shifters in our group will be presented. These strategies are expected to provide an architecture-level solution for mmW multi-bit phase shifters in wireless communication.

P2: Semi-Plenary 2

Room: Michaelmus B

Chair: Maral Ansari (CSIRO, Australia)

A Wide-Coverage End-Fire High-Gain Circularly Polarized Mobile Phone Antenna for Satellite Communication

Li-Bo Jia and Qing-Xin Chu (South China University of Technology, China)

To address the 3 dB polarization mismatch loss of linearly polarized antennas when receiving circularly polarized satellite signals, this work proposes an end-fire, high-gain circularly polarized mobile phone antenna with wide beamwidth. The antenna comprises three elements: a patch antenna integrated with the camera decoration (Deco), a frame antenna located at the top of the phone, and choke structures embedded in the side frames. The patch and frame antennas generate parallel electric and magnetic currents, respectively, whose combination produces end-fire left-handed circular polarization (LHCP). The antenna operates at a center frequency of 1.7 GHz with a bandwidth of 20 MHz. It features high gain and wide beamwidth, achieving a minimum LHCP gain higher than −5 dBic within a beam range exceeding a 90° cone angle across the operating band.

Wednesday, July 22 11:30 - 12:45

S1: CMOS and BiCMOS Power Amplifiers I

Room: Michaelmus B

A 300-GHz Broadband Power-Reconfigurable Load-Modulated Balanced Amplifier

Kaiyuan Du (Institute of Electronics, Chinese Academy of Sciences, China); Peng Wu (Chinese Academy of Sciences, China & University of Chinese Academy of Sciences, China); Juncheng Min (Aerospace Information Research Institute, Chinese Academy of Sciences, China); Zhongjun Yu (Aerospace Information Research Institute Chinese Academy of Sciences, China)

This paper presents a 300 GHz broadband power-reconfigurable load-modulated balanced amplifier (PR-LMBA) for broadband sub-terahertz applications. The proposed architecture leverages intrinsic load modulation within a balanced topology to realize dual-mode power operation without employing RF switches or reconfigurable matching networks. Implemented in a 0.13-um SiGe BiCMOS technology, the PR-LMBA achieves a peak small-signal gain of 19.4 dB with a 3-dB bandwidth of 62 GHz (246-308 GHz). In high-power mode, a maximum output power of 11.4 dBm and a peak power-added efficiency (PAE) of 2.3% are obtained. In low-power mode, the amplifier provides 4.7 dBm output power with 1.89% PAE, corresponding to a 6.3 dB reconfigurable power range.

Wave-Based Triple-Band CMOS Voltage-Controlled Oscillator

Wen Cheng Lai (National Taiwan University of Science and Technology, Taiwan)

By exploiting the intrinsic multiple resonant modes of a 6th-order LC resonator, a triple-band wave-based oscillator is designed. The LC resonator consists of two units of left-handed transmission LC network ended with parallel-tuned LC resonator, and a cross-coupled switching transistor pair is used to start up the oscillation. Two pairs of varactors are used for band tuning and switching. The proposed oscillator has been implemented with the tsmc 0.18 μm 1P6M CMOS technology and the core power consumption is 3.735 mW at the dc drain-source bias of 0.75 V. The VCO can generate differential signals in the frequency range of 8.04 - 8.68 GHz, 5.82 - 6.15 GHz, and 3.68 - 4.08 GHz. The die area of the triple-band oscillator is 0.568 × 1.189 mm2.

Presenter bio: Dr. Wen-Cheng Lai has been working in the field of radio-frequency circuits, analog IC integrated design, computer and communication for more than 20 years. He received the Ph.D. degree from National Taiwan University of Science and Technology. He is Assistant Professor in Department of Electronic Engineering National Yunlin University of Science and Technology, Taiwan.

Bandwidth Reconfigurable Low-Noise Amplifier Based on Magnetic Coupling Effect

Guangbao Shan, Pan Zhang, Yanwen Zheng, Ruixin Wang and Wang Fangqian (Xidian University, China)

This paper presents a band-reconfigurable low-noise amplifier (LNA) that utilizing transformer-based magnetic coupling technique. It consists of source-degenerated cascode amplifier integrated with a tunable magnetic coupling network. By manipulating the amplitude and phase of the voltage ratio(β), the position of the transmission zero can be dynamically adjusted, enabling flexible tuning of bandwidth. Simulation results

demonstrate that the 3-dB bandwidths range from 15.64 to 23.55 GHz and from 18.35 to 31.38 GHz, with corresponding gains of 16.84 dB and 16.98 dB, respectively.

Exploiting LDMOS-PA for kW SSPA Applications

Xin Tong, Shiyang Luo, Xidi Hu, Hao Zhang and He Guan (Northwestern Polytechnical University, China)

This paper presents the design and implementation of a 250-W S-band Class-B solid-state power amplifier (SSPA) module based on the Ampleon BLC2425M10LS250 laterally diffused metal-oxide-semiconductor (LDMOS) transistor. Stepped-impedance microstrip matching networks are employed to achieve broadband impedance matching over 2.4-2.6 GHz. The amplifier is measured under pulsed operation with a 10% duty cycle and a 100-µs pulse period. Measured results demonstrate that the proposed module delivers 53.69-53.98 dBm (233-250 W) output power, 14.0-14.4 dB power gain, 66.5%-75.8% drain efficiency, and 63.6%-72.5% power-added efficiency across the operating band. In addition, a high-efficiency power-combining scheme is proposed to facilitate future kW-class industrial microwave systems.

An Energy-Efficient Reconfigurable BLE RF Receiving Front-End Based on Mixer-First Architecture for IoT Applications

Yan Zhao, Jiawen Zhang, Tongde Huang, Wenhua Gu and Wen Wu (Nanjing University of Science and Technology, China)

This paper presents an energy-efficient reconfigurable Bluetooth Low Energy (BLE) RF receiver front-end based on a mixer-first architecture for Internet-of Things (IoT) applications. To eliminate the hardware redundancy and high cost associated with conventional designs using separate wake-up receiver (WuRX) and main receiver (RX) front-ends, the proposed architecture enables full hardware reuse between two parallel operating modes by reconfiguring the core transimpedance amplifier (TIA) to operate either as a linear amplifier or as a nonlinear active rectifier. The mixer-first architecture facilitates on-chip channel selection while reducing power consumption. Fabricated in a TSMC 28-nm CMOS process, the prototype consumes 0.2 mW in RX mode and achieves a minimum power consumption of 30 µW in non-duty-cycled WuRX mode. The measured input reflection coefficient, S11, is below -10 dB in both modes across the target frequency band. In WuRX mode, the front-end achieves a noise figure of approximately 21 dB over the signal bandwidth of interest. Based on the classical RF sensitivity calculation, the overall WuRX system is expected to achieve a receiving sensitivity better than -90 dBm at a data rate of 100 kbps. This work provides a low-cost, highly integrated RF front-end solution for BLE IoT terminals.

S10: Metamaterials and Metasurfaces I

Room: Reef

Chair: Yuanxi Cao (Xi'an Jiaotong University, China)

Space-Time Metasurface Antennas: Concept, Design, and Applications

Geng-Bo Wu (City University of Hong Kong, Hong Kong)

While the global commercialization of the fifth-generation (5G) wireless communications is gradually taking off, there is already significant interest in the next generation of wireless communications. 6G scheduled to be launched in 2030, will provide a Tbps data rate, microsecond latency, and almost unlimited bandwidth to the connectivity of numerous mobile and intelligent networks. Antennas and metasurfaces are ubiquitous and indispensable components for generating and manipulating electromagnetic (EM) waves. In this talk, I will share the development and design of the space-time metasurface antenna that can control all fundamental properties of EM waves. The space-time metasurface antenna can further facilitate information manipulation, which can fundamentally simplify the architecture of information transmitter systems. The unparalleled wave and information manipulation capabilities of the metasurface antenna will spark a surge of applications from next-generation wireless systems, cognitive sensing, to imaging.

Broadband Phase-Dispersive Conformal Metamaterial for EM Backscattering Enhancement

Weizhi Chen (South China University of Technology, China); Xin Xiu (South China University of Technology & Nanjing University of Science and Technology, China); Yixi Tang (Nanjing University of Posts and Telecommunications, China); Kun Tang, Wenjie Feng and Wenquan Che (South China University of Technology, China)

A phase-dispersive conformal metamaterial for broadband electromagnetic (EM) backscattering enhancement is presented. The metamaterial comprises two layers of LC resonant structures to achieve broadband phase-dispersive characteristics. To enable a conformal design, the first layer employs a low-profile dielectric substrate with excellent flexibility, while the second layer is conformally attached to the target surface using an insertion-based method. The metamaterial is designed for backscattering enhancement, and a prototype was fabricated for experimental validation. The results demonstrate significant backscattering enhancement over a broadband from 4.0 to 7.0 GHz (54.5%) for dual polarizations. With respect to a bare metal target without the metamaterial, the y-polarized backscattering is enhanced to 97.5% over a metal plate of identical projected area, and the x-polarized backscattering reaches 74.5%.

Semantics-Guided End-to-End Intelligent Design Framework for Metasurface Absorbers

Yongqi Lv, Wenhua Gu and Yanghui Wu (Nanjing University of Science and Technology, China)

Metasurface absorbers, as a type of two-dimensional metamaterial, control electromagnetic waves by adjusting the phase, amplitude, and polarization response of the units. Traditional design methods face challenges with high computational costs and low optimization efficiency. This paper proposes a semantic-guided, cross-modal end-to-end intelligent design framework, combining natural language processing and deep learning. A SigLIP-based visual-language alignment module connects natural language descriptions with target spectra, while a forward modeling method based on the SV-MC-FNO addresses the multi-solution problem in inverse design using a mixture density network (MDN). The introduction of cyclical consistency training with physical constraints enhances model reliability. Experimental results show significant improvements in design efficiency and accuracy.

Absorptivity Evaluation of Broadband FSS Absorbers Considering Higher-Order Floquet Modes

Chonghuan Zhang, Liping Yan, Yanping Zhou and Changjun Liu (Sichuan University, China)

Frequency selective surface (FSS) absorbers are inherently periodic electromagnetic structures whose scattering characteristics are governed by the superposition of Floquet modes. When the structural period satisfies specific conditions, higher-order Floquet modes (i.e., grating lobes) become propagation and carrying additional scattering power. This energy is not captured by conventional fundamental-mode S-parameters, which may lead to inaccuracies in conventional absorptivity evaluation based on |S11| and |S21|. In this work, the modal composition of the scattered fields of an FSS absorber is analyzed using Floquet theory. A broadband resistive-sheet FSS absorber is employed as an example to compare reflection characteristics and absorptivity with fundamental-mode-only and full-mode considerations. The results demonstrate that, when higher-order propagating modes are included, the 90% absorption bandwidth shrinks from 6.6 - 27.4 GHz to 6.6 - 20 GHz.

A Highly-Selective 3-D FSS with Exceptional Precision for Liquid Dielectric Constant Detection

Xiaojing Lv (University of Technology Sydney, Australia); Zhichao Sun (University of Technology Sydeny, Australia); Jiexin Lai and Yang Yang (University of Technology Sydney, Australia)

This paper presents a novel 3-D FSS sensor for the high-accuracy dielectric characterization of liquid materials across a wide dynamic range. Featuring a miniaturized honeycomb lattice and an ultrathin profile, the proposed architecture uniquely leverages surface tension for stable liquid retention. To interpret the spectral response, a systematic two-step analytical framework is developed, mapping specific higher-order harmonic resonance peaks to low, medium, and high dielectric constants. Furthermore, the sensor's high frequency selectivity and multiple harmonic resonances are intuitively elucidated via Smith chart impedance trajectories, providing profound physical insight into the underlying matching mechanisms.

S19: Biomedical and Wearable Sensing II

Room: Urchins 2

Chair: Amir Ebrahimi (RMIT University, Australia)

Materials-Aware Design Strategies for Wearable Antenna Design

Shengjian Jammy Chen (Flinders University, Australia & The University of Adelaide, Australia)

This review synthesises recent advances that co-optimise materials and electromagnetics for robust wearable antennas. It adopts a materials-aware design mindset that treats the substrate, radiator, and ground as coupled variables. In practice, one can shape dielectric loss and effective permittivity only where they matter; form the operating spectrum through interpretable modal control rather than add-on resonators; manage non-ideal conductors via coordinated radiator-ground co-design; miniaturise through ground-mediated propagation control; and embed biosymbiotic mechanics using additive manufacturing. Together, these strategies provide practical, material-oriented, application-focused guidance for future WBAN platforms.

Presenter bio: Shengjian Jammy Chen received M.E and Ph.D degrees in electrical and electronic engineering from the University of Adelaide, Australia. From 2017 to 2021, he was a lecturer and a postdoctoral researcher at the School of Electrical and Electronic Engineering of the University of Adelaide. Since 2022, he is a lecturer with College of Science and Engineering at Finders University. His current research interests include wearable and reconfigurable electromagnetic structures based on novel conductive materials such as conductive polymers and conductive fabrics, RFID-based wearable applications and leaky wave antennas. Dr. Chen was the recipient of the Young Scientist Best Paper Award at ICEAA 2015 & ICEAA 2016, and Travel Bursary Award in ICEAA 2016. He also received the Honorable Mention in APS/URSI 2017, the CST University Publication Award 2017, and Best Paper Award at IEEE APMC 2021.

Dosimetric Assessment of a Birdcage-Coil Wireless Power Transfer at 6.78 MHz for Capsule Robots

Valerio De Santis, Riccardo Olivieri and Wassim Boumerdassi (University of L'Aquila, Italy); Tommaso Campi (Sapienza University of Rome, Italy); Francescaromana Maradei (University of Rome La Sapienza, Italy); Mauro Feliziani (Roma, Italy)

This work addresses the electromagnetic field (EMF) safety of a capsule robot moving inside the human body during wireless power transfer (WPT) operations. The WPT system consists of an innovative birdcage coil capable of generating a nearly uniform rotating magnetic field with non-zero components along all three spatial axes. This solution is wearable, enabling comfortable and efficient power transfer to any patient. However, for obese human body models (HBMs), the current needed to transfer a reasonable power to the capsule battery could pose several EMF exposure risks due to the deeper colon tract and larger body cross-sections. A dosimetric analysis is therefore performed to assess compliance of the proposed WPT system with EMF safety standards. Different frequencies and HBMs are investigated to find the worst-case scenarios.

Presenter bio: Prof. De Santis is an Associate Professor at the University of L'Aquila, Italy. He serves as Secretary of IEEE-ICES-TC95-SC6 and expert member of IEC TC-106. His current research interests include biological effects of electromagnetic fields (EMFs), electromagnetic compatibility (EMC), and compliance assessment of EMF exposures.

A Wideband Terahertz Interconnection Between Microstrip Line and Waveguide Using Novel Short-Circuited Stub

Juncheng Min (Aerospace Information Research Institute, Chinese Academy of Sciences, China); Peng Wu (Chinese Academy of Sciences, China & University of Chinese Academy of Sciences, China); Kaiyuan Du and Chao Xue (Institute of Electronics, Chinese Academy of Sciences, China)

A novel wideband terahertz interconnection between microstrip line and waveguide is proposed for full-band applications, addressing the requirements of high-frequency test equipment, radar modules, and communication systems. A short-circuited stub is newly introduced to enhance the performance of the microstrip-to-waveguide transition. The short-circuited stub adjacent to the probe provides additional inductive loading, generating multiple resonant matching frequencies and thereby improving impedance matching across a wider bandwidth. With the proposed interconnection scheme, the D band is entirely covered, and in the frequency range from 95 GHz to 200 GHz, the simulated return loss and insertion loss are better than -15 dB and -0.75 dB. To experimentally validate the design, a back-to-back probe transition is fabricated. The measured return loss and insertion loss are better than -13 dB and -1.1 dB, respectively, from 103 GHz to 177 GHz, demonstrating excellent wideband performance. The proposed interconnection exhibits not only broad operational bandwidth but also strong potential for compact integration in high-frequency systems.

2006-2026: Two Decades of Innovation with Metamaterial and Metasurfaces for an Array of Applications

Chinmoy Saha (Indian Institute of Space Science and Technology, India & Royal Military College of Canada, Canada)

Over the past two decades, metamaterials and metasurfaces have revolutionized the field of electromagnetics by enabling unprecedented control over electromagnetic waves through engineered subwavelength structures. This invited talk presents a comprehensive overview of the research contributions in our group from 2006 to 2026, highlighting innovative developments in metamaterial and metasurface-inspired technologies for a wide spectrum of wireless and sensing applications.

The talk will cover the evolution of compact and multifunctional antennas, high-selectivity microwave filters, and advanced metasurface-enabled systems addressing the growing demands of modern wireless communications. Special emphasis will be given to the development of antennas for 4G/5G and beyond systems, cognitive radio platforms with frequency-reconfigurable and spectrum-sensing capabilities, and compact wideband radiators employing artificial electromagnetic structures for enhanced performance. Furthermore, the presentation will discuss recent advances in RF energy harvesting and rectenna technologies, including metasurface-assisted wireless power transfer and ambient energy-scavenging systems aimed at sustainable and self-powered wireless networks.

The talk will also highlight the translation of theoretical concepts into experimentally validated prototypes and practical systems, demonstrating how metamaterials and metasurfaces have evolved from scientific curiosities into enabling technologies for next-generation communication, sensing, and energy applications. Finally, future research directions involving intelligent metasurfaces, integrated wireless power and communication systems, and sub-THz platforms for 6G applications will be outlined.

Design of Millimeter Wave Ultra Wideband Solid-State LNA Module Based on Metal Cavity Packaging

Hui Peng (Kashi University, China); Zhongqian Niu (University of Electronic Science and Technology of China & School of Electronic Science and Engineering, China); Jincai Qiao (Chongqing Institute of Microelectronics Industry Technology, UESTC, China); Ya Fei Wu (UESTC, China); Bo Zhang and Zuqiang Ou (University of Electronic Science and Technology of China, China)

This paper presents a 67-110 GHz low-noise amplifier (LNA) module designed to suppress harmful resonances within a metallic packaging cavity, which can otherwise lead to self-oscillation and performance degradation. By optimizing the cavity dimensions and incorporating specifically designed perturbation structures, the proposed approach effectively eliminates unwanted resonant modes. The viability of the design is experimentally verified, with measurement results confirming stable LNA operation across the full frequency band.

W1: Workshop: Recent Advancement in Emerging Materials and Processing Technologies

Room: Michaelmus A

Chairs: Chenhao Chu (ETH Zurich, Switzerland), He Zhu (Charles Darwin University, Australia)

Additive Manufacturing of High-Performance Filters with Unconventional Geometries

Cristiano Tomassoni (University of Perugia, Italy)

Additive Manufacturing (AM) offers exciting capabilities for microwave engineering, enabling rapid prototyping, geometric flexibility, and easily customizable products. However, applying 3D printing to high-performance filters is not immediate, as these technologies are not originally tailored for high-frequency hardware. To meet strict electrical specifications, specific design adaptations and targeted post-processing steps are often required. This presentation highlights how AM can be effectively leveraged to build advanced microwave filters. Using selected hardware examples, we will discuss some of the most common 3D printing techniques adopted in this field and the practical actions needed to ensure optimal component performance. Finally, the talk will demonstrate how the geometric freedom of AM unlocks unconventional 3D topologies, allowing the development of a new class of filters that are highly optimized in terms of compactness, weight, and insertion losses.

Additively Manufactured Microwave Devices and Antennas

Yang Yang (University of Technology Sydney, Australia)

The race to develop next-generation wireless electronics is accelerating at a rapid pace. Thanks to advanced additive manufacturing technology, fast prototyping, low-entry-cost, and in-house short-run manufacturing empower millions of start-ups and companies with demanding confidentiality and accelerated innovation. We aim to build a new class of high-performance metamaterials and metasurfaces to advance the knowledge for future wireless devices. Compact and low-cost 3D-printed metasurfaces and metamaterials will be delivered to circumvent the limitations of traditional manufacturing technologies. The proposed 3D metadevices should be easily integrated into high-speed wireless systems in a dynamic environment. The cutting-edge additive manufacturing technologies advance 3D Radio frequency circuits with exceptional performance for emerging intelligent and immersive technologies, which will critically impact 5G/6G high-speed wireless devices in the millimetre-wave and terahertz applications. The 3D-printed radio frequency electronics will immediately benefit biomedical engineering, defence, space and telecommunication industries.

Reconfigurable and Tunable Millimeter-Waves Devices Based on Functional Materials

Aurelian Crunteanu (XLIM, CNRS/ University of Limoges, France)

The increasing complexity of high-frequency transmission and reception front-ends resulting from the addition of new frequency bands and frequency diversification, requires reconfigurable topologies throughout the entire telecommunication chain (antennas, phase shifters, filters, amplifiers, etc.) for reducing fabrication costs, system size, and overall power consumption. Most reported reconfiguration solutions in RF circuits are based on the integration of localized tunable devices and commonly rely on semiconductor-based devices, RF-MEMS, liquid crystals or functional materials. We are presenting the performances of a selection of reconfigurable devices (switches, tunable capacitors, agile filters, frequency- and polarization- reconfigurable antennas) designed for millimeter-waves operation and built upon a variety of constituent functional materials with controlled and tuned permittivity or conductivity (ferroelectrics, phase transition and phase change materials). We discuss the requirements for materials integration and emphasize the advantages of specific reconfiguration schemes enabling devices with on-demand agile functionalities.

Wednesday, July 22 12:45 - 2:00

Wednesday, July 22 2:00 - 3:15

S11: Terahertz Technologies and Systems IV

Room: Reef

Chair: Zong-Rui Xu (City University of Hong Kong, Hong Kong)

A Terahertz Scattering-Type Scanning near-Field Optical Microscopy for Single Cell Imaging

Zhaomin Peng and Jun Shi (National Space Science Center Chinese Academy of Sciences, China); Dehai Zhang (National Space Science Center, China)

Imaging biological cells at sub-terahertz (sub-THz) frequencies is difficult because cellular structures often exhibit weak scattering and low dielectric contrast. We report a 100-GHz scattering-type scanning near-field optical microscopy (s-SNOM) platform designed to improve sensitivity for label-free cellular measurements. The system combines a zero-intermediate frequency (Zero-IF) detection architecture with strong transmitter-receiver isolation and a custom probe with an approximately 100-nm tip radius. As a proof of concept, we image semi-dry SKOV3 ovarian cancer cells on a Au-coated substrate and distinguish two morphological states:

a rounded, poorly differentiated state and an elongated state. Measurable near-field contrast is retrieved via first- and second-harmonic demodulation, yielding stable 1st-2nd order near-field signals at 100 GHz.

Terahertz near-Field Scanning Microscopy for Nanoscale Imaging of Ovarian Cancer Cells

Dehai Zhang (National Space Science Center, China); Zhaomin Peng (National Space Science Center Chinese Academy of Sciences, China); Jin Meng (National Space Science Center, Chinese Academy of Sciences, China)

Terahertz scanning type near-field optical microscopy, as high-resolution imaging platforms with nanometer-scale resolution, have been extensively utilized in materials science, physics, and biological research. Central to this imaging mechanism is the use of nanoscale probe tip vibration to modulate incident electromagnetic waves. By selectively detecting the scattered signals arising from tip-sample interactions and extracting near-field information from both the fundamental vibration frequency components (termed first-order signals) and their harmonic frequency components (e.g., second-order signals or higher-order signals), these systems achieve nanometric spatial resolution.

Research on Beam Steering Rectenna Array for Drone Microwave Wireless Power Supply

Liwei Song (Xidian University, China)

To address the issue of unstable power supply caused by the difficulty in maintaining continuous beam alignment between transmitting and receiving antennas due to the dynamic changes in drone flight attitude, this study proposes a design for a beam-steering rectenna array. First, a pattern-reconfigurable receiving antenna element was designed by integrating a PIN diode switching network into the antenna parasitic layer. Second, a rectifier circuit suitable for wide input power ranges was designed using a dual-parallel Schottky diode topology. Finally, the designed antenna element and rectifier circuit were integrated into a rectenna element using a bent structure and a shared ground plane via the antenna's metal ground. The impact of the DC bias circuit structure on antenna performance was analyzed, and a 2×2 beam-steering rectenna array was constructed. Test results of the rectenna array at different power transmission distances show that the array can electrically adjust the receiving antenna beam direction. When the array is rotated to the aforementioned three angles, the maximum DC power received is 1.6 W, 1.2 W, and 1.3 W, respectively.

Microwave Beam-Steering Using near-Field Metasurfaces

Maira Islam Nabeel and Karu Esselle (University of Technology Sydney, Australia); Khushboo Singh (University of Technology Sydney, Australia & Macquarie University, Australia); Purna B. Samal and Dush Thalakotuna (University of Technology Sydney, Australia)

Near-field meta-steering (NFMS) antennas have emerged as an effective class of beam-steering antennas for applications such as high-power microwave systems and are increasingly extending into the terahertz domain since their first introduction in 2017. These antennas have gained significant interest in both academia and industry due to their low profile, ease of implementation, and excellent performance. This manuscript presents several emerging implementations of NFMS antennas in high-power microwave and THz applications. As an example case study, a simple one-dimensional beam-steering antenna system is demonstrated to illustrate the operating principle. The proposed antenna employs a short horn feed, whose gain is enhanced by 11 dB while the beam is tilted to 19° using a dual-purpose near-field phase transformation metasurface. The proposed design is capable of steering the beam in the azimuth plane from 0° to 360°.

A Single Substrate Pancharatnam-Berry (PB) Phase Huygens' Metasurface for Dynamic Steering of Vortex Beams

Jiechen Wang (Tianjin University, China); Yuxi Hu (Hebei University of Technology, China); Xiaoxuan Guo and Yang Yang (University of Technology Sydney, Australia)

This article presents a single-substrate Pancharatnam-Berry (PB) phase metasurface capable of dynamically steering vortex beams carrying orbital angular momentum (OAM). Based on the Huygens' resonance principle, the proposed metasurface achieves an overall thickness of only $0.125\lambda_0$ and a maximum transmission coefficient of −0.29 dB at 37.4 GHz. By spatially translating a left-hand circularly polarized (LHCP) patch antenna, high-

purity OAM beams with a scanning range of ±10° are realized. The proposed design provides a compact and efficient solution for generating steerable vortex waves, showing significant potential for high-capacity wireless communication and sensing applications.

S2: CMOS and BiCMOS Power Amplifiers II

Room: Michaelmus B

Photo-Tunable Chip Scale THz Ring Modulator

Dingxuan Gu, Xuecou Tu, Yunjie Rui, Bingnan Yan, Zhanzhang Mai, Huilin Zhang, Zeyu Xu, Cheng Liang, Heng Tang and Xiaoqing Jia (Nanjing University, China); Jian Chen (Nanjing University & Research Institute of Superconductor Electronics, China); Lin Kang and Peiheng Wu (Nanjing University, China)

This paper reports a low-loss on-chip optically tunable terahertz (THz) ring modulator (TRM) based on an all-silicon platform. Optical pumping technology enables the device to achieve active tunable resonant response with a minimum through-insertion loss of just 2 dB, dynamically controlling the coupling state from the overcoupled region to the critical region and then to the undercoupled region. At 458.75 GHz, modulation depth reaches 22.7 dB with an optical control speed exceeding 150 kHz, demonstrating practical value for high-speed switching and modulation. These findings represent a significant step forward in THz photonics by introducing a tunable ring resonator that combines electromagnetic field manipulation, reconfigurable coupling states, and on-chip compatibility, opening opportunities for applications in nonlinear optics, microcavity optics, and photonic integrated circuits (PICs).

A 110-150 GHz OOK Receiver for High-Speed Wireless Communication in 65-nm CMOS

Wangmin Liao and Shuang Song (South China University of Technology, China); Taotao Xu (Anhui University, China); Quan Xue and Pei Qin (South China University of Technology, China)

This paper presents a fully integrated 110-150 GHz on-off keying (OOK) receiver implemented in 65-nm CMOS technology. To enable high-speed transmission despite parasitic limitations in the D-band, the proposed design features a wideband low-noise amplifier (LNA) with parasitic-aware layout optimization, a gain-boosted envelope detector (ED), and a bandwidth-extended baseband amplifier. The LNA achieves a peak gain of 20.3 dB with a 3-dB bandwidth of 40 GHz. The complete receiver occupies an area of 0.49 mm^2 and consumes 62.6 mW from a 1.2 V supply. At a carrier frequency of 130 GHz, the receiver supports data rates exceeding 25 Gb/s with an energy efficiency of 2.5 pJ/bit.

A 105 dBΩ High Gain, 1.5 mW Low Power Muti-Stage NRZ CMOS-TIA for Optical Receiver Systems

Umar Mohammad (Nanjing University of Posts and Telecommunications, China)

This work proposes a multistage transimpedance amplifier (TIA) with multiple bandwidth and gain extension techniques. The TIA exhibits a high transimpedance gain of 105 dBΩ, a sensitivity of −8.2 dBm, and a data rate of 20 Gbps for non-return-to-zero (NRZ) scheme. The demonstrated results validate the proposed TIA for high-speed and low-noise intelligent optical communication systems. Bandwidth extension is achieved through techniques such as parasitic shunt capacitance splitting and inductive peaking are applied across various stages. To maximize gain, the TIA incorporates a single-input-to-differential circuit implemented using a simple RL shunt feedback inverter. Additionally, a differential amplifier followed by a buffer circuit contributes an additional gain of 16 dB. The design achieves an input-referred noise current density of 2.5 pA/√Hz and consumes a total power of 1.5 mW. The proposed TIA is implemented in a 65-nm TSMC technology node, operating at a nominal supply voltage of 1.2 V. The complete chip, including I/O pads, occupies a compact area of 1 mm2.

An Isolated Ultra-Low Power Modulator for OOK/BPSK Backscatter Communication

Luchen Shen (Nanjing University of Science and Technology ,Nanjing China & The University of Hong Kong, Hong Kong SAR China); Hao Zhang (Nanjing University of Science and Technology)

To meet the growing ultra-low power demand in backscatter sensing networks, switching modulation (e.g., OOK/BPSK) is widely adopted. Yet existing backscatter modulators confront the challenges of inherent static power consumption with SPDT switches and signal crosstalk. To address these issues, this paper proposes an ultra-low power modulator employing near-zero static power failsafe SPST switches for backscatter communication supporting OOK and BPSK with the quiescent power lower than 1 μW.

A Compact 24-to-30-GHz GaAs Series Doherty Power Amplifier Using a Three-Coupled-Line Balun

Xin He, Haoshen Zhu, Dingyuan Zeng, Zeqi Liu, Dayan Yuan and Quan Xue (South China University of Technology, China)

This paper presents a millimeter-wave (mm-wave) Doherty power amplifier (PA) monolithic microwave integrated circuit (MMIC) fabricated in a 0.1-μm gallium arsenide (GaAs) process for 5G-NR FR2 applications. To extend bandwidth, a series voltage combining architecture is adopted for output power synthesis. A compact three-coupled-line balun is implemented to realize low-loss differential-to-single-ended combining. In addition, an adaptive bias technique is applied to the peak amplifier output stage to improve AM-AM linearity. The proposed PA operates at 24-30 GHz. Simulation results show a small-signal gain of 13.5 dB and a large-signal gain of 14 dB. The saturated output power is 27.6-28.3 dBm. A peak power-added efficiency (PAE) above 35% is achieved, with PAE exceeding 30% at 6-dB back-off and 25% at 8-dB back-off. The AM-AM distortion is within ±1.2 and the AM-PM variation is less than 18°. The chip area is 2.2 mm × 1.6 mm.

S20: Metamaterials and Metasurfaces III

Room: Urchins 2

Chair: Zhichao Sun (University of Technology Sydeny, Australia)

W-Band Wide-Angle Coverage Pillbox Multibeam Antenna Based on Bifocal Phase Compensation

Yuanxi Cao, Cheng Guo, Jianxing Li, Juan Chen and Sen Yan (Xi'an Jiaotong University, China)

A pillbox beamforming network (BFN) based W-band multibeam antenna is proposed in the paper. The antenna is composed of a BFN, several phase delay lines, and a ridged waveguide (RWG) slot array. The phase delay lines convert the rectangular waveguide output ports of the pillbox BFN to the RWG, thus reducing the element space between the adjacent radiation slots and increasing the beam scanning range. Additional phase compensation is used to optimize the SLL and gain of beams, which is realized by the taper width of the RWG. The simulated results show that the antenna can achieve the beam scanning range of ±45°, and the gain variation of the beam switching is below 2.3 dB.

Non-Volatile Reflective Intelligent Surface Based on 2D Material Switches for 6G Wireless Communications

Xiaoyu Xiao (University of Manchester, United Kingdom (Great Britain)); Zixing Peng (The University of Manchester, United Kingdom (Great Britain)); Xuzhao Liu, Jiaqiu He, Yifan Zhang, Cinzia Casiraghi and Zhirun Hu (University of Manchester, United Kingdom (Great Britain))

Currently reflective intelligent surface (RIS) implementations typically rely on semiconductor switches (e.g., PIN diodes or transistors) hence require continuous biasing, leading to non-negligible static power consumption that scales with the number of unit cells. Here we present an highly energy-efficient, efficient, intelligent surface enabled by non-volatile 2D-material-enabled RF switches. The switch is consisting of sandwiched Ag/MoS_2/Ag structure and exhibits stable non-volatile resistive switching and favorable RF characteristics, enabling two persistent states without DC holding power. By integrating these switches into a 1-bit reflective unit cell, a 6×6 RIS prototype operating at 3.5 GHz is demonstrated with programmable reflection patterns under different coding sequences, validating its capability for beam steering and wavefront control. Furthermore. system-level energy benefit of eliminating static bias power, which becomes increasingly significant for large-scale RIS and sensing arrays is presented. These results indicate that non-volatile 2D-material switches provide a practical pathway toward low-power pro-grammable metasurfaces for 6G wireless communications.

A Curved Broadside-Coupled Stripline Phase Shifter and Its Application to Metasurface Designs

Jiexin Lai and Xiaojing Lv (University of Technology Sydney, Australia); Zhichao Sun (University of Technology Sydeny, Australia); Yang Yang (University of Technology Sydney, Australia)

In this paper, a metasurface based on a compact curved broadside-coupled stripline (BCS) phase shifter is proposed for gain enhancement applications. The unit cell consists of a receiving antenna, a BCS phase shifter, and a transmitting antenna, all fabricated using standard printed circuit board (PCB) technology. The proposed metasurface exhibits stable radiation performance with a boresight gain of approximately 19 dBi and cross-polarization levels below -20 dB, and a 3-dB gain bandwidth of 18% (25 - 30 GHz).

High-Frequency Narrowband to Low-Frequency Broadband Transition in an SMA-Actuated Bandpass Frequency-Selective Surface

Xiaojing Lv and Zhenlin Dai (University of Technology Sydney, Australia); Zhichao Sun (University of Technology Sydeny, Australia); Zhiwei Yin and Yang Yang (University of Technology Sydney, Australia)

This study presents a thermally actuated, dynamically reconfigurable FSS utilizing laser-cut Ni-Ti SMA elements. By exploiting a bistable SMA architecture, the unit-cell topology is physically reconfigured via temperature-triggered deformation, thereby re-routing the surface current paths without the need for complex voltage-biasing networks or bulky mechanical assemblies. The proposed FSS seamlessly transitions between two distinct spectral states: a highly selective high-frequency narrowband response when the SMA branches are engaged and a broadband response in the lower-frequency regime when the branches are disengaged. Correspondingly, the fractional bandwidth dynamically expands from 5.66% to 51.72%. The underlying electromagnetic mechanisms and bandwidth transition are further elucidated through Babinet's principle and Smith-chart impedance trajectories.

Liquid Crystal Tunable Phase Shifter Using Post-Wall Coplanar Waveguide

Haoyu Zhou and Lei Guo (The University of Queensland, Australia)

A continuously tunable phase shifter based on liquid crystal from 10 GHz to 60 GHz is presented. In this design, most of the waves travel through the LC mixture via a post-wall coplanar waveguide, rather than the traditionally employed inverted microstrip line, maximizing the liquid crystal's tunability. Additionally, the proposed design offers straightforward fabrication and improved mechanical stability compared to the stripline designs. To validate the effectiveness of the proposed design, three delay line phase shifters employing inverted microstrip line, stripline, and post-wall coplanar waveguide are designed and simulated. The results show that, while all the structures have reflection coefficients less than -18 dB, the suggested structure demonstrates figure of merit values between 89.6 Degree/dB and 124.9 Degree/dB, which is, on average, 35 % greater than those attained by stripline designs. The enhanced FoM and decreased fabrication complexity make the proposed structure a promising candidate for applications in millimeter-wave beamforming.

W2: Workshop: Recent Advancement in Emerging Materials and Processing Technologies

Room: Michaelmus A

Chairs: Chenhao Chu (ETH Zurich, Switzerland), He Zhu (Charles Darwin University, Australia)

Liquid Metal Enabled Reconfigurable Microwave Devices and Antennas

Yi Wang (University of Birmingham, United Kingdom (Great Britain))

The terahertz (THz) frequency band (0.1-10 THz) offers immense potential for advanced imaging applications due to its non-ionizing nature, ability to penetrate non-polar materials, and distinctive spectral signatures. A critical component of THz systems is the THz lens, which facilitates high-resolution biosensing, biological imaging, and the detection of concealed details. However, traditional dielectric refractive lenses are bulky, suffer from significant aberrations, and often fail to achieve the high imaging resolution required for emerging applications. To overcome these limitations, metasurfaces have been widely employed in the design of THz metalenses. Metasurfaces provide a compact and versatile alternative to traditional lenses. In this talk, we will present various THz metalens designs, including achromatic metalenses, hyper-dispersive metalenses, and super-oscillatory metalenses, all fabricated using advanced dielectric 3D printing technology. We will also highlight their transformative applications, such as THz super-resolution imaging, axial-scan-free 3D object imaging, and resilient wireless communications. These 3D-printed metalenses, with their unique characteristics, pave the way for next-generation compact, high-resolution, and in vivo THz imaging systems.

3-D Printed Metalenses for Terahertz Imaging

Geng-Bo Wu (City University of Hong Kong, Hong Kong)

The terahertz (THz) frequency band (0.1-10 THz) offers immense potential for advanced imaging applications due to its non-ionizing nature, ability to penetrate non-polar materials, and distinctive spectral signatures. A critical component of THz systems is the THz lens, which facilitates high-resolution biosensing, biological imaging, and the detection of concealed details. However, traditional dielectric refractive lenses are bulky, suffer from significant aberrations, and often fail to achieve the high imaging resolution required for emerging applications. To overcome these limitations, metasurfaces have been widely employed in the design of THz metalenses. Metasurfaces provide a compact and versatile alternative to traditional lenses. In this talk, we will present various THz metalens designs, including achromatic metalenses, hyper-dispersive metalenses, and super-oscillatory metalenses, all fabricated using advanced dielectric 3D printing technology. We will also highlight their transformative applications, such as THz super-resolution imaging, axial-scan-free 3D object imaging, and resilient wireless communications. These 3D-printed metalenses, with their unique characteristics, pave the way for next-generation compact, high-resolution, and in vivo THz imaging systems.

General-Purpose Terahertz Quasi-Optics and Mechanical Beamformers Enabled by 3D-Printing

Daniel Headland (The University of Adelaide, Australia)

Owing to their short wavelength and light-like propagation behavior, terahertz waves require quasi-optical components to control the flow of radiation. To meet this need, 3D-printing has evolved over the past decade from a niche technique to a highly customizable, general-purpose methodology to produce terahertz quasi-optics, using consumer-grade hardware.

Wednesday, July 22 3:45 - 5:00

S12: Biomedical and Wearable Sensing I

Room: Reef

Chair: Shengjian Jammy Chen (Flinders University, Australia & The University of Adelaide, Australia)

Integrated Microwave Photonics for Signal Processing and Sensing

Xiaoke Yi (University of Sydney, Australia)

The field of microwave photonics has evolved significantly over the last decade, ushered by the breakthroughs in integrated photonics in realizing integrated microwave photonic devices with an array of functionalities packed on a nanoscale footprint. The combination of photonic integration with microwave photonics, enables the realization of reproducible, compact, lightweight, low-power consumption and low-cost microwave photonic systems that are physically and economically competitive against their electronic counterparts. Microwave photonics techniques have attracted dramatically increased attention. In this paper, we present recent advances across three interconnected themes: adaptive RF signal processing, high performance sensing, and photonic neural computing.

We first discuss adaptive microwave photonic interference mitigation for dynamic RF environments. By combining photonic amplitude and phase control, the system can suppress unknown and time-varying interference. Experimental results demonstrate robust recovery of signals of interest under continuous-wave, phase-modulated and multi-interference conditions. We then present machine-learning-enhanced microwave photonic sensing, where integrated photonic sensors convert optical responses into rich RF spectral signatures that can be interpreted by machine/deep learning (ML/DL) models. In our recent work, ML/DL-assisted microwave photonic sensors have enabled athermal operation, noise resilience, multi-parameter detection and extended sensing range. Finally, we discuss our recent photonic neural network accelerators based on inverse-designed nanophotonic structures. The photonic neural network perform classification within ultra-compact silicon photonic devices. The demonstrated photonic neural networks achieve a computational density of approximately 400 million parameters per mm^2, providing a scalable pathway towards energy-efficient analog photonic computing.

A Communication Signal Based Vital-Sign Sensing Method for Consumer Electronic Devices

Chenming Li, Xingqi Xuan, Junhao Zhang, Yulin Zhou, Shilie Zheng, Xiaonan Hui and Xianmin Zhang (Zhejiang University, China)

In the information society, consumer electronic devices naturally possess wearable and portable characteristics. In light of this, we introduce a vital-sign detecting system for consumer electronic devices that utilizes wireless communication signals. Given the proximity of these devices to the human body, radio frequency energy is directed into a confined internal region, thereby facilitating the modulation of backscattered signals with pronounced bodily vibrations. Consequently, the received signals exhibit variations corresponding to the vital signs. After simply filtering out the high-speed modulated digital information, target signals can be obtained without complicated demodulation. The theoretical framework, numerical computations, and experimental results demonstrate congruence, thereby validating the efficacy of the proposed methodology for achieving stable, long-term monitoring across diverse wearing scenarios. The average heart rate aligned with the established gold standard, and the root-mean-square error (RMSE) for instantaneous heart rate was 1.02 bpm.

Characterization of Knitted Textiles for Wearable Antennas

David Mitchell (University of Illinois at Urbana-Champaign, USA); Jennifer T. Bernhard (University of Illinois at Urbana-Champaign & Electromagnetics Laboratory, USA)

Textile-integrated antennas have been the subject of much investigation due in part to their easy integration into everyday life. There are several methods that have been established for creating textile-integrated antennas. Two such methods are embroidery and knitting. Both employ the use of existing textile manufacturing methods and conductive threads and yarns. Embroidered antennas have been studied extensively and have made use of high precision, computer controlled embroidery machines (A. Kiourti, C. Lee, and J. L. Volakis, "Fabrication of Textile Antennas and Circuits With 0.1 mm Precision," IEEE Antennas and Wireless Propagation Letters, vol. 15, pp. 151-153, 2016). Knitted antennas, on the other hand, have not been as extensively studied. Some work has been done in characterizing the effective sheet impedance of knitted antennas and transmission lines, however this was only done for a single knit pattern (M. A. S. Tajin, C. E. Amanatides, G. Dion and K. R. Dandekar, "Passive UHF RFID-Based Knitted Wearable Compression Sensor," in IEEE Internet of Things Journal, vol. 8, no. 17, pp. 13763-13773, 1 Sept.1, 2021). A major advantage of knitted textiles is the ability to design and program different mechanical properties of the textile based on the knit pattern (Singal, K., Dimitriyev, M.S., Gonzalez, S.E. et al. "Programming mechanics in knitted materials, stitch by stitch". Nature Communications 15, 2622, 2024). This work will examine and characterize a variety of textiles with differing knit patterns and will attempt to establish a relationship between their mechanical and electrical properties. This will be done using techniques from metasurface design, where a knit stitch will be treated as the unit cell and the bulk surface impedance properties will be extracted from HFSS simulations (A. M. Patel and A. Grbic, "A Printed Leaky-Wave Antenna Based on a Sinusoidally-Modulated Reactance Surface," in IEEE Transactions on Antennas and Propagation, vol. 59, no. 6, pp. 2087-2096, June 2011). Those metasurface simulations will then be used to design a pattern on a textile, which will be manufactured and compared against the simulated results. This research was supported by an appointment to the Intelligence Community Postdoctoral Research Fellowship Program at The University of Illinois Urbana-Champaign administered by Oak Ridge Institute for Science and Education (ORISE) through an interagency agreement between the U.S. Department of Energy and the Office of the Director of National Intelligence (ODNI)

Ultra-Wideband Multi-Channel Millimeter-Wave Receiver for Solar Sensing

Jun Shi (National Space Science Center Chinese Academy of Sciences, China); Dehai Zhang (National Space Science Center, China); Zhaomin Peng (National Space Science Center Chinese Academy of Sciences, China)

Solar radio emissions provide critical insights into dynamic solar atmospheric processes, including coronal heating, solar eruptions, and solar wind acceleration. We present a high-sensitivity, multi-channel receiver system operating across the 15-36 GHz range, specifically engineered to bridge observational gaps in capturing non-thermal phenomena, such as small-scale microwave bursts in the solar transition region. The system architecture employs low-noise amplifiers (LNAs) in the initial stage to minimize the overall noise figure, followed by multi-band filters and power dividers that split the signal into three primary sub-bands-15-22 GHz, 22-29 GHz, and 29-36 GHz-supporting dual-polarization observations. By integrating frequency down-conversion with high-speed digital spectroscopy, the system achieves the temporal and spectral resolution requisite for characterizing rapid frequency drift and transient burst dynamics in real-time. Currently, the system is deployed at the Lenghu Station on the Qinghai-Tibet Plateau at an altitude of 4,100 meters for pilot observations. Comparative measurements of solar and the cold sky demonstrate that the system possesses high observational sensitivity. This successful deployment validates the system's efficacy for comprehensive solar monitoring and establishes a robust foundation for future observations aimed at advancing solar physics and space weather research.

PDMS-MWCNT Composite Material Properties, Preparation and Role in Wearable Antennas

Musa Hussain (Griffith University, Queensland, Australia); Hajra Khan (Comsats University Islamabad Abbottabad Campus, Pakistan); Syed Muzahir Abbas (Macquarie University, Australia)

In this paper, the properties, preparation and applications of PDMS-MWCNT composite is discussed. The main focus of the paper remains on the applications of flexible antennas used in wearable electronic devices. The flow diagram of making of the PDMS and PDMS-MWCNT composite is given. Moreover, the detailed analysis of both materials in terms of scanning electron microscope (SEM) is analyzed. Later, some examples are given from the literature, which shows the role of these materials in the antenna designing applications.

S21: Antenna Arrays and Beamforming II

Room: Urchins 2

Chair: Muhammad Ali Babar Abbasi (Queen's University Belfast & Centre for Wireless Innovation (CWI), United Kingdom (Great Britain))

Power-Based Direction-Finding Enabled by a Null-Scanning Space-Time Leaky-Wave Antenna

Yiqing Sun, Geng-Bo Wu and Chi Hou Chan (City University of Hong Kong, Hong Kong)

This paper presents a power-based direction-finding (DF) scheme based on a space-time leaky-wave antenna (STLWA) with fixed-frequency radiation null scanning capability. The direction of arrival (DoA) can be estimated by identifying the power-minimum angle between two lobes in the spatial power spectrum. To be specific, by programming the 1-bit phase-control unit cells with distinct time-periodic signals, the amplitude of the aperture field at the fundamental frequency can be flexibly controlled. By leveraging space-time modulation, the STLWA provides steerable radiation nulls at the fundamental frequency. DF experiments are conducted to validate the system's performance. The proposed approach offers a compact, phase-shifter-free, fixed-frequency solution for sensing and localization.

Presenter bio: SUN Yiqing received the B.Eng. degree in electronic engineering from Nanjing University of Science and Technology, Nanjing, China, in 2019, and received the M.Sc. degree in electronic science and technology from Beijing Institute of Technology, Beijing, China, in 2022. Currently, she is pursuing the Ph.D. degree in electrical engineering at the City University of Hong Kong (CityU), Hong Kong. Her current research interests include antenna design and spacetime-coding technology

Planar EBG Monostatic Antenna with Wideband Interport Isolation Characteristics for 5G in-Band Full Duplex Applications

Haq Nawaz (Military Technological College, Oman); Hajra Khan (Comsats University Islamabad Abbottabad Campus, Pakistan); Syed Muzahir Abbas (Macquarie University, Australia)

This work presents a dual port, dual polarized shared-aperture (monostatic) based planar antenna with wideband interport isolation characteristics for sub-6 GHz simultaneous transmit and receive (STAR) or in band full duplex (IBFD) wireless applications. The presented compact metasurfaces antenna offers wider impedance

bandwidth and excellent interport isolation levels across its entire operating bandwidth. The wideband impedance bandwidth characteristics have been achieved through combination of parasitic feeding and electromagnetic band gap (EBG) radiator excited through proximity feeding from modified four-pointed star shaped driven patch. The high interport isolation levels across entire operational bandwidth of the antenna have been established through balanced transmit and receive modes operation. The presented EBG antenna with unidirectional radiation characteristics resonates at center operating frequency of 3.75 GHz with -10 dB impedance bandwidth of 1.5 GHz (40%) spanning over 3 GHz to 4.5 GHz. The isolation between transmit and receive ports of presented antenna is better than 62 dB across the entire operating bandwidth of 1.5 GHz. The presented dual port, dual polarized antenna offers superior gain performance for each port excitation attributed to the differential excitation of EBG patch. The proposed unidirectional antenna offers wider impedance bandwidth and high port to port isolation levels across wider impedance bandwidth compared to the earlier reported unidirectional antennas intended for IBFD or STAR applications.

Presenter bio: Syed Muzahir Abbas received his B.Sc. degree in Electrical (Telecommunication) Engineering from COMSATS Institute of Information Technology, Islamabad, Pakistan and his M.Sc. degree in Computer Engineering from the Center for Advanced Studies in Engineering (CASE), Islamabad, Pakistan in 2006 and 2009 respectively. He completed his Ph.D. degree in Electronics Engineering at Macquarie University, Sydney, Australia. He has served as RF Engineer (R & D, Mobility soultions) at Commscope, Australia, and as Transmission Engineer for Alcatel-Lucent Pakistan. He has also served as academic at various universities University of Sydney, Western Sydney University, Macquarie University and COMSATS. His research interests include high impedance surfaces, carbon nanotube (CNT) yarns and the development of antennas for ultra-wideband (UWB) and wireless body area network (WBAN) applications.

Low-Profile Broadband Beam-Scanning Antenna

Shuo Sun (Beijing University of Posts and Telecommunications, China); Xiuping Li (Beijing University of Post and Telecommunications, China); Zihang Qi (Beijing University of Posts and Telecommunications, China); Wenyu Zhao (Beijing University of Posts and Telecommunications, China & EE, China); Jianxun Su (Beijing University of Posts and Telecommunications, China)

This paper presents a low-profile beam-scanning antenna, where the monopole antenna and metasurface are integrated on the same plane for ultra-compact configuration. A 7-mm-tall monopole antenna serves as the feed to excite surface waves (SW), while the metasurface generates Pancharatnam-Berry (PB) phase and propagation (PG) phase to regulate SW radiation. Specifically, the PB phase is fixed as a preset component, and the PG phase features 1-bit reconfigurable phase resolution. The broadband phase responses of both phases endow the antenna with excellent broadband radiation capability. At the boresight direction (0 °), the antenna achieves a 16.6% 3-dB gain bandwidth spanning 10.5-12.4 GHz. Furthermore, two-dimensional beam scanning over a range of ± 60 ° is realized within the operating band, with a scanning loss of less than 3 dB. Owing to its advantages of low profile, high integration, and broadband radiation performance, the proposed design is expected to be a promising candidate for mobile communication applications.

Generation of Scanning Self-Accelerating Beam by Manipulating Phase Distribution

Qing You (University of Macau, Macao); Shi-Tong Wang (City University of Hong Kong, Hong Kong); Pui-In Mak, Rui P. Martins and Jun Yin (University of Macau, Macao)

This paper presents a method for achieving scanning of self-accelerating beams by simply reversing the phase from 0 degree to 180 degree. Building upon conventional approaches, this method leverages both gradient amplitude and abrupt phase profiles, requiring only phase manipulation to achieve beam scanning. A waveguide slot antenna array is designed based on this principle, and simulated results demonstrate its effectiveness and feasibility

Compact High-Gain 300 GHz Metasurface Antenna for Future 6G Terahertz Communications

Mohammad Nasrat Zaqumi, Syed Muzahir Abbas and Subhas Chandra Mukhopadhyay (Macquarie University, Australia)

This paper presents a compact resonant cavity antenna (RCA) enhanced by a single-layer negative-epsilon surface (NEPS) metasurface operating at 300 GHz for terahertz communication systems. The proposed metasurface is composed of periodic circular patch resonators engineered to exhibit a stable reflection magnitude together with an effective negative permittivity ($\varepsilon<0$) around the target frequency. These electromagnetic characteristics enable efficient manipulation of the reflection phase and control of the electromagnetic wave propagation inside the Fabry-Perot cavity. By regulating the reflection phase distribution, the metasurface improves the near-field phase uniformity and promotes constructive interference at the partially reflective aperture, resulting in enhanced radiation collimation and power radiation efficiency. Full-wave numerical simulations demonstrate that the proposed antenna achieves a maximum directivity of approximately 20 dBi with an aperture efficiency of about 40% while maintaining a compact and low-profile structure. The proposed NEPS-assisted RCA provides a promising high-gain antenna platform for terahertz and future 6G communication applications.

Presenter bio: Syed Muzahir Abbas received his B.Sc. degree in Electrical (Telecommunication) Engineering from COMSATS Institute of Information Technology, Islamabad, Pakistan and his M.Sc. degree in Computer Engineering from the Center for Advanced Studies in Engineering (CASE), Islamabad, Pakistan in 2006 and 2009 respectively. He completed his Ph.D. degree in Electronics Engineering at Macquarie University, Sydney, Australia. He has served as RF Engineer (R & D, Mobility soultions) at Commscope, Australia, and as Transmission Engineer for Alcatel-Lucent Pakistan. He has also served as academic at various universities University of Sydney, Western Sydney University, Macquarie University and COMSATS. His research interests include high impedance surfaces, carbon nanotube (CNT) yarns and the development of antennas for ultra-wideband (UWB) and wireless body area network (WBAN) applications.

S3: Terahertz Technologies and Systems I

Room: Michaelmus B

Chair: Safumi Suzuki (Institute of Science Tokyo, Japan)

Terahertz Microsystems Front-End Integration Technologies and Communication Application

Peng Wu (Chinese Academy of Sciences, China & University of Chinese Academy of Sciences, China)

Terahertz wave possesses wide available high frequency spectrum bandwidth and thus has potential applications in high-resolution imaging sensing and high-speed communication. Due to limitations in terahertz integration technologies and MMIC manufacturing processes, terahertz radar and communication systems still face bottlenecks such as low power output, high noise, and difficulties in array integration. The front-end SiP integration is still one of the key terahertz microsystem technologies. In the session, the newly proposed integration solutions, such as the planner transmission line and waveguide interconnection, 3D multilayer module, and multi-channel integration, will be presented, and terahertz SiP arrays will be further introduced for the high-speed communication.

Presenter bio: Peng Wu is a Research Fellow and the Deputy Director of Research Department with Aerospace Information Research Institute, Chinese Academy of Sciences, Beijing, China. At the same time, he is also currently a Professor and PhD supervisor with University of Chinese Academy of Sciences, Beijing, China. He is a member of the Satellite Communication Committee, China Institute of Communications. His current research interests include millimeter-wave/terahertz microsystems and their applications. He has led science and technology innovation projects, e.g., antenna systems for satellite communications, terahertz integration, and reconfigurable radar systems. His research outcomes have been applied in fields such as satellite communication and radar sensing.

Metatronics for High-Performance Terahertz Integrated Circuits

Mohammad Samizadeh Nikoo (NTU Singapore, Singapore)

Approaching the terahertz band from the electronics side is of great technological importance, with the promise of advancing next-generation wireless communication systems toward 6G and beyond [1]. However, inherent limitations of high-speed transistors, the primary building blocks of monolithically integrated high-frequency circuits, have hindered the realization of high-performance terahertz electronics [2], [3]. Electrical metastructures offer an alternative paradigm, in which electrical control of the conductivity of a semiconducting layer manipulates collective quasi-electrostatic responses within a device layout, enabling electronic functionalities such as switching, mixing, and parametric amplification. Compared with conventional transistors, electrical metastructures enable ultra-low contact resistances, leading to record-high switching cutoff frequencies beyond 10 THz in a compact device platform, referred to as electronic metadevices [4]-[7]. The first part of this talk highlights recent advances in III-nitride electronic metadevices operating up to 1 THz and introduces a new generation based on quasi-one-dimensional electrical metastructures with enhanced electrical performance [8]. We present theoretical insights into the collective responses governing the operation of electronic metadevices and elucidate their ultimate performance limits. In the second part, we introduce a metastructure-based paradigm for directly realizing high-performance millimeter-wave and terahertz components with ultracompact footprints, demonstrated the compatibility of metatronic devices with commercial silicon processes [9].

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Design of a High-Performance Terahertz Multiplier Based on Thin-Film Technology

Li Wang (National Space Science Center, China); Jin Meng (National Space Science Center, Chinese Academy of Sciences, China); Dehai Zhang (National Space Science Center, China)

This paper presents a high-performance 510 GHz monolithic GaAs Schottky barrier diode (SBD) frequency tripler for terahertz local oscillator (LO) applications. As the operating frequency extends into the sub-millimeter-wave regime, traditional multipliers are often limited by inaccurate parasitic modeling and significant substrate-induced dielectric losses. To address the parasitic modeling issue, a deterministic two-port, four-structure parasitic extraction method is proposed. Compared with conventional equivalent-circuit modeling or empirical fitting methods, it enables clearer separation of extrinsic parasitics and supports more accurate parasitic modeling and Schottky diode structure optimization. Four specifically designed test structures-Single Pad (SP), Pin-Open (PO), Diode-Short (DS), and Diode-Open (DO)-are employed to systematically extract pad-related parasitics (Lpad, Cpad), finger-related components (Lf, Rf), and inter-electrode coupling effects (Cpp). By de-embedding these extrinsic parasitics from Y-parameters, a more accurate parasitic model of the SBD can be established, which helps reduce the adverse impact of overall parasitic effects on multiplier performance and provides a basis for optimizing the Schottky diode structure. The tripler is implemented using a 3-μm-thick GaAs membrane process with backside substrate etching, which removes the bulk GaAs to form a thin-film structure and effectively reduces substrate-induced dielectric loss and suppresses parasitic substrate modes at 510 GHz. A balanced topology is also adopted to suppress even-order harmonics. Experimental characterization was performed using a frequency multiplier chain and an Erickson power meter. The fabricated MMIC demonstrates robust performance across the 490-530 GHz band. Under an input drive power ranging from 63 to 104 mW, the tripler achieves a peak output power of 3.72 mW at 508 GHz, with a maximum conversion efficiency of 4.2%. Milliwatt-level output power is maintained across the entire measured bandwidth, although the upper end of the band approaches the operating limit of the test equipment. These results demonstrate that the proposed four-structure extraction method and 3-μm thin-film technology together provide an effective means of improving the output performance of terahertz frequency triplers.

Design and Analysis of Circular Hollow Polymer Waveguide at THz Frequency Band

Shengjie Zhou (Shanghai Jiaotong University, China); Changsheng Sun, Xiaochun LI and Junfa Mao (Shanghai Jiao Tong University, China)

This paper presents the design and analysis of a circular hollow polymer waveguide (CHPW) operating at W-band (75-110 GHz). The proposed structure consists of an air core surrounded by a polymer cladding, which effectively reduces dielectric loss compared to solid polymer waveguides. Mode analysis reveals that the designed CHPW supports single-mode propagation throughout the entire W-band, with the fundamental HE11 mode and higher-order TM01 mode identified. Parametric studies show that increasing the inner radius or polymer thickness raises both the phase and attenuation constants, with polymer thickness exhibiting a more significant influence. Material comparison indicates that PTFE offers lower loss and wider single-mode bandwidth than HDPE and PMMA, making it a promising candidate for terahertz (THz) applications. Compared with circular solid polymer waveguides (CSPW), the CHPW demonstrates lower attenuation and broader single-

mode bandwidth but suffers from weaker field confinement. This work provides a useful guidance for the development of polymer waveguides at THz frequencies.

Hybrid Modeling Method of FT-Transformer and XGBoost for TFsurface

Yihao Li (Nanjing University of Science and Technology. China); Shijie Wang (National University of Singapore, Singapore); Wen Lyu (Nanjing University of Science and Technology, China)

Terahertz field-effect transistors integrated with metasurfaces (TFsurfaces) hold significant promise for high-sensitivity chemical detection and imaging. However, optimizing the asymmetric interdigitated grating gate (AIGG) structure remains challenging due to complex near-field coupling effects and a high-dimensional parameter space spanning periodicity, gate number, asymmetry coefficient, and structural dimensions. Conventional empirical design methods are inefficient and struggle to globally optimize these detectors. This paper proposes a hybrid intelligent modeling framework that combines a Feature Tokenizer Transformer (FT-Transformer) with Extreme Gradient Boosting (XGBoost) to accurately predict the electromagnetic spectral response of TFsurfaces from structural parameters. Structure-frequency joint inputs are encoded by the FT-Transformer to capture complex nonlinear feature interactions; the resulting deep embeddings are then concatenated with original structural parameters and fed into XGBoost for regression. Evaluated on an independent test set, the proposed model achieves an (R^{2}) of 0.9985 and an MSE of (1.8 \times 10^{-5}), outperforming single-model baselines. This data-driven framework significantly accelerates the design of high-sensitivity THz detectors and offers a scalable solution for complex metasurface optimization.

W3: Workshop: Recent Advancement in Emerging Materials and Processing Technologies

Room: Michaelmus A

Chairs: Chenhao Chu (ETH Zurich, Switzerland), He Zhu (Charles Darwin University, Australia)

High-Tc Superconducting Monolithic Microwave Integrated Circuits (MMICs) for High-Sensitivity RF Receivers

He Zhu (Charles Darwin University, Australia)

High-temperature superconducting (HTS) technologies have many potential applications, such as power transmission, medical imaging, quantum computing, military and aerospace, etc., due to their significant advantages of high energy efficiency, easy cooling as well as high reliability and stability. High-temperature superconducting technologies also play a critical role in wireless communications as they offer unique advantages for applications in high-frequency electromagnetic domains. High-sensitivity and broadband nature of superconducting devices can be applied for high-speed wireless communication systems, especially the heterodyne mixers are highly desirable for high-gain and low-noise RF receivers. This talk will introduce a series of monolithic microwave integrated circuits (MMICs), mainly heterodyne mixers and on-chip antennas, which are used in microwave and millimeter-wave RF receivers. The MMIC mixers are developed based on the quantum tunnelling effect of Josephson junctions and will significantly reduce power consumption and enhance the sensitivity of RF receivers. Besides, advanced antenna technologies, including the packaging techniques of a high-gain waveguide antenna with MMICs and a frequency-scanning leaky-wave antenna, will also be touched in this talk.

Presenter bio: He Zhu is a currently a Lecturer in Charles Darwin University, Australia. He served as a Research Scientist in the Electromagnetic Systems and Devices Group of CSIRO, Australia, from 2023 to April 2026. He was a Postdoctoral Research Fellow and then a Chancellor's Research Fellow with the Global Big Data Technologies Centre at the University of Technology Sydney from 2017 to 2023. Dr Zhu is now a Senior Member of IEEE and serving as an Associate Editor for Microwave and Optical Technology Letter (MOTL) and a reviewer for multiple prestigious journals.

Multi-Function Multi-Band Reconfigurable High-Q Filters

Raafat R. Mansour (University of Waterloo, Canada)

Reconfigurable filters are key components in the development of agile multi-standard receivers.. This talk starts by addressing the needs for using multi-band and tunable filters in wireless communication systems and in flexible satellite payloads. It then addresses existing tuning technologies, providing a comparison between piezoelectric, Semiconductor, MEMS and PCM tuning elements in terms of linearity, insertion loss, suitability for use at millimeter-wave frequencies and ease of integration with high-Q filters. It outlines major design considerations for tunable filters presenting techniques to realize tunable filters with an absolute constant absolute bandwidth and a constant frequency spacing between transmission zeros, over a wide tuning range. The talk also illustrates examples of tunable filters and diplexers tuned only a by single tuning element, while exhibiting a constant absolute bandwidth. It then addresses approaches for realizing multi-band filters including dual-band and triple-band filters. Finally, it presents techniques for realizing multi-band filters where the various bands are tunable in both center frequency and bandwidth. Very recent work on realizing reconfigurable acoustic filters is also presented.

Wednesday, July 22 5:00 - 6:30

Welcome Reception @ Roof Top Pool Deck

Room: Michaelmus A, Michaelmus B, Reef, Urchins 2

Thursday, July 23

Thursday, July 23 9:00 - 9:45

K2: Keynote: Reconfigurable Microwave and Millimeter-Wave Devices Enabled by Phase-Change Materials, BST and Liquid Crystal Technologies - Raafat Mansour

Raafat Mansour

Room: Michaelmus A, Michaelmus B

Chair: Yang Yang (University of Technology Sydney, Australia)

The ability to dynamically reconfigure RF front ends allows a single hardware platform to accommodate multiple operating bands, communication protocols, adaptive beamforming, and efficient spectrum utilization. This multifunctional approach minimizes hardware complexity while reducing size, weight, power, and cost. The successful implementation of such systems depends on the availability of advanced switching and tuning technologies. The presentation will address the applications of Phase Change Material (PCM) switches to the realization of switch matrices, phase shifters, variable attenuators, and reflective intelligent surfaces (RISs). The presentation will further highlight the complementary capabilities of barium strontium titanate (BST) and liquid crystal (LC) technologies for realizing continuously tunable microwave and millimeter-wave components. Recent results on chip-scale millimeter-wave phase shifters employing BST and LC will be presented, illustrating how these technologies provide low-power analog tuning that complements the discrete, non-volatile reconfiguration offered by the PCM technology.

Thursday, July 23 9:45 - 10:45

P3: Semi-Plenary 3

Room: Michaelmus A

Chair: Amir Ebrahimi (RMIT University, Australia)

Semiconductor Electronics for High Power/High Speed Reconfigurable RF and Microwave Electronics

Robert Caverly (Villanova University, USA)

Microwave and RF design engineers always seek to develop a design that will meet specifications the first time that the circuit is fabricated. To do so requires that as many elements and phenomenon as possible associated with the control devices and circuit be accurately modeled. In the case of the microwave and RF semiconductor control circuits, accurate modeling of the solid-state control components over frequency, voltage, current and power is key to successful control system design. This talk will cover material that will provide the RF and microwave design engineer insight into the physical operation and modeling of semiconductor devices for high-speed reconfigurability: PIN diodes and field-effect transistors (FETs) as control components and their use in microwave and RF control circuits. The talk will briefly cover basic RF and microwave control circuits for reconfigurable electronics, and then focus on linear and nonlinear models for PIN diode, MESFET and MOSFET control elements to implement these circuits. The talk will conclude with control circuit examples using these models for use in reconfigurable RF and microwave electronics.

Presenter bio: Dr. Robert H. Caverly received his Ph.D. degree in electrical engineering from The Johns Hopkins University, Baltimore, MD, in 1983. He is currently with the Department of Electrical and Computer Engineering since 1997 and is a Professor Emeritus. r. Caverly's research interests are focused on the characterization of semiconductor devices such as PIN diodes and FETs in the microwave and RF control environment for communication and biomedical applications. He has published more than 200 journal, conference and editorial papers, and is the author of the books Microwave and RF Semiconductor Control Device Modeling and CMOS RFIC Design Principles, both from Artech House. An IEEE Life Fellow, Dr. Caverly is currently the Editor in Chief of the IEEE Microwave Magazine.

Filters for Space Applications: CNC Milling and Additive Manufacturing Perspectives

Cristiano Tomassoni (University of Perugia, Italy)

High-performance waveguide filters are critical components in space communications, where mass reduction and signal integrity are paramount. This presentation explores the design and realization of these devices, comparing traditional high-precision CNC milling with emerging Additive Manufacturing techniques. By evaluating experimental results, we analyze how different fabrication perspectives influence design flexibility, surface roughness, and overall RF performance in demanding space environments.

Presenter bio: Cristiano Tomassoni received the Ph.D. degree in electronics engineering from the University of Perugia, Italy, in 1999. Since 2007, he has been an Assistant Professor with the University of Perugia. His main area of research concerns the modeling and design of waveguide devices and antennas. He is a member of the MTT-8 Filters and Passive Components Technical Committee of the IEEE Microwave Theory and Technique Society (MTT-S). Prof. Tomassoni was the recipient of the 2012 Microwave Prize presented by the IEEE Microwave Theory and Technique Society.

P4: Semi-Plenary 4

Room: Michaelmus B

Chair: He Zhu (Charles Darwin University, Australia)

A Review of Microwave Beam-Steering Using near-Field Metasurfaces

Karu Esselle (University of Technology Sydney, Australia)

Since its seminal publication in 2017, The Near Field Meta-Steering (NFMS) technology, which is also known as Near-Field Phase Transformation or Risley Prism Method, has become popular worldwide to find solutions to beam-steering challenges from microwaves through millimeter-wave to Terahertz, in both academia and industry. Especially it has significant advantages over alternatives at millimeter-wave, sub-Terahertz and Terahertz frequencies in which alternative methods for steering narrow beams have significant challenges. Another advantage is its very high radio-frequency efficiency relative to alternatives when steering high power microwave beams. This invited semi-plenary speech will review the progress of this technology since its invention, and outline what can be expected in the future.

Printable Nonlinear Tags and Handheld Devices for Clutter-Resilient Contactless Monitoring and Tracking

Changzhi Li and Leya Zeng (Texas Tech University, USA)

This talk presents the development of printable nonlinear passive tags and portable harmonic radar systems for clutter-resilient contactless monitoring and tracking across object localization and biomedical sensing applications. The research integrates compact nonlinear tag design, scalable fabrication strategies, and high-linearity harmonic radar architectures operating at 4-8 GHz and 8-16 GHz. By exploiting second-order harmonic generation from passive diode-based tags, the system selectively detects nonlinear responses while inherently rejecting linear environmental reflections, enabling reliable operation in electromagnetically complex and motion-rich environments.

At the tag level, lightweight, battery-less nonlinear transponders were designed using Schottky diodes embedded within dipole-based and multi-element antenna geometries optimized for harmonic radiation. Early prototypes were fabricated using laser-cut masks and conductive coatings, enabling rapid, low-cost implementation of passive tags capable of meter-scale detection without onboard power. Multi-element configurations increased effective aperture and enhanced harmonic signal strength, significantly improving signal-to-noise ratio. Subsequent implementations advanced toward inkjet-printed and materials-dispensed structures on flexible substrates such as paper and PET, producing compact millimeter-scale tags suitable for conformal attachment to curved surfaces, including the human chest. Full-wave electromagnetic simulations were employed to optimize impedance matching, radiation characteristics, and antenna-diode integration at both fundamental and harmonic frequencies, ensuring efficient nonlinear conversion and stable backscatter performance.

At the system level, two harmonic radar platforms were developed. The 4-8 GHz harmonic radar system transmits a 4 GHz fundamental tone and receives the 8 GHz second harmonic generated by the nonlinear tag. The architecture incorporates frequency multiplication, cascaded filtering, and carefully distributed amplification stages to maintain transmit-receive isolation and suppress harmonic leakage. The 8-16 GHz harmonic radar system follows the same nonlinear detection principle, transmitting at 8 GHz and receiving at 16 GHz. Implemented on a multilayer PCB platform, this configuration employs high-linearity gain stages, low-pass and high-pass filtering networks, and coherent down-conversion to baseband for signal processing. Both systems operate in continuous-wave mode and emphasize spectral purity and harmonic isolation to ensure robust detection of weak nonlinear returns.

For biomedical applications, battery-free wearable tags attached beneath clothing enabled accurate, noninvasive respiratory monitoring with strong agreement with ground-truth measurements, even in the presence of nearby moving subjects and high radar cross-section reflectors. Beyond healthcare, the same nonlinear tagging principle supports lightweight object localization and tracking without onboard power.

Collectively, this presentation establishes a scalable framework that combines printable nonlinear tags with compact harmonic radar devices, enabling selective clutter-resilient detection for healthcare monitoring, asset tracking, search applications, and emerging nonlinear IoT sensing systems.

Presenter bio: Changzhi Li received the B.S. degree in electrical engineering from Zhejiang University, China, in 2004, and the Ph.D. degree in electrical engineering from the University of Florida, Gainesville, FL, in 2009. He is a Professor at Texas Tech University. His research interest is microwave/millimeter-wave sensing for healthcare, security, energy efficiency, structural monitoring, and human-machine interface. Dr. Li is an IEEE Microwave Theory and Techniques Society (MTT-S) Distinguished Microwave Lecturer, in the Tatsuo Itoh class of 2022-2024. He was a recipient of the IEEE MTT-S Outstanding Young Engineer Award, the IEEE Sensors Council Early Career Technical Achievement Award, the ASEE Frederick Emmons Terman Award, the IEEE-HKN Outstanding Young Professional Award, and the NSF Faculty Early CAREER Award. He is a Fellow of the National Academy of Inventors.

Thursday, July 23 11:15 - 12:30

BPC: Ask Us Anything

Broadening Participation Committee: Ask Us Anything

Room: Michaelmus A

Chair: Sulekha Chattopadhyay (Chattopadhyay, USA)

S13: Metamaterials and Metasurfaces II

Room: Reef

Chair: Geng-Bo Wu (City University of Hong Kong, Hong Kong)

Terminating Magnetostatic Surface Waves with Metallic Patterns

Zequn Zeng (National University of Singapore, Singapore); Si-Ping Gao (Nanjing University of Aeronautics and Astronautics, China); Yongxin Guo (City University of Hong Kong, Hong Kong)

Magnetostatic surface waves (MSSWs) have been widely utilized in microwave ferrite devices due to their nonreciprocal propagation and ease of excitation. Conventional MSSW-based devices typically employ a single propagation channel. However, as microwave ferrite devices move toward higher integration density and multi-channel operation, unwanted reflections within a single MSSW channel and coupling between adjacent channels can lead to signal interference and performance degradation. Therefore, effective suppression of MSSW reflections and isolation between channels become crucial. In this paper, MSSW termination using metallic patterns is proposed to achieve both reflection suppression and inter-channel isolation. The termination mechanism is analyzed based on the dispersion relation of MSSWs. Bowtie- and zigzag-shaped metallic patterns are introduced to redirect waves and achieve MSSW termination. A test device incorporating two MSSW channels is designed and fabricated for validation. Measurement results confirm that the proposed structures effectively suppress reflections within a channel and reduce coupling between adjacent MSSW channels.

Ultra-Wideband Energy Selective Surface Based on Symmetrical Bow-Tie Topology for High-Power Electromagnetic Protection

Tianyu Shi, Shaobin Liu and Meng Xing (Nanjing University of Aeronautics and Astronautics, China)

This paper presents an ultra-wideband (UWB) millimeter-wave energy selective surface (ESS) designed for adaptive electromagnetic protection in complex environments. The core innovation lies in the utilization of a symmetrical bow-tie topology that achieves an exceptionally broad transmission window. By loading adaptive GaAs PIN diodes at the center of the resonators, the surface dynamically reconfigures its impedance based on the incident power level. Simulation results demonstrate that the ESS provides a low-insertion-loss (IL < 1 dB) transparent window from 4 GHz to 16.7 GHz. Under high-power microwave (HPM) incidence, the surface provides robust shielding effectiveness (SE) exceeding 10 dB from 4 GHz to 12 GHz. The proposed ESS effectively balances the requirements of wideband communication and high-intensity interference mitigation.

Reflection-Type TTD Phase Shifter Based on Propagation-Controlled Reflective Loading

Yang Xu (University of Technology Sydney, Australia); He Zhu (Charles Darwin University, Australia); Yang Yang (University of Technology Sydney, Australia)

This paper presents a reflection-type true time-delay (TTD) phase shifter based on propagation-controlled reflective loading, combining the compactness of conventional reflection-type phase shifters with frequency-linear phase response. By switching the electrical length of short-circuited reflective transmission lines, the proposed architecture achieves a constant group delay, satisfying the fundamental TTD condition. Simulated results across 3GHz-8 GHz demonstrate maximum phase range exceeding 360 deg, group delay variation within 20 ps, insertion loss below 0.3 dB, and return loss exceeding 10 dB.

Presenter bio: He Zhu is a currently a Lecturer in Charles Darwin University, Australia. He served as a Research Scientist in the Electromagnetic Systems and Devices Group of CSIRO, Australia, from 2023 to April 2026. He was a Postdoctoral Research Fellow and then a Chancellor's Research Fellow with the Global Big Data Technologies Centre at the University of Technology Sydney from 2017 to 2023. Dr Zhu is now a Senior Member of IEEE and serving as an Associate Editor for Microwave and Optical Technology Letter (MOTL) and a reviewer for multiple prestigious journals.

Presenter bio: Dr Yang received PhD in Electrical and Computer System Engineering in 2013 from Monash University and currently is working as a research assistant at Monash University Clayton Campus. Dr Yang has published 2 book chapters 5 international journals and 6 international conference papers during the past 4 years. His major reserach interests are microwave and electronics active and passive component and system level designs.

A Wideband Ultra-Large-Angle Dual-Polarized Bandpass Frequency Selective Surface

Jiaxin Wang and Xin Xiu (South China University of Technology, China); Ye Han (Nanjing University of Posts and Telecommunications, China); Bao Wang (AVIC Research Institute for Special Structures of Aeronautical Composites, China); Mengzhu Yan and Wenquan Che (South China University of Technology, China)

This work proposes a wideband dual-polarized bandpass frequency selective surface (FSS) with ultra-large-angle stability for application scenarios under large-angle incidence. To overcome the inherent TE-TM wave impedance mismatch at large incident angles, a polarization-decoupling design methodology is employed. Based on this strategy, individual TE- and TM-polarized FSSs are developed, featuring stable wideband performance across 0-75° incidence and low cross-polarization interference. The desired dual-polarized FSS is then obtained by orthogonally combining the two types of FSSs, and further dimensional adjustment ensures an excellent polarization consistency in both transmission magnitude and phase. Simulation results show that across 45-75° incidence, the proposed FSS achieves a dual-polarization −3-dB passband of 7-13 GHz (60%), with a transmission phase difference of less than 25° between TE and TM polarizations. These simulations effectively validate the feasibility and superiority of the proposed design strategy.

Design of 3-D Frequency Selective Surface Based on Spatial Coupling

Jun Ma, Kai-Ran Xiang, Zhihong Tu and Fu-Chang Chen (South China University of Technology, China)

In this paper, spatial coupling is introduced in the design of a three-dimensional (3-D) bandpass frequency selective surface (FSS). The 3-D configuration naturally establishes additional spatial coupling paths among the ports and resonators. As a result, both the source and load are coupled to each resonator as well as to each other, allowing an N-th-order FSS to generate N transmission zeros (TZs). This behavior enhances the TZ generation capability compared with conventional filter synthesis theory. To demonstrate this concept, a third-order 3-D FSS is designed, which exhibits three TZs. The resonant elements are realized using microstrip resonators, leading to a compact implementation with structural simplicity. The simulated results confirm the feasibility of incorporating spatial coupling into the design of 3-D bandpass FSSs

Presenter bio: Jun Ma was born in Shuangyashan, Heilongjiang, China. He received the B.S. degree from the South China University of Technology, Guangzhou, China, in 2022, where he is currently pursuing the Ph.D. degree with the School of Electronic and Information Engineering.His research interests include the synthesis theory, reflectionless antenna, and filtering antenna.

S22: Antenna Arrays and Beamforming I

Room: Urchins 2

Chairs: Xiaoxuan Guo (University of Technology Sydney, Australia), Qing You (University of Macau, Macao)

Invited Talk: Plasma-Based Reconfigurable FSS for Adaptive High-Power Microwave Shielding

Krushna Kanth Varikuntla (Queen's University Belfast, United Kingdom (Great Britain) & Queens's University Belfast, United Kingdom (Great Britain)); Okan Yurduseven (Queen's University Belfast, United Kingdom (Great Britain)); Muhammad Ali Babar Abbasi (Queen's University Belfast & Centre for Wireless Innovation (CWI), United Kingdom (Great Britain))

This invited talk provides a focused overview of plasma-based reconfigurable frequency selective surfaces (FSS) for adaptive high-power microwave (HPM) shielding. Unlike conventional metallic FSS, plasma elements exhibit inherently power-dependent behaviour, enabling self-actuated reconfiguration without dedicated DC bias networks. We outline how plasma confined in commercially available gas-discharge tubes (GDTs) can be modelled as a dispersive medium, and highlight the key design levers: collision frequency primarily governs loss and reflectivity (with reduced pressure improving selectivity), while electron density drives tunability toward a highly conductive state.

Building on these fundamentals, two experimentally validated FSS architectures are presented, supported by equivalent-circuit modelling and full-wave simulations. A double-layer GDT-loaded FSS provides a wide, flat-top bandpass centred at 4 GHz with low insertion loss in the low-power state, then transitions to strong isolation at high power due to resonance-driven field enhancement and plasma ignition. A second, cross-topology energy-selective surface autonomously shifts its stopband from 6 GHz (OFF) to 3 GHz (ON) without external bias. Waveguide measurements up to 50 dBm confirm robust high-power handling, alongside stable performance under oblique incidence and pressure-dependent quality factor. These results position plasma-FSS as a practical route to adaptive electromagnetic protection for satellite and aeronautical platforms, telecom infrastructure, and high-power medical and industrial environments.

A Reconfigurable Transmit-Reflect-Array Antenna Based on Tightly Coupled Dipole

Shangsen Huang, Wei Hu, Yuchen Gao and Zhaoling Wang (Xidian University, China)

This paper presents a reconfigurable tightly coupled transmit-reflect-array (TRA) antenna for broadband wireless communication applications. The antenna features an active unit cell comprising tightly coupled dipole elements interconnected by PIN diodes and a polarizer grid for polarization selection, facilitating 1-bit phase reconfiguration. The reflection layer operates in reflection mode for x-polarized waves, while the transmission layer operates in transmission mode for y-polarized waves. By employing different coding sequences to control the ON and OFF states of the PIN diodes, the reflection and transmission phases can be precisely configured, enabling accurate independent beam steering at desired angles. With an F/D ratio of 0.8 and a 16×16 element array, the antenna achieves high gain and low sidelobe levels for both polarization modes. This reconfigurable TRA antenna is ideally suited for advanced wireless communication systems requiring simultaneous dual-mode operation.

Presenter bio: Wei Hu received the Ph.D. degree in electromagnetic fields and microwave technology from Xidian University, China, in 2013. From 2018 to 2019, he was an Academic Visitor with the School of Engineering from the University of Kent, U.K. He is currently a Full Professor with the National Key Laboratory of Radar Detection and Sensing, Xidian University. His research interests include broadband/multiband antennas, terminal antennas, conformal arrays, and wideband wide-scanning phased arrays.

Reconfigurable Bandpass Ultrathin Angular-Selective Surfaces

Hao Jiang (City University of Hong Kong, Hong Kong); Mei Qian (South China University of Technology, China)

This work proposes an ultrathin bandpass angularselective surface (ASS). Unlike most previously reported structures relying on multilayer configurations, the proposed design employs a metallic pattern printed on a single substrate, resulting in a significantly reduced profile. The operating mechanism is interpreted using an equivalent circuit model in which the incident angle is treated as the independent variable to realize the desired angular-domain bandpass response. Full-wave simulations demonstrate that the passive ASS achieves angularselective filtering over a wide incidence range within the operating band. Moreover, a reconfigurable ASS is realized by integrating PIN diodes into the metallic-slot structure, enabling dynamic switching between bandpass and stopband states.

Presenter bio: Hao Jiang (Graduate Student Member, IEEE) was born in Macheng, Hubei, China. He received his M.S. degree from the University of Electronic Science and Technology of China (UESTC), Chengdu, China, in 2021. Since 2022, he has been pursuing his Ph.D. degree at the South China University of Technology (SCUT), Guangzhou, China. Since 2025, he has been a Visiting Ph.D. Student at the National University of Singapore (NUS), Singapore. He has authored or co-authored over 30 peer-reviewed journal and conference papers. His research interests include RF front-end circuits and systems, satellite communication (SATCOM) phased-array transceivers, and metamaterials. Mr. Jiang served as an IEEE MTT-S Student Ambassador in 2023. He has received numerous awards and scholarships, including the Honorable Mention Award at the 2022 IEEE MTT-S IMWS-AMP, the First Prize in the Best Student Paper Award at the IEEE RFIT 2024, three consecutive recipients of the Chinese National Scholarship for Doctoral Students (from 2023 to 2025), three consecutive recipients of the SCUT Principal Scholarships (from 2023 to 2025), an IEEE MTT-S Graduate Fellowship for 2025, and the Best Applied Antenna Technology Paper

Modal Expansion Analysis and Inverse-Design of Reconfigurable AIS-Loaded Antennas

Mengyuan Bie and Zhi Hao Jiang (Southeast University, China)

This paper presents two reconfigurable antennas loaded with anisotropic impedance surfaces. The first one achieves reconfigurable frequency and bandwidth with a 76.6% tuning range in the narrowband mode and 82.9% bandwidth in the wideband mode. The second antenna features 360° beam scanning with a step of 11.25° in the S-band. A semi-analytical mode expansion method is developed for the inverse-design of these two antennas by predicting accurate impedance bandwidth and radiation patterns.

A Data-Efficient and Physics-Constrained Deep Learning Framework for Reflectarray Antenna Inverse Design

Qinghua Liu and Xue Ren (Shenzhen University, China)

A physics-guided Conditional Variational Autoencoder (cVAE) framework for the rapid inverse design of high-aperture-efficiency reflectarray antennas is proposed in this paper. Addressing the ill-posed nature of mapping electromagnetic responses to complex topologies, we incorporate structural symmetry, manufacturability constraints, and morphological filtering as prior rules to regularize the unit topology and enhance dataset quality. A high-precision Residual Network (ResNet), is embedded into the cVAE loop to enforce physical consistency, is trained as a forward proxy to replace time-consuming full-wave simulations. In this way, model efficiency enhancement is achieved through the regularized unit design, while antenna efficiency is ensured by the accurate proxy-constrained generative model. To validate the method, an 18×18 element reflectarray operating at 10 GHz is designed. Full-wave simulations demonstrate a realized gain of 23.9 dB, a sidelobe level of −19.6 dB, and an aperture efficiency of 60.4%. The proposed approach accelerates design iterations while maintaining engineering feasibility, providing a practical tool for advanced metasurface systems.

S4: Terahertz Technologies and Systems II

Room: Michaelmus B

Chair: Zhaomin Peng (National Space Science Center Chinese Academy of Sciences, China)

Semiconductor-grade Dry Nano-Island Coating Technology: Translating Advanced Materials from Lab Scale to Next-Gen 6G mm-Wave Substrates

Hung-Wei Wu, Shuai Sun and Muhammad Waqas (Institute of Semiconductors, Guangdong Academy of Sciences, China); Deniz Eren Erisen (Laboratory for New Materials in Nano and Millimeter Waves Institute of Semicondu, China)

This invited paper presents our recent progress in translating semiconductor-grade nano-island-coating technology into high-value functional materials for 6G millimeter-wave substrates. The core concept is to engineer silica-based carrier powder with PVD-based nanoscale Al-nanoparticle island coating, followed by controlled conversion into AlN/Al_2O_3 nanoparticle-island-coated fillers. These engineered fillers are integrated into a non-fluorinated thermoset composite system to achieve low dielectric constant, low loss tangent, and improved thermal/mechanical reliability for high-frequency substrate applications. By combining powder surface modification, vacuum mixing, tape casting, and vacuum hot pressing, the proposed platform provides a practical pathway from nano-engineered particles to the fabrication of 250 mm × 250 mm panel-scale substrates with thicknesses ranging from 100 µm to 100 mm. The target performance of the developed materials is Dk = 1.6-2.4 and Df < 0.0009 at 10 GHz, making them attractive for advanced RF packaging, satellite communications, radar sensing, and future THz devices. This work highlights how a coating-centered materials platform can bridge advanced processing, scalable manufacturing, and next-generation microwave system requirements.

D Band Terahertz Driving Source Based on GaN Monolithic Integrated Frequency Multiplier

YH Li, S Jun and XM Zheng (National Space Science Center Chinese Academy of Sciences, China); Dehai Zhang (National Space Science Center, China); Jin Meng (National Space Science Center, Chinese Academy of Sciences, China)

Terahertz technology, characterized by its extensive development potential and broad application prospects, has emerged as a significant trend in future technological development. The radio-frequency (RF) front - end of a terahertz superheterodyne receiver is predominantly comprised of a mixer and a local oscillator (LO). Consequently, the LO, serving as the core component of the RF front-end, is critical for ensuring the proper operation of the entire superheterodyne system. The solid-state terahertz LO, which typically utilizes a Schottky diode-based multiplier as its core component, offers notable advantages such as high reliability, room-temperature operation, simple architecture, and low cost. These characteristics have led to its application in various fields such as meteorological detection, radio astronomy, and security inspection, solidifying its status as a vital branch of terahertz source research. The architecture of a solid-state terahertz LO typically comprises a pre-stage driver source and a final-stage multiplier. Given that the driver source, as the initial part of the entire LO chain, mainly functions to supply input power to the final - stage multiplier in the chain, effectively enhancing its output power is of great significance. To enhance power-handling capacity and thermal-dissipation performance, a 120 GHz driver source based on a GaN monolithic integrated multiplier is developed. Due to the advantages of GaN material, such as high thermal conductivity, high voltage withstand capability and high electron saturation rate, when utilized in Schottky diodes for frequency doublers, its defect in electron mobility is avoided. For the research on the 120 GHz driver source based on GaN monolithic integrated frequency doubler, a reasonable overall link composition scheme is proposed. The overall frequency - generation chain adopts a frequency multiplication scheme of 10 GHz microwave signals through a x6x2

cascade. Through an analysis of GaN material properties and their applicability to doubler design, a novel GaN Schottky diode design is conceived. The Schottky barrier diodes applied to terahertz frequency doublers usually have a relatively high input power, and the internal self-heating effect is quite obvious. Under actual operating conditions, material properties such as electrical conductivity, thermal conductivity, and heat capacity for each diode layer will change with temperature. Meanwhile, the internal temperature and parameters such as current, parasitic capacitance and parasitic resistance will affect each other. Therefore, the saturation current and series resistance parameters in the commonly used SPICE model of Schottky diodes are not constant, but should be temperature-related variables. The intrinsic and extrinsic parameters of Schottky barrier diodes related to temperature change with the working state, which will have a significant impact on the I-V characteristics of the diode. Therefore, the study of the thermal effect of Schottky barrier diodes cannot be ignored, which is crucial for improving the accuracy of the Schottky barrier diode model. To this end, a thermal resistance matrix is integrated into the diode model. The physical electrothermal model is composed of the drift-diffusion equation and the heat conduction equation. Furthermore, analyze the impact of adjacent metallized components in the matching structure on heat dissipation. The design of the 120 GHz monolithic doubler adopts a balanced circuit structure, mainly consists of WR15 input waveguide, WR8 RF waveguide, GaN Schottky diode, DC bias filter and matching circuit structure. For the fundamental frequency matching network, matching performance is optimized by tuning the lengths of the reduced-height and reduced-width waveguide sections and the position of the input short-circuit termination. The optimal output impedance value extracted from the chip is substituted into the lumped port of the diode. For the design of the output end model, the bias circuit adopts an improved compact microstrip resonator (CMRC) filter, which has a more compact structure compared to the high and low impedance filters. This design effectively confines the second-harmonic signal to the output waveguide port while preventing it from leaking from the DC bias circuit, thus meeting the design requirements. The measured results demonstrate that incorporating the thermal resistance matrix into the core diode model significantly reduced the discrepancy between simulated and experimental results. Within the frequency range of 109-129 GHz, the maximum output power of the driver source measured is 35.56 mW. This research provides beneficial ideas for the manufacturing and design of Schottky diodes, and also lays a model foundation for the subsequent realization of high-performance terahertz frequency conversion devices.

Resonant Tunneling Diodes for Terahertz Sensing

Safumi Suzuki (Institute of Science Tokyo, Japan)

Resonant tunneling diodes (RTDs) can oscillate at frequencies exceeding 2 THz at room temperature and generate milliwatt-level output power above 800 GHz. In the frequency range above 300 GHz, RTDs have demonstrated relatively high DC-to-RF conversion efficiency compared with other electronic devices. RTDs also exhibit unique functionalities, such as frequency-comb generation and signal detection, which are useful for terahertz sensing applications. This paper reviews recent developments in RTD oscillators.

Presenter bio: Safumi Suzuki received the B.E. degree in Electrical and Electronic Engineering and the M.E. and D.E. degrees in Electronics and Applied Physics from the Tokyo Institute of Technology, Japan, in 2005, 2007, and 2009, respectively. From 2009 to 2014, he was an Assistant Professor with the Department of Electronics and Applied Physics, from 2014 to 2016, an Associate Professor with the Department of Physical Electronics, and from 2016 to 2024, an Associate Professor with the Department of Electrical and Electronic Engineering, Tokyo Institute of Technology, respectively. Since 2024, he has been a Professor with the Institute of Integrated Research, Institute of Science Tokyo. His research interests include terahertz electronic devices and applications.

Dual-Wideband Antenna Decoupling via Hybrid Conduction-Radiation Mitigation

Meng Xing, Shaobin Liu and Tianyu Shi (Nanjing University of Aeronautics and Astronautics, China)

This paper presents a hybrid decoupling strategy that synergistically integrates defected ground structures and metallic reflectors to address the strong long-distance mutual coupling problem in dual-antenna systems sharing a common ground plane over the 0.8-2.0 GHz band, where surface creeping waves dominate. Through full-wave simulations, we first characterize the surface current propagation on the metallic ground plane, identifying the central region between the two antennas as the critical coupling path. Based on this analysis, we design a transverse slotted defected ground structure (Mode 1) that perturbs the surface current distribution to effectively suppress low-frequency coupling. Concurrently, we introduce a folded metallic reflector (Mode 2) that modifies the propagation paths of high-frequency spatial waves, enhancing energy dissipation through reflection and phase manipulation. The synergistic integration of both mechanisms (Mode 3) is rigorously validated through full-wave simulations, demonstrating an average isolation enhancement exceeding 17 dB across the entire 0.8-2.0 GHz band. Our results reveal the complementary nature of the proposed approach: the defected ground structure outperforms the reflector at lower frequencies, while the reflector exhibits superior decoupling at higher frequencies. The combined strategy achieves broadband synergistic decoupling, offering a structurally simple and cost-effective engineering solution for high-isolation integration of multi-antenna systems on metallic platforms.

Thursday, July 23 12:30 - 1:45

Thursday, July 23 1:45 - 3:00

ISTP: Meet the Editors

Intersociety Technology Panel: Meet the Editors

Room: Michaelmus A

Chairs: Robert Caverly (Villanova University, USA), Imran Mehdi (Jet Propulsion Laboratory, California Institute of Technology, USA)

S14: Machine Learning in RF and Microwave Applications

Room: Reef

Chair: Qing You (University of Macau, Macao)

Surface Mount Radiator - Intelligent AiP for Physical AI and Edge Eevices

Yifan Wang (Millibeam, Australia)

The rapid growth of 5G/6G, satellite communications, and AI-enabled edge devices is driving strong demand for compact, high-efficiency, and scalable antenna platforms. This presentation presents recent developments in surface-mounted Antenna-in-Package (AiP) technologies at MILLIBEAM, focusing on antenna radiation engineering, low-profile array architectures, RF materials, and integrated packaging approaches. The presentation highlights how advanced surface-mounted AiP platforms can enable intelligent RF systems for next-generation wireless infrastructure, sensing, Physical AI, and edge applications through vertically integrated "Silicon to Intelligent RF Systems" design strategies.

A Classification of Scattering Characteristics for Typical Artificial Structures via Attention-Augmented Dual-Branch Convolutional Neural Network

Shuxin Wu, Yancheng Li, Meijun Qu and Jianxun Su (Communication University of China, China)

This paper presents a novel attention-augmented dual-branch convolutional neural network (DBA-Net) for classifying monostatic radar cross-section (RCS) characteristics of six typical artificial structures. A large-scale dataset is generated by computing full-azimuth RCS distribution and converting them into 2D heatmaps. The DBA-Net employs dual branches to extract multi-scale features and a dual-attention mechanism to focus on discriminative patterns. Experiments show the model achieves perfect classification accuracy with rapid convergence, demonstrating strong robustness and generalizability for intelligent electromagnetic target recognition.

Improved Hybrid Quantum Models for More Accurate Phase Prediction of Expansion Coefficients in Large Finite Periodic Structures

Bingbing Song, Zhuoyue Zhao and Tian Liu (Southeast University, China); Fei Guo (Southeaset University, China); Zijun Hu, Wu Yang and Wei Bing Lu (Southeast University, China)

Accurately and efficiently analyzing the electromagnetic characteristics of large finite periodic structures (LFPSs) has always been a challenging problem in computational electromagnetics. In the past decade, several artificial neural networks (ANNs) based studies have been proposed to alleviate this challenge. However, with the rapid development of quantum technologies, the performance of ANN-based predictive models still exhibits significant potential for further improvement. In this paper, the hybrid quantum model proposed in previous work is enhanced by incorporating the residual architecture, enabling more accurate prediction for the phase of the expansion coefficients in sub-entire domain basis functions. Numerical experiments demonstrate that the improved hybrid quantum model exhibits faster learning capability and higher prediction accuracy.

Machine Learning-Assisted End-to-End Synthesis of RF Transformer-Based Matching Networks

Tao Wang, Li Gao, Yao Fo Chen and Xiuyin Zhang (South China University of Technology, China)

This paper proposes a learning-driven synthesis framework for RF transformer-based matching networks with three-dimensional electromagnetic (EM) structures. Unlike conventional methods that derive EM structures from target circuit element values and topologies, the proposed method directly synthesizes passive networks from desired performance metrics and given topologies. Using on-chip transformer impedance matching networks as a case study, the model first extracts key features from input impedance and load capacitance via neural networks to predict initial geometric parameters of the transformer's 3D EM structure in 28-nm TSMC CMOS technology. Subsequently, Bayesian optimization (BO) refines these geometric parameters for precise performance tuning. The resulting structures achieve arbitrary impedance matching while simultaneously accommodating two load capacitances. As a proof of concept, multiple transformer designs were synthesized and validated by Cadence simulations, confirming their compliance with the targeted impedance characteristics.

S23: Terahertz Technologies and Systems V

Room: Urchins 2

Chair: Zong-Rui Xu (City University of Hong Kong, Hong Kong)

High Q Terahertz Detector in Hybrid Metal–Optical Tamm State Cavity

Zhanzhang Mai, Xuecou Tu, Bingnan Yan, Hongshan Jing, Dingxuan Gu, Yunjie Rui, Zeyu Xu, Cheng Liang, Baoran Lai, Xiaoqing Jia and Lin Kang (Nanjing University, China); Jian Chen (Nanjing University & Research Institute of Superconductor Electronics, China); Peiheng Wu (Nanjing University, China)

Terahertz optical cavity is one of the major elements to enhance and control the weak interaction between the atom-thick layer and normal incident terahertz light. Here we present a hybrid metal-optical Tamm state cavity with a Nb5N6 microbolometer detector embed, exhibiting a Q value of 1529 for direct detection. The cavity is formed by sandwiching a silicon substrate with the detector between two Si/air distributed Bragg reflectors (DBR), one of which is capped with an Au layer. The resonant frequency can be flexibly tuned by adjusting the substrate's thickness. The substrate and DBRs can be fabricated separately and assemble easily, which paves the way to effectively realize versatile high performance terahertz devices and strong interaction between terahertz light and matter.

A High-Performance Hybrid FBAR Chip Based on TGV Technology

Keyan Li and Yongle Wu (Beijing University of Posts and Telecommunications, China); Zhiguo Lai and Qinghua Yang (HunterSun Electronics Company Ltd., China); Weimin Wang (Beijing University of Posts and Telecommunications, China)

In this paper, a hybrid chip combining a film bulk acoustic resonator (FBAR) chip and a glass-based integrated passive device (IPD) chip is proposed. The inductors in the hybrid circuit are implemented using through-glass via (TGV) as vertical spiral inductors. Such implementation can provide a high-Q inductor compared to a conventional planar spiral inductor, but also decrease the influence between the vertically stacked chips. Compared with the filter chip based on the same circuit implemented by conventional Si-based IPD technology, the insertion loss of the hybrid chip is lower while showing higher integration.

Geometry Scalable Model of on-Chip Multilayer Interdigital Capacitors

Yiwen Liu, Huanpeng Wang, Yunqiu Wu, Jie Liu, Huihua Liu, Yiming Yu, Chenxi Zhao, Qingfeng Zhang and Kai Kang (University of Electronic Science and Technology of China, China)

Interdigital capacitors, composed of multiple metal layers, exhibit superior performance in compact form due to their high integration. In this paper, a scalable equivalent circuit model tailored for multilayer interdigital capacitors is proposed. The circuit parameters are accurately derived and the characteristics can be predicted based on the finger dimensions. The accuracy of the scalable model has been validated with an accuracy exceeding 92% across a frequency range of up to 40 GHz. This makes it highly significant for the modeling of on-chip passive devices.

High-Tc Superconducting Josephson Mixers from X- to Sub-THz Band

He Zhu (Charles Darwin University, Australia)

This talk presents a unified approach to the design and integration of high-temperature superconducting (HTS) Josephson mixers across microwave, millimetre-wave, and sub-terahertz frequencies. A systematic design methodology is developed, combining circuit modelling, impedance matching, harmonic mixing techniques, and experimental validation to ensure predictable and scalable performance. The study emphasizes the importance of optimising Josephson junction parameters and demonstrates how accurate modelling can bridge the gap between simulation and measurement. Beyond circuit design, the work introduces advanced integration strategies, including compact waveguide transitions and antenna-coupled architectures, enabling efficient coupling between superconducting devices and radiating structures. By combining harmonic mixing concepts with frequency-scanning antenna technologies, the research establishes a pathway toward compact, low-noise, and energy-efficient superconducting receiver systems. The results provide a foundation for scalable HTS mixer technologies suitable for high-sensitivity communication, sensing, and imaging applications from microwave to sub-terahertz regimes.

Presenter bio: He Zhu is a currently a Lecturer in Charles Darwin University, Australia. He served as a Research Scientist in the Electromagnetic Systems and Devices Group of CSIRO, Australia, from 2023 to April 2026. He was a Postdoctoral Research Fellow and then a Chancellor's Research Fellow with the Global Big Data Technologies Centre at the University of Technology Sydney from 2017 to 2023. Dr Zhu is now a Senior Member of IEEE and serving as an Associate Editor for Microwave and Optical Technology Letter (MOTL) and a reviewer for multiple prestigious journals.

Metasurface Antenna Applied in Millimeter-Wave Imaging Systems

Panpan Zuo, Lan Longpeng, Keyan Wei and Bin Gao (Civil Aviation University of China, China); Xiaoxuan Guo (University of Technology Sydney, Australia); Lei Yang (Civil Aviation University of China, China)

This paper presents the design of a Ku-band metasurface antenna for near-field millimeter-wave radar imaging. The proposed antenna features a three-layer structure. The slot-coupling feeding network integrating a Wilkinson power divider is employed to ensure amplitude and phase consistency across all radiating elements. Simulation results demonstrate that the antenna achieves a compact profile with an average gain exceeding 11 dBi and a 3-dB beamwidth confined within 35° across the Ku-band, fully satisfying the requirements for high-precision near-field millimeter-wave imaging, and the proposed digital imaging system based on metasurface antenna is expected to play a greater role as a key solution in next-generation personnel security screening and non-destructive testing.

S5: CMOS and BiCMOS Power Amplifiers III

Room: Michaelmus B

Chair: Fatemeh Norouzian (University of Birmingham, United Kingdom (Great Britain))

A 30-W Tri-Mode GaN Power Amplifier Based on Reconfigurable Multi-Network Architecture

Tang Bowen, Chi Chen, Zhan Zhao and Yuehang Xu (University of Electronic Science and Technology of China, China)

This paper presents a fully integrated 30-W tri-mode gallium nitride (GaN) high power amplifier (HPA) supporting ultra-wideband (0.03-6.5 GHz), single-narrowband (SNB) (2.7-3.3 GHz), and concurrent dual-narrowband (DNB) operation. A dual-path single-transistor-driven distributed architecture with a shared-drain artificial transmission line enables broadband power combination. Frequency reconfiguration is achieved through gate artificial transmission lines, while switchable harmonic tuning enhances narrowband efficiency.

The PA achieves over 44.8 dBm saturated output power across UWB and up to 53% peak power-added-efficiency (PAE) in SNB mode. Fabricated in 0.25-μm GaN-on-silicon carbide (SiC) process, the design maintains high efficiency under continuous-wave operation.

[A Fully Integrated Low-Cost 5-GHz Doherty Power Amplifier Using Compact Triple-Coil Splitter-Combiner in 180-nm CMOS]

Zhuoyin Chen, Yongle Wu, Shuchen Zhen, Zhixuan Gong, Xiaopan Chen and Weimin Wang (Beijing University of Posts and Telecommunications, China)

This paper presents a 5-GHz Doherty power amplifier (PA) implemented in a cost-effective 180-nm 1P6M CMOS technology with only one ultra thick metal (UTM) layer. To enable practical integration in legacy nodes with limited passive quality factors, an integrated transformer-based triple-coil network is adopted to realize signal splitting and load combining within a unified passive structure, reducing interconnection complexity and layout parasitics. The PA employs a differential cascode architecture with double neutralization to enhance gain and stability. Designed for 5-GHz applications, the simulated results show a small-signal gain of 12.7 dB, a PSAT of 21.4 dBm, a PAEmax of 23.0%, and a PAE6dB of 13.8%. The core circuit area is 1.42 mm2.

[A Compact Wideband Filtering Power Dividers Using D-CRLH Resonators]

Xueyu Huang, Wenjie Feng, Wenquan Che, Kun Tang and Haoshen Zhu (South China University of Technology, China)

A design method for realizing a wideband filtering power divider (FPD) by adjusting the line-width of the resonators is proposed in this paper. Due to the slow-wave characteristic of the D-CRLH resonator, a compact circuit size is achieved. In addition, a stopband rejection exceeding 10f0 with a suppression level of better than 20 dB is realized by cascading a low-pass structure with the D-CRLH resonator. A wideband FPD with center frequency of 0.66 GHz and the fractional bandwidth of 44.2% is designed, fabricated and measured. The measured insertion loss is less than 4.05 dB and the isolation between two output ports is better than 21.5 dB from DC to 4.42 GHz (6.7f0). Simulated and measured results are in good agreement, validating the proposed approach

[Optimized Design of Compact Multi-Coil Arrays for Misalignment-Tolerant Wireless Power Transfer]

Zihang Huang and Jingchen Wang (Xi'an Jiaotong-Liverpool University, China); Zhao Wang (Xi'an Jiaotong Liverpool University & University of Liverpool, China); Rui Pei (Xi'an Jiaotong-Liverpool University, China); Bintao Hu (University of Liverpool, United Kingdom (Great Britain)); Wenzhang Zhang (Xi'an Jiaotong-Liverpool University, China & University of Liverpool, United Kingdom (Great Britain)); Qian Dong and Eng Gee Lim (Xi'an Jiaotong-Liverpool University, China)

While magnetic resonant wireless power transfer (WPT) offers significant convenience, its performance typically degrades under misalignments. To address this, an optimized hybrid multi-coil transmitter array was designed for enhanced robustness. The proposed approach optimizes the array topology by removing redundant, weakly coupled elements and incorporating auxiliary gap coils to bridge magnetic nulls. This structural refinement not only intensifies the magnetic field but also achieves a more uniform field distribution. Simulation results indicate that the proposed WPT link delivers a power transfer efficiency of 81% at a transfer distance of 30 mm, exhibiting high tolerance to lateral and angular offsets. This compact transmitter configuration provides a practical solution for maintaining high-efficiency power delivery in misalignment-prone near-field charging scenarios.

[Study on the Design of 50-75GHz Up-Conversion Module]

Hui Peng (Kashi University, China); Jincai Qiao (Chongqing Institute of Microelectronics Industry Technology, UESTC, China); Zuqiang Ou, Zhongqian Niu and Bo Zhang (University of Electronic Science and Technology of China, China); Ya Fei Wu (UESTC, China)

The up-conversion spread spectrum module, which can shift low-frequency signals to extremely high frequencies within the usable bandwidth, is a critical hardware component for enabling next-generation high-capacity communications, high-rate sensing, and other cutting-edge applications, and is of great significance to

modern communication. As the application frequency of electromagnetic waves extends into the millimeter-wave and even terahertz bands, the requirements for signal sources as signal testing instruments are also gradually increasing. There is an urgent need to extend measurement frequencies to higher bands, which can be achieved by integrating an up-converter at the front end of the system. This paper conducts research based on up-conversion technology for 50GHz to 75GHz broadband signals. Several key devices in the frequency conversion system were developed, including a wide-stopband waveguide filter for splitting the 50GHz to 110GHz signal and suppressing image frequency signals, and a local oscillator based on a frequency multiplier and amplifier module. A 50GHz to 75GHz broadband signal up-conversion system was also constructed to down-convert a 28.95GHz to 30.15GHz broadband signal to the 50GHz to 75GHz range. Experiments show that the output power of the up-converted signal is not less than 13 dBm, the link gain is not less than 20 dB, and the output spurious suppression is greater than 40 dBc, meeting the system specifications.

Thursday, July 23 3:30 - 5:00

Panel Discussion

Room: Michaelmus A

The 2026 IEEE MTT-S International Microwave Workshop Series on Advanced Materials and Processes for RF and THz Applications (IMWS-AMP) includes a dedicated panel discussion featuring nine recognized researchers in electromagnetic engineering.

This panel convenes IEEE Fellows, MTT-S leadership, journal Editors-in-Chief, and specialized researchers to discuss current technical parameters and future implementations in the field. The participating panelists are: Prof. Kamran Ghorbani, Prof. Ke Wu, Prof. Quan Xue, Prof. Anding Zhu, Prof. Almudena Suárez Rodriguez, Prof. Qiaowei Yuan, Prof. Wenquan (Cherry) Che, Prof. Rodica Ramer, and Prof. Malgorzata Celuch.

Collectively, these panelists possess extensive empirical and theoretical backgrounds across multiple relevant disciplines. Their technical expertise encompasses microwave and millimeter-wave circuits, terahertz integration, non-linear modeling of RF systems, wireless power transfer, adaptive array antennas, and numerical methods for computational electromagnetics. Their research output directly supports application areas such as 5G/6G mobile communications, radar systems, microwave photonics, and substrate-integrated waveguides.

This session is designed to provide attendees with a structured, objective analysis of the practical development and physical realization of advanced RF and THz systems directly from the individuals guiding current research, system integration, and publication standards.

S15: Dielectric and Magnetic Materials

Room: Reef

Chair: David Mitchell (University of Illinois at Urbana-Champaign, USA)

Formula-Based Design of Bias Tees with Wide DC-Path Bandwidth and Transmission Zeros

Keebaek Lee, Jongheun Lee and Juseop Lee (Korea University, Korea (South))

This paper presents a formula-based synthesis and design method for bias tees capable of superimposing low-frequency AC signals onto DC path while maintaining sharp frequency selectivity. By modeling the bias tee as a parallel connection of lowpass and highpass sections, closed-form expressions are derived to directly relate the element values of the RF path highpass section to those of the DC path lowpass section, allowing systematic circuit synthesis with reduced design complexity. The proposed approach enables the introduction of finite-frequency transmission zeros, resulting in a steep skirt response beyond those of conventional first-order bias tees. The fabricated prototype demonstrates an RF insertion loss better than 1 dB above 2.7 GHz and maintains acceptable matching.

Electromagnetic-Thermal-Fluid Multiphysics Coupling Simulation of Electronic Packaging Based on the FDTD Method

Yan Peng, Guo Song, Tiancheng Zhang, Huaguang Bao and Dazhi Ding (Nanjing University of Science and Technology, China)

This paper focuses on the transient electromagnetic-thermal-fluid coupling analysis of microchannel cooling in electronic packages using the finite difference method. Complex geometric models are comprehensively modeled and analyzed, with numerical discretization and iterative computation implemented through the finite difference scheme. The effectiveness and efficiency of the proposed method are validated through case studies and comparisons with the commercial software COMSOL.

Rapid Analysis of Scattering Problem for LFPSs with Physics-Informed Attention Network

Tian Liu (Southeast University, China); Fei Guo (Southeaset University, China); Wenzhe Song (Southeast University, China); Yanzhe Luo (Southeaset University, China); Wu Yang and Wei Bing Lu (Southeast University, China)

In this work, a physics-informed attention network (PIAN) is proposed for the rapid analysis of scattering problems in large-scale finite periodic structures (LFPSs). The encoder captures the relationship between array features and global coupling with self-attention mechanism, which guides the decoder to generate the final current coefficients of LFPSs based on the NASED initial current coefficients with cross-attention mechanism. The introduction of initial current coefficients enables the characterization of cell structure for different cells. The well-trained network can generalize to various cell structures, which significantly reduces the cost of dataset generation. Numerical experiments validate the accuracy, generalization capability, and efficiency of the proposed method.

Characteristic Mode-Based Efficient Analysis Method for Electromagnetic Scattering of Complex Electromagnetic Structures with Lossy Dielectric Materials

Yutong Qiu, Jihong Gu, Zhaoyuan Wang and Zhou Cong (Nanjing University of Science and Technology, China); Chao-Fu Wang (National University of Singapore, Singapore); Dazhi Ding (Nanjing University of Science and Technology, China)

This paper proposes a fast solution method to analysis the electromagnetic scattering characteristics of the complex electromagnetic structures with lossy dielectric materials. In this method, the characteristic mode (CM) formulation for complex electromagnetic structures with lossy dielectric materials is first established based on the energy theory and the surface integral equation. Utilizing the modal reconstruction property of the theory of characteristic mode (TCM), the surface induced electromagnetic currents of individual array elements are accurately solved, and the scattering fields are obtained. The scattering field of the array is then rapidly acquired through phase superposition, enabling the calculation of RCS. Numerical examples demonstrate that the proposed method significantly reduces computation time and memory overhead while maintaining accuracy.

Background Separation and Cancellation in Complex Indoor Testing Environments Based on the TTP Algorithm

Wei Gao, Wen Jiang, Tao Hong, Wei Hu, Kun Wei and Yuchen Gao (Xidian University, China)

In indoor Radar Cross Section (RCS) test ranges, multipath signals generated by reflections from fixed structures such as walls and ceilings severely contaminate the true measured values of targets. This is particularly prominent in low-frequency band measurements and for low-RCS targets. Traditional background subtraction or time-gating methods often fail to isolate interference that is coherent or closely spaced with the target echo. To effectively suppress background clutter in indoor testing environments, this paper conducts an in-depth study on background separation and cancellation techniques. A target-background coupling model based on the Target Translation Processing (TTP) method is proposed. By utilizing a single translation of the target between two measurements, the phase of the multipath signal is actively altered, thereby achieving the separation of the target echo from the background multipath at the signal level. Simulation analysis determines that the optimal translation range is between 0.2λ and 0.3λ to minimize the ill-conditioning of the solution matrix. Experimental results on a flat plate demonstrate that the proposed algorithm can effectively suppress significant false interference peaks introduced by fixed wall reflections in the expected multipath directions, significantly improving the accuracy of target measurements and recovering the true RCS characteristics.

Presenter bio: Tao Hong, born in 1983, associate profrssor of Xidian University, interests on ultra wide band antennas, frequenccy selective surfaces and metamaterials.

S24: Antenna Arrays and Beamforming III

Room: Urchins 2

Chair: Zhichao Sun (University of Technology Sydeny, Australia)

S Parameters Matrix Estimation for E-MIMO-Based Beamforming

Qiaowei Yuan (Tohoku Institute of Technology, Japan)

The Efficiency Maximum Multiple-Input Multiple-Output (E-MIMO) approach has recently been proposed as an effective beamforming technique for array antennas [1]. Practical implementation of E-MIMO requires accurate knowledge of the coupling matrix between transmitting and receiving elements, typically represented by the S-parameter or Z-parameter matrix. In realistic environments, however, direct measurement of the full multi-port matrix is time-consuming and often difficult, particularly when the receiving antennas are located far from the transmitting antennas. This paper proposes a method for estimating the coupling matrix using pilot signals. In the proposed approach, the mutual admittance or impedance matrix between the transmitting and receiving ports is derived from measured port voltages under known termination conditions at the transmitting side induced by pilot signal excitation. Numerical simulations are conducted to validate the proposed estimation method.

Modelling Clock Stability to Enabling Synchronisation for Multi-Static Passive Radar

Konstanty S Bialkowski (The University of Queensland, Australia)

Passive radar is a type of radar system that offers several advantages over traditional active radar systems. Unlike active radar, passive radar does not require a dedicated transmitter and instead uses existing signals from the environment, like radio or television signals as a source of illumination, making it low cost, low power and portable. With advancements in receiver technology and computational power, passive radar has become an increasingly attractive option in many applications where active radar would have been used. However, the detection range and accuracy of passive radar are limited by the geometry of a single receiver scenario and the signal-to-noise ratio of the received signal. One way to overcome these limitations is to use multiple receivers to triangulate the position of a target, which provides increased coverage and the ability to detect smaller targets. To fully make use of the signals, coherent detection provides the opportunity to maximally combine the signals from all of the receivers. However, this depends on accurate synchronisation between receivers. In practice, this is challenging, as differences in receivers caused by both manufacturing defects as well as temperature fluctuations, can degrade the level of synchronisation. This work investigates the effect of synchronisation through experimental modelling of RF receivers and then looks at how these effect radar signal processing in terms of localisation performance in a virtual radar environment. Using the Generalised Canonical Correlation Analysis (GCCA) detector, a high-performance coherent detector is used. The key output of this work demonstrates that synchronization errors significantly affect localization performance, particularly where the detection performance is relying on coherent detection. However, when conditions, particularly temperature, remain stable, a calibration process can be used to mitigate most of the error. Understanding the impact of synchronization errors is crucial for improving and developing future multi-receiver passive radar and distributed beamforming systems.

Multi-Template Differential Correction for Subarray-Based Pattern Reconstruction of Large Phased Arrays

Yuqing Yang, Weimin Wang and Yongle Wu (Beijing University of Posts and Telecommunications, China); Yuanan Liu (Beijing University of Posts and Telecom, China)

Electrically large phased arrays for satellite communications often exceed anechoic-chamber (AC) test-zone dimensions, motivating subarray-based pattern reconstruction realized through subarray stitching for OTA characterization. However, conventional stitching tiles an isolated-subarray pattern and implicitly assumes identical embedded behavior across the aperture. This assumption produces systematic boundary-induced errors that accumulate in the reconstructed pattern, particularly at wide zenith angles. This paper proposes a multi-template differential correction method that uses one isolated subarray and four representative embedded templates (middle, two edges, and one corner). The method models template deviations as differential fields, propagates them across the aperture via symmetry mapping, and applies an angle-dependent least-squares weight for direction-selective compensation. Numerical simulations show up to a 53% reduction in full-angle gain MSE and a 65% reduction in wide-zenith MSE, validating improved wide-angle reconstruction under test-zone constraints.

Multi-Material Additively Manufactured Wideband Dual-Linear Polarized Antenna with High Isolation

Zhichao Sun (University of Technology Sydeny, Australia); Xiaojing Lv, Jiexin Lai and Yang Yang (University of Technology Sydney, Australia)

A multi-material additively manufactured wideband dual-linear polarized (dual-LP) antenna with high isolation is proposed in this paper. The structure integrates a magnetoelectric-dipole (ME-dipole) and a quasi-Yagi antenna. The ME-dipole utilizes a slot-coupled feed to produce horizontal polarization (HP), while the quasi-Yagi features two pairs of symmetrical dipoles with obliquely angled feed lines to realize vertical polarization (VP). The antenna is realized using multi-material additive manufacturing in a single integrated process, resulting in a highly compact design. Simulation results demonstrate that the antenna achieves a shared impedance bandwidth (IMBW) of 48.71% in the millimeter-wave (mm-wave) band, while maintaining an isolation level below −34.5 dB. Owing to its compact configuration, wide bandwidth, and high isolation, the proposed antenna is well-suited for a variety of modern communication and sensing applications.

General-Purpose Terahertz Quasi-Optics and Mechanical Beamformers Enabled by 3D-Printing

Bryce Chung, Daniel Headland and Withawat Withayachumnankul (Terahertz Engineering Laboratory, Adelaide University, Australia)

Owing to their short wavelength and light-like propagation behavior, terahertz waves require quasi-optical components to control the flow of radiation. To meet this need, 3D-printing has evolved over the past decade from a niche technique to a highly customizable, general-purpose methodology to produce terahertz quasi-optics, using consumer-grade hardware.

S6: GaN and Compound Semiconductor Devices

Room: Michaelmus B

Chair: Yuehang Xu (University of Electronic Science and Technology of China, China)

Phase-Tapered Bus-Bar Combiner for Efficiency Enhancement in C-Band GaN MMIC Power Amplifier

Nupur Sood (Defence Research and Development Organization, India); Pinaki Sen (Defence Electronics Applications Laboratory & DRDO, India); Karun Rawat (Indian Institute of Technology Roorkee, India)

This work presents a layout-only phase-tapered bus bar combiner for Gallium Nitride (GaN) MMIC power amplifiers (PAs) in foundry compatible form. The approach improves power-added efficiency (PAE) by introducing asymmetry in drain-feed without increasing circuit complexity or addition of extra components. A graded drain feed taper is used to introduce controlled phase delays of 18.2° for the edge devices, 7.1° for second-edge devices and less than 1° for center devices at 4.65 GHz. This results in 12.5 percent reduction in DC current while maintaining excellent vector combining efficiency (ηcomb= 99.2 percent). Second, a single output-per-four-transistor topology reduces the required impedance transformation thus lowering the matching loss as well as avoiding closed metal loops. EM co-simulations carried out using UMS GaN technology (0.25 µm) with eight GH25-10 HEMTs (total periphery of 20 mm) results in a PAE of (44.5-46.3) percent in CW mode (improved by 5-points over conventional bus-bar), an output power of 47.6W and (21-22.7) dB of gain with a negligible linearity degradation over (4.35-4.97) GHz.

Design of Titanium SAW Phononic Crystal on Lithium Niobate LiNbO3/Si Structure

Bao Jingfu, Mohammed Awad Ahmed Mohammed, Zijiang Yang, Taiyu Jiang and Ken-Ya Hashimoto (University of Electronic Science and Technology of China, China)

This study explores the use of surface acoustic wave (SAW) phononic crystals (PnCs), specifically square pillar-based PnCs reflectors in SAW resonators. The PnC generate acoustic band gap that reflects the wave to the resonator body, which enhances the stored energy and Bode Q in comparison to a traditional reflector. In this work, we propose a square-shaped titanium PnC implemented on a 15 ° Y-X $LiNbO_3/SiO_2/Si$ layered substrate. The proposed design generates a wide acoustic bandgap that. To evaluate the practical impact of PnCs in SAW devices, two SAW resonators employing PnC and reflector designs are compared and analyzed. From the simulated frequency responses, we find that using the Square-PnC as the reflector reduces resonator energy loss and enhances the stored energy

High-Efficiency Broadband S-Shaped Thin-Film Lithium Niobate Electro-Optic Modulator

Xupeng Gu (University of Electronic Science and Technology of China, China); Ya Fei Wu (UESTC, China)

In this work, we propose and demonstrate an S-shaped Mach-Zehnder modulator (MZM) on a silicon substrate. As global data traffic demands surge, thin-film lithium niobate on silicon has emerged as a premier platform due to its high electro-optic coefficient and seamless integration with CMOS-compatible processes. However, conventional straight-path traveling-wave electrodes are often limited by severe conductor losses and velocity mismatch at millimeter-wave frequencies. By utilizing an innovative S-shaped topological layout, we effectively mitigate microwave transmission loss by alleviating high-frequency current crowding at the electrode edges. This geometry also provides the added benefit of increasing the optical group index, thereby enhancing both velocity matching and modulation efficiency. We fabricated a prototype with a 5 mm interaction length, and experimental results-which align well with numerical simulations-show a 1 dB reduction in electrode loss compared to traditional straight-path designs of the same length. Consequently, the device achieves a record EO bandwidth exceeding 110 GHz. This silicon-based S-shaped MZM offers a high-performance and scalable solution for the next generation of ultra-broadband photonic integrated circuits.

Characterisation of Dynamic Particulate Media Using Broadband FMCW Spectrometry

James Elgy (University of Birmingham, United Kingdom (Great Britain)); Stephan Reschke (Toptica Photonics SE, Germany); Edward Hoare (University of Birmingham, United Kingdom (Great Britain)); Marina S. Gashinova (University of Birmngham, United Kingdom (Great Britain)); Fatemeh Norouzian (University of Birmingham, United Kingdom (Great Britain))

There is a growing interest in spectrometer-based techniques to measure and characterise particulate media across diverse fields, including medicine, environmental monitoring, and manufacturing. Spectrometers provide broadband measurements in a non-destructive manner, potentially enabling the extraction of rich spectral information that can enhance the characterisation of the medium. In this paper, we present a new dataset of transmission measurements through dynamic dust clouds acquired using an optoelectronic frequency-modulated continuous-wave (FMCW) spectrometer. The experimental results demonstrate that simultaneous broadband magnitude and phase measurements enable the estimation of the effective refractive index of the particulate air-dust mixture. These findings highlight the potential of FMCW spectrometry for quantitative characterisation of dynamic mediums.

From Language to Structure: Semantic-Guided Cross-Modal End-to-End Intelligent Design of High-Performance Metasurface Absorbers

Yihao Li (Nanjing University of Science and Technology, China); Shijie Wang (National University of Singapore, Singapore); Wen Lyu, Yanghui Wu and Huanyu Yang (Nanjing University of Science and Technology, China)

Metasurface inverse design usually relies on numerical targets and therefore cannot directly use natural-language requirements. The inverse mapping from spectra to structural parameters is also non-unique. To address these issues, we propose a semantics-guided cross-modal framework for intelligent design of high-performance metasurface absorbers. The framework combines vision-language alignment, forward surrogate modeling, and probabilistic inverse design in a unified pipeline built on a four-modal dataset. Specifically, we use a CLIP-based module for text-spectrum alignment, a spatially varying multi-channel attention Fourier neural operator for forward prediction, and a mixture density network for inverse design. The forward model achieves ($R^{2}=0.9954$) on the test set and ($R^{2}=0.9939$) on the validation set. The inverse model achieves MAE = 0.024855, RMSE = 0.046434, and ($R^{2}=0.960359$), while the semantic alignment module reaches (88.24%) Top-1 accuracy and (100.00%) Top-5 accuracy.

Towards Fully Integrated Terahertz Frontends: Silicon Photonics Meets Resonant Tunneling Diodes

Weijie Gao and Nguyen Hoai Ngo (Osaka University, Japan); Daiki Ichikawa (The University of Osaka, Japan); Yuta Inose and Masayuki Fujita (Osaka University, Japan)

The terahertz frequency band offers great potential for ultrahigh-speed wireless communications and high-resolution sensing in 6G and beyond systems. However, compact and scalable terahertz frontends are still limited by the lack of a unified integration platform that supports both low-loss propagation and efficient active devices. In this work, we present a photonic-electronic co-integration framework combining effective medium silicon waveguides with resonant tunneling diodes. The platform enables low-loss, broadband propagation and compact nonlinear functionalities, including oscillation, detection, and phase control. Integrated transceivers and beam-steerable antennas at the 300-GHz band are demonstrated. This approach can be expected to promise fully integrated, reconfigurable terahertz frontends for next-generation communication and sensing systems.

Presenter bio: Postdoctoral Researcher at Osaka University with research interest focused on terahertz components, communications, and microwave reconfigurable antennas.

Thursday, July 23 6:00 - 10:30

Awards Ceremony and Banquet @ Urchins 4

Room: Michaelmus A, Michaelmus B, Reef, Urchins 2

Friday, July 24

Friday, July 24 9:00 - 9:45

K3: Keynote: The Evolution of Guided-Wave Technologies: Driving the Future of Integrated Circuits and Systems - Ke Wu

Ke Wu

Chair: Yang Yang (University of Technology Sydney, Australia)

The development of advanced materials and innovative fabrication processes has been a key driver of progress in integrated circuits and systems. In parallel, guided-wave technologies have undergone remarkable evolution, enabling increasingly compact, high-performance, and multifunctional implementations. In particular, the three-dimensional, high-density integration of transmission lines supporting diverse propagation modes is reshaping the future of circuit and system integration. This talk presents an overview of transmission lines and guided-wave structures whose evolution has been driven by continuous advances in materials and fabrication technologies, followed by a discussion of emerging high-density integration techniques. State-of-the-art substrate integration approaches, encompassing both metallic and dielectric topologies, are reviewed with an emphasis on minimizing transmission loss while maximizing integration density. Emerging waveguide architectures and heterogeneous integration strategies are then introduced, enabling unified platforms that support both TEM and non-TEM propagation for highly integrated circuits and interconnects. Finally, mode composition and mode selectivity are explored for DC-to-THz systems targeting ultrafast, ultra-broadband, and truly all-pass operation. The presentation concludes by proposing a unified all-pass transmission architecture for future DC-to-THz systems, laying the foundation for the convergence of electronic and photonic technologies.

Biography

Dr. Ke Wu is Industrial Research Chair in Future Wireless Technologies and Professor of Electrical Engineering with Polytechnique Montréal (University of Montreal). He is the Founding Director of the Institute for Wireless Intelligence (IWI). He was the Canada Research Chair in RF and millimeter-wave engineering and the Founding Director of the Center for Radiofrequency Electronics Research of Quebec, and the Director of Poly-Grames Research Center. He has authored/co-authored over 1500 technical papers, and 26 books/book chapters and filed more than 95 patents. Dr. Wu was the organizer of numerous conferences and events including the General Chair of the 2012 IEEE MTT-S International Microwave Symposium (IMS2012) and General Co-Chair of the 2025 IEEE International Symposium on Antennas and Propagation (APS). He was the 2016 President of the IEEE Microwave Theory and Technology Society (MTT-S). He also served as the two-terms inaugural representative of North America in the General Assembly of the European Microwave Association (EuMA). He was the recipient of many awards and prizes including the 2019 IEEE MTT-S Microwave Prize, the 2021 EIC Julian C. Smith Medal, 2022 IEEE MTT-S Outstanding Educator Award, 2022 IEEE AP-S John Kraus Antenna Award, and the 2025 IEEE MTT-S Pioneer Award. He was an IEEE MTT-S Distinguished Microwave Lecturer. Dr. Ke Wu is a Fellow of the IEEE, the Canadian Academy of Engineering, the Academy of Science of the Royal Society of Canada, and the German National Academy of Science and Engineering (acatech).

Friday, July 24 9:45 - 10:45

P5: Semi-Plenary 5

Room: Michaelmus A

Chair: Withawat Withayachumnankul (The University of Adelaide, Australia)

Sources and Detectors for Space THz Communication Systems

Imran Mehdi (Jet Propulsion Laboratory, California Institute of Technology, USA)

THz applications have been increasing over the years. These applications include both space-based remote sensing as well as ground-based industrial applications such wireless communications. For communication systems, the THz frequency range is attractive as it provides larger bandwidth and smaller apertures. This talk will focus on the recent advancement in the development of room-temperature based wideband, compact sources and detectors in the THz range for space communication systems.

High-Sensitivity Terahertz Sensing with Quadrature Self-Homodyne Detection

Bryce Chung, Nontiwat Amnuayphol, Harrison N Lees and Withawat Withayachumnankul (The University of Adelaide, Australia)

Terahertz sensing is often cited as a transformative solution for non-destructive evaluation, offering millimeter-scale spatial resolution and unique see-through capabilities. Despite the availability of various photonic and electronic systems, significant challenges remain. Photonic-based systems are often hampered by inherent laser drift and phase noise, while electronic systems suffer from phase noise amplification through high-order frequency multiplier chains. These issues compromise sensitivity, which is typically improved through temporal averaging at the expense of measurement speed. Furthermore, high-performance components remain costly and delicate, whilst their limited output power often restricts the effective sensing range. Sensitivity can be dramatically enhanced by comparing the probe signal with a reference of the original carrier, a technique known as self-homodyning. In this presentation, we discuss two quadrature (I/Q) self-homodyne detection systems operating around 300 GHz, a strategic band for extended-range sensing due to minimal atmospheric absorption. One architecture utilizes I/Q interferometry, while the other employs I/Q mixing. Both systems achieve nanometer-scale vibration sensitivity with a theoretical measurement bandwidth reaching gigahertz rates. This detection scheme suppresses both external noise and source phase noise, enabling the use of high-power terahertz oscillators to further extend sensing range. We will demonstrate successful applications in acoustic eavesdropping, non-contact chip sensing, and vital-sign detection. assumption.

P6: Semi-Plenary 6

Room: Michaelmus B

Chair: Shengjian Jammy Chen (Flinders University, Australia & The University of Adelaide, Australia)

Diverse Semiconductor Integrated Microelectronics in the Application-Oriented AI Era

Debabani Choudhury (SeraTech, LLC, USA)

Energy efficient materials, devices, technologies and systems will play a major role with the evolution of sensing and communication network architectures in the AI era. The progress in compound semiconductor devices combined with silicon technologies and 3D heterogeneous integration (3DHI) are defining the microelectronics future in the industry.

This talk will present the recent advancements in semiconductor and microelectronics integration technologies. The challenges and opportunities of the system-oriented compound semiconductor-based microelectronics in the Agentic AI era will also be discussed.

Friday, July 24 11:15 - 12:30

YP Session

Room: Michaelmus A

Chair: Syed Muzahir Abbas (Macquarie University, Australia)

S16: Millimeter-Wave and Terahertz Passives II

Room: Reef

Chair: Xiaojing Lv (University of Technology Sydney, Australia)

Millimeter-Wave and Sub-Terahertz Antenna and Metasurface Applications Using Screen Printed Vanadium Dioxide Switches

Junghyeon Kim, Minjae Lee and Hyunwoo Koo (Chung-Ang University, Korea (South)); Duc Anh Pham (University of Illinois at Chicago, USA); Eiyong Park and Sungjoon Lim (Chung-Ang University, Korea (South))

Millimeter-wave (mm-wave) and sub-terahertz (sub-THz) frequencies are key technologies for future wireless systems such as 6G, enabling ultra-high data rates and massive connectivity. However, implementing reconfigurable RF components at these frequencies remains challenging because conventional semiconductor switches suffer from parasitic effects and performance degradation. Phase-change materials such as vanadium dioxide (VO_2) offer a promising alternative due to their reversible insulator-metal transition and large resistance change.

This work explores screen-printed VO_2 switches as a scalable platform for reconfigurable antenna and metasurface applications across microwave, mm-wave, and sub-THz frequencies.

First, a frequency-reconfigurable metasurface absorber is proposed using a large-area VO_2 layer integrated with a resistive metasurface pattern. Unlike conventional designs that require discrete RF components, the proposed structure achieves dynamic switching of absorption bands by modulating the sheet resistance of VO_2, demonstrating a simple and scalable approach for reconfigurable metasurfaces.

Second, a screen-printed VO_2-based intelligent reflective surface (IRS) operating at 100 GHz is demonstrated for sub-THz wireless communication. The IRS employs high phase-changing-ratio VO_2 switches to control the reflection phase and beam direction, enabling large-area beam steering while avoiding the parasitic limitations of conventional semiconductor switching devices.

Third, a VO_2-switched leaky-wave antenna operating in the V-band is presented to realize reconfigurable beam steering in mm-wave antenna systems. By switching the VO_2 elements between insulating and metallic states, the antenna dynamically alters its phase constant and radiation characteristics, enabling distinct beam-scanning behaviors within the operating band.

These three demonstrations collectively show that screen-printed VO_2 switches enable low-cost, large-area, and parasitic-free reconfigurable electromagnetic structures, highlighting their strong potential for adaptive antennas and metasurfaces in future mm-wave and sub-THz communication systems.

Presenter bio: Sungjoon Lim received the B.S. degree in electronic engineering from Yonsei University, Seoul, Korea, in 2002, and the M.S. and Ph.D. degrees in electrical engineering from the University of California at Los Angeles (UCLA), in 2004 and 2006, respectively. After a postdoctoral position at the Integrated Nanosystem Research Facility (INRF), the University of California at Irvine, he joined the School of Electrical and Electronics Engineering, Chung-Ang University, Seoul, Korea, in 2007, where he is currently a Professor. He has authored and coauthored more than 100 technical conference, letter and journal papers. His research interests include engineered electromagnetic structures (metamaterials, electromagnetic bandgap materials, and frequency selective surfaces), printed antennas, and RF MEMS applications. He is also interested in the modeling and design of microwave circuits and systems. Dr. Lim received the Institution of Engineering and Technology (IET) Premium Award in 2009.

Meta-Screen: Full-Space EM Environment Reconfiguration for mmWave Communications

Jiatong Wu (Xi'an Jiaotong Liverpool University, China); Rui Pei (Xi'an Jiaotong-Liverpool University, China); Zhao Wang (Xi'an Jiaotong Liverpool University & University of Liverpool, China); Jingchen Wang, Mark Leach and Eng Gee Lim (Xi'an Jiaotong-Liverpool University, China)

This paper presents the Meta-Screen, a novel reconfigurable indoor partition for full-space millimeter-wave environment control. Utilizing a highly integrated Rx-Gnd-Tx unit cell with only two PIN diodes, the proposed architecture achieves 1-bit phase quantization for both transmission and bi-directional reflection modes. Simulations show wide fractional bandwidths of 27.1%, 23.8%, and 8.3% for transmissive, +z-reflective, and -z-reflective modes, respectively, with a common operational bandwidth of 4.1%. System-level validation of a 14×14 array at 24 GHz confirms robust beam-scanning up to 60° and peak gains of 17.94 dBi. This design offers a low-complexity, high-efficiency solution for 360° coverage in future 6G smart radio environments.

A Low-Rate Digital Predistortion with Single Real Undersampling Feedback Using Switch-Estimated Method Excited by 400 MHz Sub-6 GHz Signals

Xiaoyu Lu and Jianfeng Zhai (Southeast University, China); Zuofeng Zhang, Dongfang Ning and Yanru Cao (ZTE Corporation, China); Peng Chen and Chao Yu (Southeast University, China)

This paper proposes a low-rate digital predistortion (DPD) technique. In this DPD technique, a switch-estimated method is applied to estimate the power amplifier (PA) output signal with low-complexity model extraction iteratively by a single real undersampling feedback signal. Furthermore, the band-limited DPD model is used to reduce the sampling rate of digital-to-analog converters (DACs). A 400 MHz 5G NR signal at the center frequency of 3.6 GHz is used to verify the proposed technique. The measurement results show that the proposed DPD technique can effectively reduce the hardware resources consumed during the model extraction process while maintain good linearization performance.

Ultra-Broadband 3D-Printed Metalens Using Height-Controlled Meta-Atoms

Xuyi Zhu and Bing Zhang (Sichuan University, China)

This work presents a 15-40 GHz ultra-broadband metalens based on height-controlled meta-atoms and compatible with hybrid-material 3D printing fabrication. The proposed three-dimensional meta-atom introduces an additional vertical degree of freedom that governs multi-order mode evolution within the unit cell. By tuning the structural height, the evolution and interaction of higher-order modes are controlled, enabling effective phase control over a broad frequency range. Unlike conventional planar phase-shifting elements that rely primarily on two-dimensional geometric variations, the proposed 3D configuration leverages vertical structural modulation to extend the operational bandwidth while maintaining phase tunability. A prototype is fabricated and experimentally validated. Measured results demonstrate broadband operation from 15 to 40 GHz with a peak gain of 25.3 dBi at 25 GHz, corresponding to approximately 90% relative bandwidth. The proposed design provides a manufacturable route toward ultra-broadband metalenses.

A Switchable Dual CP Array System for CubeSat Communications Based on Collocated RHCP/LHCP 4×4 Patch Arrays

Zi-Huan Lu (University of Technology Sydney, Australia); Zhichao Sun (University of Technology Sydeny, Australia); Xiaojing Lv and Yang Yang (University of Technology Sydney, Australia)

This paper presents a switchable dual circularly polarized (CP) 4×4 patch array system for CubeSat communications. The CP element uses a slot-coupled feed to achieve wideband matching and a low axial ratio (AR). A mirror transformed element is employed to realize right-hand circular polarization (RHCP) and left-hand circular polarization (LHCP) with similar performance. A sequential rotation feeding (SRF) network is used in the 4×4 arrays to improve the impedance and AR bandwidths. Simulation results show that the 4×4 RHCP and LHCP arrays achieve an overlapped bandwidth ($|S11| < -10$ dB, AR < 3 dB) of 48.7% (28.4-46.2 GHz), with realized peak gains above 16.6 dBic. Finally, the RHCP and LHCP arrays are collocated on the CubeSat top panel, providing a compact switchable dual CP antenna system for polarization diversity and reduced polarization mismatch.

S25: Antenna Arrays and Beamforming IV

Room: Urchins 2

Chair: Maral Ansari (CSIRO, Australia)

Pattern-Reconfigurable Metasurface for Dynamic Switching Between OAM Beam and Dual-Beam

Xiaoxuan Guo (University of Technology Sydney, Australia); Yue Shi (Beijing Chenzhong Technology, China); Yang Yang (University of Technology Sydney, Australia)

A pattern-reconfigurable metasurface is proposed, which enables dynamic switching between Orbital Angular Momentum (OAM) vortex beams and dual-beam radiation patterns. The proposed metasurface is constructed using a multi-layer Printed Circuit Board (PCB), with its aperture phase distribution determining the radiation characteristics. The phase distribution for x-polarization consists of focusing phase and vortex OAM phase, while that for y-polarization comprises focusing phase and a periodically alternating phase of 0° and 180°. Simulation results demonstrate that the proposed metasurface can efficiently achieve dynamic switching between an OAM beam with a topological charge of 1 and dual-beam patterns.

A Textile Antenna for ON-/off-Body Communication

Yu-Fei Wang, Zhe Chen, Shuai Gao, Yu-Xiang Sun and Tao Yuan (Shenzhen University, China)

A textile antenna with dual-band dual-mode operation is proposed for on- and off-body communications. An omnidirectional radiation pattern is achieved by loading shorting pins to excite the TM00 mode at the 2.45-GHz band for on-body communication, while a broadside radiation pattern with high gain is realized by etching slots to modify the TM30 mode at the 5.8-GHz band for off-body communication. Both bands can be tuned independently. A prototype was fabricated using textile materials, allowing it to conform to the human body. The measured results indicate that the antenna can fully cover the 2.45- and 5.8-GHz WBAN bands, achieving measured peak gains of 1.31 dBi in free space and -1.09 dBi on a three-layer human tissue model for the 2.45-GHz band, as well as 9.97 dBi in free space and 9.62 dBi on the phantom for the 5.8-GHz band. The demonstrated properties confirm that the proposed antenna is suitable for wearable applications.

A Compact Wideband Dual-Circularly Polarized Millimeter-Wave Antenna with Isolation Enhancement

Zhichao Sun (University of Technology Sydeny, Australia); Xiaojing Lv, Jiexin Lai and Yang Yang (University of Technology Sydney, Australia)

A compact wideband dual-circularly polarized (dual-CP) antenna with isolation enhancement is proposed in this paper. First, a compact antenna element is designed, exhibiting a 27.66% dual-CP bandwidth in the Ka-band. By employing a downward-folded electric-dipole (E-dipole), the footprint of the antenna is significantly reduced, leading to a highly compact structure. However, the isolation between the two ports is low, reaching only 6.5 dB across the operating bandwidth. To address this issue, two dielectric layers are introduced above the radiator, with a cavity etched in the center of the lower dielectric layer. With the cavity-loaded structure, the port isolation is improved by up to 15 dB. Owing to its wideband dual-CP, compact configuration, and high port isolation, the proposed antenna element is well suited for satellite communication antenna arrays.

Broadband Circularly Polarized Glass Antenna with Surface Wave Suppression

Xiaofeng Hou, Keying Huang, Zhipeng Zhang, Wenhai Zhang and Yilin Zheng (Soochow University, China); Chi-Hou Chio and Kam-weng Tam (University of Macau, Macao); ZhiXing Chen (Fuyao Glass Industry Group CO., LTD, China)

This paper presents a novel circularly polarized coplanar waveguide (CPW)-fed antenna designed for integration into vehicle roof glass for satellite navigation applications. The antenna utilizes an asymmetric ground plane to achieve broadband circular polarization. A key feature is the seamless integration of a coplanar frame structure within the blackout border region of the roof glass, which effectively suppresses surface wave propagation. Measurement results demonstrate that the prototype achieves an impedance bandwidth of 36.04% (1.16-1.67 GHz) and a 3-dB axial ratio (AR) bandwidth of 34.29% (1.16-1.64 GHz). Furthermore, the antenna exhibits a boresight right-hand circularly polarized (RHCP) gain exceeding 2 dBic across the B3 and L1 navigation bands. These characteristics satisfy the stringent requirements for modern automotive Global Navigation Satellite System (GNSS) antennas. Keywords-Broadband, circular polarization, CPW feed, surface wave suppression, GNSS application

A Low Profile and High Front-to-Back Ratio Millimeter-Wave Array Based on Electromagnetic Band Gap Ground

Yu-Qi Ma, Zhihong Tu, Huan-Bin Wang and Fu-Chang Chen (South China University of Technology, China)

This paper proposes a low profile and high front-to-back ratio millimeter-wave array based on electromagnetic bandgap ground (EBGG). The proposed array consists of two SIW slot antenna elements operating in the 24 GHz ISM band. In order to enhance gain and the front-to-back ratio (FBR), a π-shape EBGG is introduced on both sides of the array, while maintaining an ultra-low profile of only 0.04λ0. Compared with the original array, the peak realized gain of the proposed array is enhanced from 8.0 dBi to 9.0 dBi at 24.0 GHz, a reduction in the 3-dB beamwidth from 105° to 91°, and a significant enhancement in FBR from 17.34 dB to 30.17 dB. These results demonstrate that the proposed π-shape EBGG is an effective solution for achieving gain and FBR enhancement in low-profile millimeter-wave antenna arrays.

S7: Low Noise Amplifiers and Receivers

Room: Michaelmus B

Chair: Xupeng Gu (University of Electronic Science and Technology of China, China)

A 19.3-23.7-GHz RTWO with Common-Mode Resonance and Distributed Varactors

Yuan Tian, Xiaosi Zhu, Pei Qin and Quan Xue (South China University of Technology, China)

This paper presents a millimeter-wave (mmW) rotary traveling-wave oscillator (RTWO) integrating distributed varactors and common-mode high-impedance techniques to mitigate dispersion-induced flicker noise upconversion. Fabricated in TSMC 65nm CMOS, the 16-phase RTWO achieves a tuning range from 19.3 GHz to 23.7 GHz with phase noise of −130.2 dBc/Hz at 10-MHz offset. With a power consumption of 9.6mW, peak Figure-of-Merit (FoM), FoMT and FoMP reach 187.8, 193.9, and 199.9 dBc/Hz, respectively.

A 8.8-12.5 GHz Dual-Core Series Resonance VCO with 201.3-dBc/Hz FoMT in 28-nm CMOS Technology

Shuai Huang, Li Gao and Xiu Yin Zhang (South China University of Technology, China)

This paper proposes a dual-core series resonance voltage-controlled oscillator (SRVCO) designed for wideband communication applications. The dual-core SRVCO topology is utilized to achieve a wide tuning range (TR), significantly lower the power consumption of SRVCO while still maintaining a decent PN and FoM performance. By manipulating the coupling coefficient between the primary and secondary coils of the transformer, mode ambiguity is eliminated. Implemented in TSMC 28-nm bulk CMOS process, the VCO achieves a simulated continuous oscillation frequency range of 8.8 to 12.5 GHz (tuning range of 34.7%). This SRVCO operates at a 0.7

V supply with a power consumption of 13.1 mW. The simulated results demonstrate a best phase noise of -137.8 dBc/Hz at 10-MHz offset, corresponding to a figure-of-merit (FoM) of 190.5 dBc/Hz and a FOM of tuning range (FoMT) of 201.3 dBc/Hz.

Super-Mode-Group Based Reduced-Order Analysis of Multi-Mode Antenna Decoupling

Yuqi Wang (South China University of Technology, China); Hao Jiang (City University of Hong Kong, Hong Kong); Yinglu Wan (Guangxi University, China)

Broadband and multiband antenna decoupling is often associated with the joint contribution of multiple characteristic modes. This paper presents a super-mode-group (SMG) framework for reduced-order analysis of symmetric multi-mode antennas. Starting from the characteristic-mode expansion of the port admittance matrix, the relevant modes are grouped into odd and even groups according to structural symmetry. Two grouped descriptors, namely the total excitation weight and the weighted modal eigenvalue, are introduced to describe the overall contribution of each group. The formulation shows that decoupling is favored when the odd and even groups remain balanced in grouped-power/conductance contribution and synchronized in near-resonant behavior. Numerical parametric results support this interpretation. The framework provides a reduced-order view for symmetric multi-mode antenna analysis.

A V-Band LNA with Pole-Tuning and Gm-Boosting Technique in 40-nm CMOS

Xiangjie Li, Hetai Zhang, Pei Qin and Quan Xue (South China University of Technology, China)

For millimeter-wave applications in short-range wireless communication, this paper proposes an LNA based on a three-stage cascode. To expand the input-matching bandwidth, the input-matching network introduces another pole at a higher frequency, thereby achieving a wider S11 bandwidth. Moreover, two transformers were used to connect the transistor drain in the previous stage to the transistor source in the subsequent stage. This enables the transistor to exhibit enhanced conductivity in the latter stage, thereby increasing its gain. The increase in gain suppresses noise. Under a 1V power supply, the power consumption is 17.6mW. This low-noise amplifier has a peak gain of 21.1 dB at 61.1 GHz within a 3-dB bandwidth of 45.7-68.9GHz and achieves the lowest noise of 3.67dB at 55.9GHz. Meanwhile, this LNA is unconditionally stable across the entire frequency range. The area of this LNA is 0.17mm2.

A High-Sensitivity Rectifier Employing a Low-ESR Distributed Spiral Inductor

Pai-Dong Lin (South China University of Technology); Jun-Hui Ou (South China University of Technology, China); Zhi-Xia Du (Guangdong University of Technology, China)

As the input power of rectifiers decreases to below -30 dBm, the rectifier exhibits a highly capacitive complex impedance, leading to a dramatic increase in power loss within the impedance matching network during energy transmission. To minimize the equivalent series resistance (ESR) of the matching structure, this paper proposes a low-ESR distributed spiral inductor, which is synergistically integrated with a T-junction microstrip structure to construct the matching network. Compared to the conventional impedance matching networks, this structure effectively minimizes parasitic ohmic losses within the matching network, achieving higher power conversion efficiency. Simulation results demonstrate that at an operating frequency of 900 MHz and an input power of -35 dBm, the rectifier circuit utilizing the proposed matching network achieves a power conversion efficiency (PCE) of approximately 10.97%.

Friday, July 24 12:30 - 1:45

Friday, July 24 1:45 - 3:00

WIM Session

Room: Michaelmus A

Chair: Wenquan Che (South China University of Technology, China)

S17: CMOS and BiCMOS Power Amplifiers IV

Room: Reef

Chair: Jingchen Wang (Xi'an Jiaotong-Liverpool University, China)

A Continuously Tunable Silicon-Based 3D Matching Network for Heterogeneous RF Transceiver

Yanwen Zheng, Guangbao Shan and Xiang Fan (Xidian University, China); Chunyu Yang (Xidian university, China); Pan Zhang (Xidian University, China)

The wideband impedance mismatch is main critical challenge to improve the efficiency. This paper presents a multi-mode tunable matching network. The matching performance can be improved with the flexible combination of tuning excitation modulus and phase. Across the 0.1-10 GHz range, the return loss is less than 10 dB. The prototype occupies an area of only 200×140μm².

Presenter bio: He is a doctoral candidate at the School of Microelectronics, Xidian University. His main research direction is chiplet-based radio frequency system integration technology.

A Broadband Tunable Matching Network Based on Magnetic Coupling

Wang Fangqian, Guangbao Shan and Yanwen Zheng (Xidian University, China)

To address the limitations of conventional lumped element matching networks in broadband applications, this paper investigates the broadband mechanism and tuning characteristics of magnetically coupled matching networks. Based on a tunable transformer structure, a matching network with adjustable bandwidth and ripple is proposed. The frequency and impedance tuning mechanisms of in-phase and out-of-phase configurations are systematically analyzed, thereby extending the theoretical framework of magnetically coupled matching networks.

Design of Filtering Power Amplifier Based on TGV-IPD Filtering Matching Network

Shiyu Zhu (South China University of Technology, China); Jin-Xu Xu (Pazhou Lab, China); Xiu Yin Zhang (South China University of Technology, China)

This paper presents a 6.425-7.125 GHz filtering power amplifier (FPA) implemented using a 0.1-um GaAs pHEMT process integrated with glass-substrate inte-grated passive device (IPD) technology. A two-stage architecture is adopted, where multiple transmission zeros are introduced to realize a bandpass filtering response. To minimize insertion loss, the output match-ing network (OMN) is fabricated using high-Q through glass via (TGV) IPD technology. Simulation results show that the proposed PA achieves a gain of 20.5-21 dB over the frequency range of 6.425-7.125 GHz with a strong out-of-band rejection. The output power reaches 32.2-32.9 dBm with a saturated power-added efficiency (PAE) of 46.5-49.5%.

Wideband High-Precision Resonator-Based Phase Shifters via Lossy Electric and Magnetic Coupling

Ji Na (South China University of Technology, China); Guangxu Shen (Nanjing University of Posts and Telecommunications, China); Wenquan Che (South China University of Technology, China)

This paper presents a novel wideband phase shifter (PS) architecture featuring a dual-state multi-resonator response, where both states integrate an admittance inverter (J-inverter) model with lossy coupling. In addition, the transistors are not only used as switches but also reused to form the resonators. Implemented in a 0.25-μm GaAs IPD process, a representative 90° PS is designed for the 22-32 GHz band. Post-layout electromagnetic simulations demonstrate a phase shift of 91.5° ± 1.5°, a maximum insertion loss of 3 dB in both states, and an amplitude imbalance below 1 dB. The proposed architecture provides a compact and robust solution for millimeter-wave phased-array systems.

Ultra-Wideband RCS Reduction Metasurface with Tunable Transmission Window

Cong Zhang, Yuchen Gao, Hui Xin and Tao Hong (Xidian University, China)

This paper presents a metasurface design that integrates polarization conversion and reconfigurable frequency selective surface (FSS) technologies to achieve ultra-wideband radar cross section (RCS) reduction with a continuously tunable transmission window. The structure comprises a tunable low-frequency polarization conversion metasurface (PCM) loaded with varactors and resistors, a high-frequency PCM orthogonally stacked to avoid Fano resonance, and a reconfigurable FSS. By adjusting varactor capacitance, the transmission window can be tuned from 4.6 GHz to 7.1 GHz with insertion loss <1 dB, while maintaining polarization conversion absorption ratio (PCAR) >0.9 in stopbands. A checkerboard array achieves >10 dB RCS reduction from 5 GHz to 26 GHz (135.5% bandwidth). This design offers unique flexibility for adaptive stealth antennas.

S26: Microwave Filters and Resonators I

Room: Urchins 2

Chair: Jing-Yu Lin (University of Birmingham, United Kingdom (Great Britain))

3D-Printed Copper Waveguide Bandpass Filter for Q-Band Ground Station Application

Lu Qian (University of Birmingham, United Kingdom (Great Britain)); John Robinson and Arun Arjunan (University of Wolverhampton, United Kingdom (Great Britain)); Yi Wang (University of Birmingham, United Kingdom (Great Britain))

Metal additive manufacturing has emerged as a transformative fabrication technique for microwave and millimetre-wave waveguide components, yet challenges persist due to degrading surface conductivity from high surface roughness, particularly in low-conductivity metals and alloys. Copper is one of the most electrically conductive metals. Its nominal bulk conductivity is 53% higher than aluminium. However, copper printing is not as well developed and utilised due to process difficulties that arise from the poor absorption of infrared laser commonly used in Laser Powder Bed Fusion (L-PBF) Additive Manufacturing (AM). This work investigates the application of pure copper printing to waveguide devices. A monolithic copper waveguide bandpass filter is fabricated using L-PBF technology, leveraging copper's superior electrical and thermal properties for high-power microwave applications. This filter employs a step-impedance low-pass design and exploits waveguide cut-off characteristics for passband frequency selectivity. The filter is designed for Q-band ground segment network applications, with a passband from 37.5 to 42.5 GHz. Optimized L-PBF processing parameters overcome copper's high reflectivity to infrared laser. RF measurements show excellent agreement with simulations, yielding a 0.45 dB insertion loss and an 18 dB worst-case return loss, with minimal frequency shift confirming high manufacturing accuracy. This study demonstrates the potential of copper 3D printing for waveguide filters.

Presenter bio: Yi Wang is Professor of Microwave Engineering with the University of Birmingham. He leads the Emerging Device Technology (EDT) Research Lab, specializing in the application of new materials and advanced manufacturing techniques to high frequency devices. He is also the Academic Lead of the Engineering Cleanroom and the Terahertz Measurement Facility at Birmingham. He served the TPC Chair of 2021 European Microwave Conference. His current research interests include: 3D printed microwave and mm-wave devices, waveguide antenna technology, multiport filtering networks, filter-antenna integration, millimeter-wave and sub-terahertz antennas and devices for metrology, communication, and sensing.

A Broadband Unequal Power Divider Based on an H-Plane Height-Reduced Waveguide T-Junction

Bo Li (Chengdu Polaris Information and Communication Technology, China)

This paper presents a method for designing a broadband unequal power divider to achieve an arbitrary power-dividing ratio. The divider is realized by reducing the height of the narrow edge of a waveguide, without affecting the phase consistency between the two output ports. Formulas for determining the power ratio and a design methodology to compensate for discontinuities in the waveguide-using irises, a septum, and a matching section-are introduced. Moreover, a 2:1 unequal power divider operating in the frequency range of 25-31 GHz is designed and fabricated. The measured bandwidth is approximately 21%, featuring an input return loss exceeding 25 dB, an insertion loss below 0.15 dB, and a phase difference between the output ports of less than 5°.

Low-Loss Millimeter-Wave Wideband Bandpass Filter in InP Technology with Cryogenic Performance Analysis

Hongliang Tian (Shenzhen University, China); Haiwen Liu (Dalian University, China); Junfa Mao (Shanghai Jiao Tong University, China)

This paper presents the design and cryogenic characterization of on-chip millimeter-wave ultra-wideband (UWB) bandpass filters (BPFs) optimized using advanced algorithms. First, an on-chip mm-wave UWB BPF is designed, which demonstrates a 0.12 dB insertion loss improvement and a 0.3 GHz frequency shift when cooled from 300 K to 77 K. Based on this design, a flip-chip InP-based balanced UWB BPF utilizing electromagnetic-circuit co-optimization with the grey wolf optimization (GWO) algorithm is designed. The filter is fabricated with spiral inductors and metal-insulator-metal capacitors on an alumina substrate, and maintains stable differential mode performance (center frequency: 15.45 GHz, bandwidth: 101.9%, common mode rejection: 20 dB over 0-24.5 GHz) across 300 K, 70 K, and 5 K. Notably, the minimum insertion loss decreases from 1.02 dB to 0.72 dB when cooled from 300 K to 70 K, with 0.3-0.8 dB improvements across the passband. Analysis reveals that enhanced gold conductivity at cryogenic temperatures is the primary mechanism for insertion loss reduction, significantly exceeding the adverse effects of dielectric loss and structural deformation. The GWO algorithm successfully extracts equivalent circuit parameters, enabling temperature-dependent performance prediction for cryogenic mm-wave applications.

A Broadband High-Selectivity Bandpass Filter Branch-Line Coupler Operating in the C-Band

Yiyang Han, Kun Wei, Wei Hu and Wen Jiang (Xidian University, China)

This paper proposes a design scheme for a broadband highly selective bandpass filter branch line coupler (BHFC) applicable to the C-band. By integrating a broadband coupling structure-comprising parallel coupling lines, high-impedance transmission lines, and parallel open-circuit branch lines-at each port of a single-section branch line coupler, it achieves bandpass filtering characteristics with excellent selectivity and a wide operating bandwidth. The circuit design has been validated through electromagnetic simulation. Experimental results demonstrate an operating frequency range of 4.02 GHz to 7.88 GHz, with a relative bandwidth reaching 64.9%. The power imbalance is ±0.6 dB, return loss exceeds 13 dB, phase imbalance is ±6.6° and selectivity exceeding 73.2%.

Ultrahigh-Sensitivity Microwave Biosensor Based on a CPW Loaded with a Modified Complementary Electric-LC Resonator

Shaghayegh Chamani and Xiaojing Lv (University of Technology Sydney, Australia); Trevor S. Bird (Antengenuity, Australia & University of Technology, Sydney, Australia); Yang Yang (University of Technology Sydney, Australia)

This paper presents an ultra-high-sensitivity microwave planar sensor for biological permittivity sensing based on a conductor-backed coplanar waveguide (CPW) integrated with a modified complementary electric-LC (CELC) resonator. The proposed structure incorporates meandered frames and an interdigital capacitor (IDC) into the CELC resonator etched on the bottom ground plane to enhance the effective inductance and capacitance of the resonant structure. The proposed sensor achieves peak and average sensitivities of 3.58% and 2.58%, respectively, demonstrating its potential for biological permittivity sensing applications.

S8: Terahertz Technologies and Systems III

Room: Michaelmus B

Chair: Daniel Headland (The University of Adelaide, Australia)

Reconfigurable Millimetre-Waves and Terahertz Devices Using Phase Change Materials

Aurelian Crunteanu (XLIM, CNRS/ University of Limoges, France); Wilfrid Renkanga Mbatchi (XLIM, France); Eduard-Nicolae Sirjita (XLIM Research Institute, CNRS- University of Limoges, France); Cyril Decroze (XLIM, France); Georges Humbert (Xlim, France); Alexandre Boulle (Institute of Ceramic Research IRCER, France); Jean-Christophe Orlianges (XLIM, CNRS/ Université de Limoges, France)

We present the integration of phase transition materials -PTM (e.g. VO_2) with volatile metal-insulator transition (MIT) and of chalcogenides (GeTe, $Ge_2Sb_2Te_5$...) phase change materials (PCM)- showing a non-volatile, reversible structural and electrical state changes, as agile elements for switching, frequency reconfiguration and amplitude modulation of devices operating at millimeter-waves and THz frequencies.

Design of a Pattern Reconfigurable Amplifier Antenna with Gain Amplification Using Transistors

Minghuan Wang (Nanjing University of Science and Technology, China); Hao Wang (Nanjing University of Science & Technology, China); Yan Wang and Jianyin Cao (Nanjing University of Science and Technology, China)

This letter proposes an amplifier antenna that integrates gain amplification and pattern reconfigurability. Using two transistors not only amplifies the antenna gain but also enables pattern switching among three states. The antenna and the microstrip-to-slotline transition serve as the input and output matching networks of the amplifier, respectively, which reduces the circuit size. This design achieves the highly efficient integration of the antenna and the amplifier. Two integrated antenna elements placed on the same dielectric substrate form a pattern reconfigurable antenna. Simulation results show that the designed pattern reconfigurable amplifier antenna operates over the frequency band 5.8 GHz to 10.3 GHz. The gain varies from 11.38 dBi to 16.88 dBi. The gain amplification over a wide operating frequency band and the radiation patterns in three states demonstrate the feasibility of the integrated design.

Characterization of 32 GT/s UCIe-Compatible Package Interconnects for Reconfigurable RF Chiplet Integration

Baoping Meng, Guangbao Shan, Guoliang Li, Yanwen Zheng, Wenbin Wei and Jiaxu Cao (Xidian University, China)

To address the critical need for modular and flexible integration in reconfigurable RF integrated systems, a substrate interconnect model based on standard packaging is designed and validated for the 32 GT/s Universal Chiplet Interconnect Express (UCIe) standard. In reconfigurable architectures, the bandwidth consistency and electromagnetic isolation of the underlying interconnects are essential for enabling dynamic functional scheduling. This work establishes a full-link model incorporating pillars, vias, and traces on an organic substrate. Frequency response simulations demonstrate that at the 16 GHz Nyquist frequency, Voltage Transfer Function (VTF) loss remains above -7.5 dB and crosstalk is suppressed below -26 dB, satisfying UCIe specifications for standard packages. Furthermore, system robustness is verified via statistical eye diagram analysis, achieving an eye width of 0.925 UI at a low Bit Error Rate (BER). This study validates the feasibility of utilizing mature standard packaging processes to build high-performance, cost-effective communication platforms for reconfigurable RF chiplet integration.

A Sub-THz Conductive-Bridging Memristive Switch for Reconfigurable RF Front-Ends

Zong-Rui Xu and Yongxin Guo (City University of Hong Kong, Hong Kong)

This paper proposes a sub-THz conductive-bridging memristive switch implemented on high-resistivity silicon for reconfigurable RF front-end applications. Driven by the increasing demand for low-power, compact, and non-volatile reconfigurable hardware in beyond-5G/6G systems, the proposed device explores the feasibility of extending conductive-bridging memristive switching mechanisms toward the sub-THz frequency range. The switch is developed based on a parasitic-aware compact model, in which the ON/OFF-state resistance transition is jointly considered with the intrinsic shunt capacitance and series inductance introduced by the device geometry and interconnect layout. To suppress high-frequency degradation, the structural design is optimized to minimize OFF-state capacitive coupling and parasitic inductive effects while maintaining a compact footprint compatible with high-density integration on silicon platforms. Compared with conventional semiconductor or volatile switching technologies, the proposed conductive-bridging memristive switch is expected to offer near-zero static power consumption, non-volatile state retention, and enhanced scalability for large-scale reconfigurable front-ends. The proposed concept provides a promising device-level solution for future sub-THz switches, switch matrices, and programmable passive networks in reconfigurable transceivers and intelligent RF systems.

On-Body Characterization of a Planar Horseshoe-Slot MXene Microstrip Antenna with an Elevated Ground Plane for Wearable Applications

Purna B. Samal (University of Technology Sydney, Australia); Shengjian Jammy Chen (Flinders University, Australia & The University of Adelaide, Australia); Christophe Fumeaux (University of Queensland, Australia)

This paper presents the on-body characterization of a horseshoe-slot microstrip antenna with an elevated ground plane fabricated using flexible MXene conductors and a PDMS substrate. The design incorporates two previously developed efficiency-enhancement techniques: radiator optimization to reduce conductor loss and an elevated ground plane to mitigate dielectric loss. These methods improve radiation efficiency by approximately 14% without altering the antenna size or bandwidth. In this work, the optimized antenna is evaluated under on-body conditions to assess its suitability for wearable applications. The results show close agreement between simulation and measurement, with stable impedance characteristics, preserved broadside radiation patterns, and minimal gain degradation when placed on the body. These findings confirm the robustness of the efficiency-driven design for wearable applications.

Presenter bio: Shengjian Jammy Chen received M.E and Ph.D degrees in electrical and electronic engineering from the University of Adelaide, Australia. From 2017 to 2021, he was a lecturer and a postdoctoral researcher at the School of Electrical and Electronic Engineering of the University of Adelaide. Since 2022, he is a lecturer with College of Science and Engineering at Finders University. His current research interests include wearable and reconfigurable electromagnetic structures based on novel conductive materials such as conductive polymers and conductive fabrics, RFID-based wearable applications and leaky wave antennas. Dr. Chen was the recipient of the Young Scientist Best Paper Award at ICEAA 2015 & ICEAA 2016, and Travel Bursary Award in ICEAA 2016. He also received the Honorable Mention in APS/URSI 2017, the CST University Publication Award 2017, and Best Paper Award at IEEE APMC 2021.

Friday, July 24 3:30 - 4:45

BPC (Debabani-Mentoring Session)

Room: Urchins 2

Chair: Debabani Choudhury (SeraTech, LLC, USA)

S18: Dielectric Characterisation

Room: Reef

Chair: Aurelian Crunteanu (XLIM, CNRS/ University of Limoges, France)

THz Material Characterization of Rough Samples

Miguel Navarro-Cía (University of Birmingham, United Kingdom (Great Britain))

The accurate extraction of material properties from free-space methods is dependent on several assumptions, including that the sample has parallel, flat surfaces, and constant thickness, and that the material is homogeneous. In reality, none of these are satisfied for standard samples probed with THz due to the usual non-negligible surface roughness in the range of tens of microns. This invited talk will give an overview on the work done at the University of Birmingham to develop methodologies that pivot around quasi-optical time- and frequency-domain spectroscopy systems to deal with rough samples

Presenter bio: Miguel Navarro-Cía received the M.Sci. and Ph.D. degrees in Telecommunication Engineering, and M.Res. degree in Introduction to Research in Communications from Universidad Pública de Navarra, in 2006, 2010 and 2007, respectively. From September 2006 to March 2011, he worked as a FPI fellow and a Research & Teaching Assistant at UPNA. He was a Research Associate at Imperial College London and University College London in 2011 and 2012, respectively, and a Junior Research Fellow at Imperial College London from December 2012 until November 2015. Currently he is Birmingham Fellow at University of Birmingham. He worked as Visiting Researcher at University of Pennsylvania for 3 months in 2010, at Imperial College London in 2008, 2009 and 2010 for 4, 6 and 3 months, respectively, and at Valencia Nanophotonics Technology Center for 2 months in 2008. His current research interests are focused on plasmonics, THz near-field time-domain spectroscopy, metamaterials and antennas.

A Branch-Independent Computational Method for Dielectric Material Characterization

Yunhao Fu (The University of New South Wales, Australia); Rodica Ramer (University of New South Wales, Australia)

A branch-independent computational method is proposed, permitting dielectric material characterization by extracting its real relative permittivity εr from a propagation factor. The propagation factor, which describes the interaction between a dielectric and an electromagnetic wave, is widely employed in material characterization. However, εr extracted from the propagation factor suffers from phase ambiguity due to the multi-valued nature of the logarithm operation. The resulting multiple phase branches correspond to different εr, making it difficult to determine the correct value. A computational method based on the first derivative of the phase branch is developed with closed-form formulas, producing the correct εr. Simulation validation in the 12-18 GHz band is conducted to demonstrate the method under ideal conditions; an experimental measurement on PTFE samples follows. Unlike traditional wideband characterization methods, which focus solely on a single frequency, the branch-independent method considers the propagation factor's overall behavior in wideband dielectric material characterization.

Application of Q-Chokes for Enhanced Characterization of Materials in FR3 Band

Malgorzata Celuch (QWED, Poland); Wojciech Gwarek (QWED Sp. z O. O., Poland); Lukasz Nowicki (Warsaw University of Technology, Poland & QWED, Poland); Marzena Olszewska-Placha (QWED Sp. z o. o, Poland)

This contribution concerns resonator-based characterization of materials. First, the relevant physical principles are discussed and illustrated with EM modeling. Then, industrial round-robin results are summarized, assessing the commercially available techniques from the viewpoint of 5G/mmWave applications. The presentation then focuses on the novel Q-Choked resonators and their advantages for materials' characterization in the forthcoming FR3 frequency band.

Microwave Probe with Enhanced Sensitivity for Wideband Dielectric Characterizations

Amir Ebrahimi (RMIT University, Australia); Syed Akbar Raza Naqvi and Amin Abbosh (The University of Queensland, Australia)

This paper presents a high-sensitivity microwave probe for broadband dielectric characterization, achieving improved accuracy compared to conventional open-ended coaxial probes based on RG405 coaxial cable. The proposed design employs a series inductive loading at the probe tip, implemented using a via-connected circular patch structure, to enhance electromagnetic interaction with the material under test. An analytical circuit model is developed to quantify amplitude and phase sensitivities, confirming significant improvement over standard probes. A fabricated prototype demonstrates superior performance across 1-7 GHz, validated through measurements of water-ethanol mixtures with up to 15% water content.

A High-Sensitivity Dielectric Characterization Method for Thin-Film Materials Using Ridge Gap Waveguide Resonator

Jiamin He (University of Electronic Science and Technology of China, China)

This paper presents a high-sensitivity dielectric characterization method for thin-film materials using a ridge gap waveguide resonator. The ridge structure enhances the electric field interaction with the material under test (MUT), achieving a 20.5% improvement in sensitivity. The method requires no vias or metal plating, offering reusability and broadband operation. It is verified in Ka-band with RO4350B and in W-band with quartz film, showing good agreement with manufacturer data and simulations.

S27: Online (TBC)

Room: Michaelmus A

Radiative Wireless Power Transfer with Advanced Materials

Naoki Shinohara (Kyoto University, Japan)

Radiative wireless power transfer (WPT) via microwaves and millimeter waves is considered a promising technology to expand the application of electricity. A lot of historical excellent research and development of the WPT via microwaves were carried out in 1960s and in 1970s. Recently, advanced WPT business has started in the world based on the WPT radio wave regulations. Especially in Japan, new legal WPT radio wave regulations at 920MHz, at 2.4GHz, and at 5.8GHz was published in 2022. After the 2022, over 800 WPT base stations has already installed and are working in Japanese buildings mainly for battery-free Billing Energy Management

System (BEMS). In Japan in 2026, we will update the Japanese WPT regulation for more conveniency. In 2026 in IEEE, discussion for new IEEE WPT regulation has already started as IEEE Standard WG3735 originally supported by MTT-S. Current WPT business is based on the wide beam WPT technology, in which wireless power is provided widely to multi-users without beam forming like conventional wireless communication system. Key technology in the wide beam WPT is a high efficiency rectenna, rectifying antenna with diode or CMOS. For the wide beam WPT, advanced diode or SMOS with high efficiency is required. In the next step of the WPT, novel beam forming technology with a phased array antenna is expected. In this talk, current R&D and business of the WPT via microwaves and millimeter waves are introduced. The expectation for the advanced materials for next step WPT is also explained in this talk.

Microwave Sensors Exploiting Nonlinear Dynamics

Almudena Suarez (Universidad de Cantabria, Spain)

Oscillator-based sensing offers compact implementations, with autonomous operation, simple readout mechanisms, and the possibility of exploiting nonlinear dynamical phenomena. These phenomena can significantly enhance sensitivity and provide new sensing modalities that go beyond conventional frequency-shift measurements. The central idea is to deliberately operate oscillators in specific nonlinear regimes in which measurable quantities-such as oscillation frequency, locking bandwidth, beat frequency, spectral structure, or switching thresholds-exhibit a strong dependence on the properties of the material under test. The presentation will first provide an insightful study of how the sensing behavior of a resonant structure is affected when it is incorporated into a loop containing an active nonlinear block. We then address oscillator sensors based on injection locking, using the boundaries of the locking band as the sensing observables. We additionally investigate the high sensitivity of the beat frequency near the locking edges, which is compared with that of the original free-running oscillator. In a different configuration, we synthesize a low-frequency self-oscillation that, through its coupling to the main one, enables sensing based on multiple spectral lines. Using self-injected configurations, we demonstrate extremely sensitive operation near the hysteresis limit, as well as the deliberate use of hysteresis to trigger a state change only when the measurand crosses specific thresholds. A key aspect is the use of rigorous nonlinear analysis and design methodologies that combine analytical modeling, bifurcation theory, describing-function techniques, and harmonic-balance simulations, enabling a systematic understanding of the various dynamical behaviors on which these sensors are based. Experimental implementations based on transistor oscillators operating in the microwave range demonstrate the practical feasibility of these concepts. They illustrate how nonlinear dynamical phenomena, often regarded as undesired effects, can instead provide powerful sensing mechanisms and open new opportunities for the design of compact, highly sensitive microwave sensors.

S9: Microwave Filters and Devices

Room: Michaelmus B

Chair: Bo Li (Chengdu Polaris Information and Communication Technology, China)

A Low-Loss Tunable Bandpass Filter Based on Boundary-Reconfigurable Patch Resonators

Huihui Fei, Ren Rong Zhao, Peng Chen and Chao Yu (Southeast University, China)

This paper presents a low-loss tunable bandpass filter (BPF) based on a boundary-reconfigurable patch resonator. Frequency tuning is realized by reconfiguring the resonator boundary conditions without using conventional lumped elements such as varactor diodes, thereby maintaining low insertion loss. The fabricated filter demonstrates a center-frequency tuning range from 0.45 to 1.15 GHz, corresponding to a tuning ratio of 2.56. Across the entire CF tuning range, the measured minimal insertion loss is maintained below 1.35 dB. In addition, bandwidth reconfigurability is realized, with the fractional bandwidth adjustable from 20.5% to 32.0%. Moreover, transmission zeros are generated at both sides of the passband which enhance the BPF's selectivity. Therefore, the proposed filter provides a practical solution for low-loss tunable filtering applications.

A Multi-Mode Tunable Bandpass Filter with the Continuous Transmission Zero

Guangbao Shan, Chunyu Yang and Yanwen Zheng (Xidian University, China)

This paper presents a compact tunable bandpass filter （TBPF） realized using Through-Silicon Via (TSV) technology. The controlled tunable transmission zeros (TZs) are introduced to achieve bandwidth tuning. The area of the filter is 720×510um2. The result demonstrates a wide continuous bandwidth tuning range from 10 GHz to 14.92 GHz, with a minimum insertion loss of 0.113 dB. Index terms: Tunable, BPF, RF front-end, 3d integration

Wideband Phased-Array Meta-Antenna Without Air Cavity for Ku-Band Satellite Communication

Qing You (University of Macau, Macao); Dianxin Luan (University of Edinburgh, United Kingdom (Great Britain)); Pui-In Mak, Rui P. Martins and Jun Yin (University of Macau, Macao)

This paper presents a wideband dual-linear polarization Ku-Band phased-array meta-antenna that eliminates the need for an air cavity. By incorporating a metasurface, the proposed antenna achieves a broad operational bandwidth from 10.7 GHz to 14.5 GHz with a realized gain exceeding 1.7 dBi. The wideband performance is realized without an air cavity, thereby simplifying the fabrication process. By leveraging this antenna design, a method for achieving both dual-linear and dual-circular polarization is demonstrated. Implemented on a cost-effective PCB platform, the proposed phased array offers a low-cost solution well-suited for satellite communication applications.

A Hexagonal Six-Port Hybrid Coupler for Beamforming Applications

Zhiwei Yin (University of Technology Sydney, Australia); He Zhu (Charles Darwin University, Australia); Xiaojing Lv and Yang Yang (University of Technology Sydney, Australia)

Multibeam scanning capabilities are essential for modern wireless communication systems, including 5G/6G MIMO and satellite technology. This paper presents a novel approach to implementing a 3-beam feeding network using a compact planar six-port regular hexagonal hybrid coupler. Compared to conventional Nolen matrix (NM) designs that rely on a cascaded arrangement of multiple couplers and phase shifters, the proposed design integrates these functionalities into a single planar component. This approach achieves a significant size reduction of over 70% while maintaining excellent RF performance. To verify the concept, a prototype operating at 2.45 GHz was designed and fabricated. The measured results demonstrate an equal power division of 5±0.9 dB and phase differences of ±120 deg and ±0 deg across the 2.28--2.61 GHz band. The simplicity and effectiveness of this approach make it highly suitable for compact, scalable beamforming systems.

Short-Circuit Ring Patch Bandpass Filter on Glass Substrate with MLP-Based Optimization

Jing-Yu Lin (University of Birmingham)

This paper presents a novel design framework for 3rd-order on-chip bandpass filters (BPFs) based on short-circuited ring patch (SCRP) resonators fabricated using through-glass via (TGV) technology on fused silica substrates. The filter units are implemented using 1/n-mode SCRP resonators. To achieve efficient and precise structural optimization, a multilayer perceptron (MLP)-based model is employed, trained on electromagnetic simulation data to map geometric parameters to S-parameter responses. The optimized design, targeting 5G n257/n258 bands, and filter prototypes were designed, fabricated, and experimentally characterized. Both filters exhibit excellent performance, with measured insertion loss (IL) below 1.5 dB and return loss (RL) exceeding 15 dB. The measured results show strong agreement with simulations, validating the effectiveness of the proposed MLP-assisted design methodology.

Friday, July 24 4:45 - 5:00

Awards & Closing Ceremony

Room: Michaelmus A