International Microwave Symposium
11-16 June 2023, San Diego, CA

Workshops at IMS2023

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At the IEEE Microwave Theory and Technology Society (MTT-S) 2023 International Microwave Symposium (IMS), in San Diego, CA, USA, there will be three days of workshops, on Sunday, Monday, and Friday, to accommodate all properly selected high-quality workshops. In San Diego, Fridays are the new Mondays, so we strongly believe that the Friday workshops will also be very well attended.

Sunday is dedicated mostly to RF Integrated Circuits (ICs) Symposium workshops and joint IMS/RFIC ones, with the breakdown given in Table 1. There will be 10 full-day workshops and six half-day workshops. On Monday, there will be a total of 12 workshops, with four joint workshops with the Automatic RF Techniques Group (ARFTG). Eight of the workshops on Monday will be full day, while four will be half day. Finally, on Friday, there will be two full-day workshops and three half-day workshops. Workshop details can be found in Table 2 (check for updated info at https://ims-ieee.org/technical-program/workshops).

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TABLE 1. The IMS RFIC and ARFTG workshops.

Sunday	RFIC	9
	Joint IMS/RFIC	4
	IMS	3
Monday	IMS	8
	Joint IMS/ARFTG	4
Friday	IMS	5

ARFTG: Automatic RF Techniques Group.

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Digital Object Identifier 10.1109/MMM.2023.3242803
Date of current version: 6 April 2023

Figure 1. *Workshop sessions at IMS2022. a) RFIC2022 workshop presentation, b) IMS2022 workshop panel session, and c) IMS2022 workshop presentation.*

This year, we returned to an old tradition that consisted of involving MTT-S technical committees (TCs) in the review of the workshop proposals. The idea was to avoid uncomfortable last-minute petitions for endorsement from workshop organizers to TCs. Therefore, when submitting their proposal, workshop organizers were asked to select at least one TC with affinity with the topics addressed in the workshop proposal. MTT-S TCs did a great job reviewing all workshop proposals, and their feedback was very useful to workshop organizers to refine their proposals and make them more appealing to the audience. As a results, 33 high-quality workshops have been selected out of the 49 original workshop proposals.

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The topics of the workshops range from traditional microwave topics, such as the design and linearization of power amplifiers (PAs), to new areas for the MTT-S, such as microwave solutions for quantum computing. Other nonoverlapping topics include 6G, phased arrays, millimeter-wave (mm-wave) and sub-terahertz (THz) technologies, acoustic filters, RF sensing applications for biomedical applications and more. We are excited by the quality of the proposed workshops and hope you will find the time to attend a few of them, benefit from the excellent speakers, and challenge them with some excellent questions.

Nos vemos en San Diego en Junio!

TABLE 2. The IMS workshops.

Day—Conference	Code	Duration	Title/Organizers/Abstract
Sunday—RFIC	WSA	Half day	**Recent Advancements in Ultralow-Power (ULP) Wireless Communication Technology** *Sai-Wang Tam, Yao-Hong Liu, Oren Eliezer, and Minyoung Song* **Abstract:** ULP wireless communication technology provides many unique features over conventional wireless communication, such as high energy efficiency, low cost, a small form factor, large-scale deployments, reconfigurability, and a simple architecture. This workshop will bring together experts from academia and industry to highlight recent works and applications in this exciting technology. In the first topic, we are going to review the industry impacts on the most successful and large-scale commercialization using ULP wireless communication technologies, such as RFID and near-field communication. After that, we are going to shift our focus to recent research advancements on using RF backscattering techniques in reconfigurable intelligent surfaces and wireless local area network/Bluetooth connectivity solutions. In the final topic of this workshop, we will discuss recent advancements from both the medical industry and academia on biomedical implants, with technologies such as co-optimizing antennas and RFIC to miniature radio module volume. Unconventional wireless propagation methods will also be introduced, such as body channel communication, magnetoelectric applications, ultrasound, and so on.
Sunday—RFIC	WSB	Half day	**A Deep Dive Into Circuit Design for Wireline/Optical and Wireless Transceivers: Commonalities and Differences** *Mahdi Parvizi and Bahar Jalali* **Abstract:** This workshop presents the audience with the similarities and differences between wireless and wireline/optical along with circuit design innovations that enable the next generations of wireline and wireless communications. There are undeniable similarities between the electronic building blocks in wireline and wireless transceivers. On the transmitter side, the linearity of both power amplifiers (PAs) and modulator drivers is the subject of extensive research. On the receiver side, the design of low-noise low-power front ends inspired novel ideas in the design of low-noise amplifiers (LNAs) and transimpedance amplifiers. High-speed data converters, clock generation, and distribution are the essential parts of both wireless and wireline transceivers.
Sunday—RFIC	WSC	Full day	**6G Challenge: Overpass RF Bandwidth Limitation to Reach 100 Gb/s to 1 Tb/s** *Didier Belot, Hao Gao, and Pierre Busson* **Abstract:** Wireless systems with small RF bandwidths, high-order modulations, and advanced signal processing techniques have reached a saturation point. They run into spectrum saturation and interference troubles under the sub-6-GHz frequency band. The International Telecommunication Union announced the opening of 275–450 GHz for superhigh-data-rate communication applications. 5G is becoming a reality worldwide, and 6G is in a championship worldwide. The complete paradigm change of this new generation implies the evolution from today, and one of the elements to be defined will be the revolution in transceiver functions: the data rate is targeted beyond 100 Gb/s, and the carrier frequency to support such data transfer will be in the combination of millimeter-wave (mm-wave) and subterahertz (THz). In 6G, the mm-wave/sub-THz front end has challenges in bandwidth, power consumption, antenna coupling, array integration, and so on. In this workshop, we are also dedicated to silico-based building blocks to present realizations targeting 5G to 6G evolution.

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TABLE 2. The IMS workshops. (*Continued*)

Day—Conference	Code	Duration	Title/Organizers/Abstract
Sunday—RFIC	WSD	Half day	**Electromagnetic (EM) Circuit Codesign and Conflation of Passive/Active Circuits at mm-Wave Frequency** *Vadim Issakov and Ruonan Han* **Abstract:** The integration of passive EM structures and, particularly, the integration of antennas on silicon (Si) becomes feasible at frequencies above 100 GHz, due to wavelength-related size reduction. The goal of this workshop is to give an inspiration on the various novel circuit techniques relying on the conflation of passive and active devices. We discuss how to realize passive on-chip components, such as transformers, coupler baluns, and antennas, and how to combine them with the active circuitry. Furthermore, antennas can be codesigned synergistically with active circuits to realize novel hybrid antenna–electronics with "on-radiator" and near-field functions, such as power combining/splitting, impedance scaling/filtering, active load modulation, noise cancellation, and reconfigurability. A significant research challenge is the application of suitable multiphysics simulation tools and codesign/co-optimization methodologies. This requires 3D full physics solutions for EM simulations. In this workshop, we will discuss emerging techniques for on-chip mm-wave active/passive circuit codesign and applications of these new techniques.
Sunday—RFIC	WSE	Half day	**Fully Depleted (FD)-Si-on-Insulator (SOI) CMOS Energy-Efficient 5G and Internet of Things (IoT) Design Techniques and Related Technology** *Wu Wanghua and Andreia Cathelin* **Abstract:** Thanks to the extended body biasing feature, the FD-SOI process has enabled new system and circuit design techniques to improve RF and mm-wave system performance drastically. Tremendous industry collaboration efforts have committed to taking FD-SOI to higher volumes of production to serve the wireless, IoT, and automotive market in the near future. This workshop includes an overview introductory presentation followed by four talks on FD-SOI technology and industry design examples for RF and mm-wave applications. The introduction provides the overview of FD-SOI technology and its benefits for analog/RF/mm-wave circuit design, focusing on the technology perspective. The following three talks demonstrate RF and mm-wave system design examples using FD-SOI technology for 5G infrastructure and user terminals as well as for the ULP IoT. The final talk reveals the advanced FD-SOI process design road map and what to expect in the near future.
Sunday—RFIC	WSF	Full day	**Enabling Quantum Computing: A Survey of Readout Technologies** *Duane Howard, Fabio Sebastiano, and Kevin Tien* **Abstract:** The continued prevalence of microwave system techniques for interacting with superconducting transmon qubits and spin qubits has driven a resurgence of interest in cryogenic circuits and systems for quantum computing. Moreover, quantum computing applications demand low power, high scalability, and high precision in control signal generation and readout signal processing, which has led to several recent demonstrations of innovative system building blocks as well as end-to-end control and readout chains. In this workshop, we introduce the state of the art in system architectures for qubit control and readout and then focus on the recent developments in technologies related to qubit readout. We examine current building blocks found in high-end systems, then look at the next generation of high-performance cryo-LNA technologies. Finally, we conclude with deep dives into full readout chain construction and testing and metrology for this very challenging ecosystem of components.

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TABLE 2. The IMS workshops. (*Continued*)

Day—Conference	Code	Duration	Title/Organizers/Abstract
Sunday—IMS/RFIC	WSG	Full day	**Fundamentals of RF PAs: From the Basics to Advanced PA Architectures, Practical Design Aspects, and Process Technologies** *Debopriyo Chowdhury and Jennifer Kitchen* **Abstract:** As the performance bottleneck to most RF wireless transmit systems and a critical design component to any RF system, RF PA fundamental design knowledge and realization expertise are highly desired and regarded traits in the RF community. This workshop will walk you through the various aspects of RF PA design, starting from the basics and then introducing the most popular advanced PA architectures. PA designers with decades of experience will provide insight into successfully implementing RF PAs, including practical design aspects ("tricks of the trade"), accounting for PA memory and thermal effects (the big "gotcha"), process technologies, and effectively simulating PA designs to closely predict measured performance. This workshop will provide design insights not obtained from textbook reading, thus benefiting those who are new to the RF PA design field and seasoned warriors who would like a rapid refresher.
Sunday—RFIC	WSH	Full day	**Integration of 6G Systems, From Baseband to Antenna for 6G Phased Arrays** *Gernot Hueber and Shariar Shahramian* **Abstract:** Wireless networks have enabled socioeconomic growth worldwide and are expected to further advance to foster new applications, such as autonomous vehicles, virtual/augmented reality, and smart cities. Due to the limitations of further growth in capacity in the sub-6-GHz spectrum, mm-wave and sub-THz frequencies are gaining an important role in emerging 6G and communication-on-the-move applications. In 6G, RF/mm-wave/sub-THz front ends have challenges in bandwidth, power consumption, antenna coupling, array integration, and so on, considering the integration technologies and packaging challenges. 6G coverage from sub-10 GHz to high frequency and the complexity of systems are increasing, which demands implementations in the right technology [CMOS, Si–germanium (Ge), and so on] and the heterogeneous integration of chipsets, from the baseband and transceiver to the antenna. Heterogeneous integration will be important with the multitude of frequency bands covered, e.g., 7–14-GHz bands up to frequencies >100 GHz.
Sunday—RFIC	WSI	Full day	**mm-Wave Integrated Radars: Opportunities and Challenges** *Yahya Tousi and Vito Giannini* **Abstract:** The unique sensing capabilities of mm-wave radars, bolstered by modern nanoscale Si technology and advanced image processing, have created the opportunity for integrated radar technology to create substantially improved image perception at a considerably lower size and cost compared to the radars of the 20th century. There is a growing effort in both academia and industry to bring this technology to fruition. In this workshop, we overview the existing opportunities in this field and the challenges that need to be overcome to standardize and commercialize integrated radar technology. The workshop brings together a complementary mix of top academic and industry speakers with a breadth of expertise and experience in this field, ranging from the fundamental aspects of circuit design and system integration to sensor fusion, product design, and testing.
Sunday—IMS/RFIC	WSJ	Full day	**mm-Wave and Sub-THz PA Design for Next-Generation Wireless and Sensing Applications** *Steven Callender and Sungwon Chung* **Abstract:** There is no silver bullet PA design that provides a one-size-fits-all solution for next-generation communication and imaging systems, due to the diversity of applications and their associated PA specs (e.g., output power, linearity, bandwidth, and back-off efficiency). The goal of this workshop is to explore leading mm-wave and sub-THz applications and the associated PA specs for these systems. The applications of focus are massive multiple-input, multiple-output (MIMO) and large-scale phased arrays, suborbital satellite communication (satcom), and sub-THz radar. A balanced mixed of both industry and academic perspectives will be provided, offering both a high-level familiarization of the application and associated specifications along with deeper technical dives into current leading PA design techniques in modern process nodes.

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Day—Conference	Code	Duration	Title/Organizers/Abstract
Sunday—RFIC	WSK	Full day	**To 100 Gb/s and Beyond: High-Data-Rate Interconnect Technologies—Who Will Win at Which Scenario?** *Jane Gu and Wooram Lee* **Abstract:** The interconnect bottleneck has been a long-standing grand challenge over decades, caused by the increasing gap between exponentially growing data generation and transmission demand and slowly increasing data bandwidth. Both the electrical interconnect (EI) and optical interconnect (OI) have been investigated extensively to try to combat the challenge; however, both of them face their own inherent constraints. The newly emerging sub-THz/THz interconnect (TI) aims to complement the EI and OI to close the interconnect gap. This workshop plans to bring experts from different domains—OI, EI, and emerging TI—to discuss the challenges, opportunities, and best use scenarios of each interconnect scheme.
Sunday—IMS/RFIC	WSL	Full day	**State-of-the-Art mm-Wave Gallium Nitride (GaN) Transistor and Monolithic Microwave IC (MMIC) Technologies and Future Perspective** *Farid Medjdoub and Keisuke Shinohara* **Abstract:** Owing to the superior electrical and thermal properties of GaN-on-Si-carbide material systems, tremendous progress has been made on GaN-based transistor and MMIC technologies. Advanced heterostructure material designs, epitaxial growth techniques, and transistor scaling processes enabled GaN MMICs to extend their applications from microwave to mm-wave frequencies (up to the W-band). Next-generation RF systems require high efficiency and high linearity for more complex modulation schemes to support very high data rates. The traditional tradeoff among efficiency, linearity, and power density imposes performance limitations on GaN MMICs, which become more pronounced at mm-wave frequencies. In this workshop, world-leading experts will discuss the present status, challenges, and future perspective of mm-wave GaN transistor and MMIC technologies, covering emerging materials and devices, device modeling, thermal management, reliability, and circuit designs.
Sunday—IMS	WSM	Full day	**Advances in Microwave and mm-Wave Wideband Measurements for Radar and Communications Applications** *Gian Piero Gibiino and Nicholas C. Miller* **Abstract:** Wideband measurement and characterization techniques at microwave and mm-wave frequencies are becoming increasingly demanding to satisfy the specifications of the ever-evolving communications and radar industry. This workshop presents recent research and technology advancements from industry, research centers, and academia by discussing relevant performance metrics and their experimental evaluation across different hardware platforms. Advanced characterization techniques are presented for transistors, PAs, and beamformers, encompassing the over-the-air testing, linearity, load pull, and calibration of precision radar. The first half of the workshop is dedicated to state-of-the-art wideband device characterization techniques and load pull. The second half of the workshop is focused on beamformers and over-the-air characterization techniques and standards. Both the morning and afternoon sessions of this workshop will end with open interactive discussions useful to outline future trends and research on these topics.
Sunday—IMS	WSN	Half day	**Engineered Surfaces and Materials for EM Propagation Control in Emerging Applications** *Ryan Cadwell and Connor Devitt* **Abstract:** Engineered surfaces and materials have shown interesting qualities in EM propagation that may be useful in various applications. Characteristics such as reflection, transmission, and absorption can be designed by the control of properties, including metal and dielectric geometry, material permittivity and the refractive index, and the consideration of phenomena such as surface waves. New and reconsidered EM design perspectives, newly enabled geometries from additive manufacturing approaches, and new material compositions, including flexible and tunable (such as phase change) materials, present emerging opportunities for investigation. These areas of exploration may yield advances in communication and sensing ranging from microwave to optical frequencies, including potential applications in 5G and 6G technology.

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Day—Conference	Code	Duration	Title/Organizers/Abstract
Sunday—IMS/RFIC	WSO	Half day	**Advanced Wafer-Level Heterogeneous Integration and Packaging for mm-Wave 5G and 6G Applications** *Kamal Samanta and Kevin Gu* **Abstract:** This workshop will cover various recently developed technologies and the state-of-the-art performance in wafer-level integration and packaging technologies and manufacturing techniques, with challenges and possible future directions and solutions. In particular, it will highlight the latest advancements in areas such as embedded wafer-level ball grid array (eWLB) technology for system integration with high-Q interconnects and passives in thin-film redistribution layers, wafer-level heterogeneous integration of different substrates, bipolar CMOS embedded through-Si vias, sub-THz on-chip antenna integration, innovative fan-out technologies for wafer-level packaging, RF integrated passive devices, fan-out systems in packages, and embedding various chips within the Si metal-embedded chip/chiplet assembly. Further, the workshop will present the practical realization of highly integrated systems, including 60- and 77-GHz eWLB transceiver modules with integrated antennas, 3D wafer-level packaging for mm-wave and submm-wave space systems, and heterointegration technology solutions to enable a full 2D arrays of phased-array systems above 120 GHz.
Sunday—IMS	WSP	Full day	**RF Devices Exploiting Intimately Coupled Multiphysics** *Chris Nordquist and Roy Olsson* **Abstract:** Advances in materials, fabrication, modeling, and testing have enabled devices that achieve new functionality through the coupling of multiple physical phenomena. These devices combine piezoelectric, ferroelectric, magnetostatic, acoustoelectric, and other physics to achieve performance beyond that of mass-produced bulk and surface-wave devices. These unique attributes provide potential for significant impacts on future RF applications. Interactions among different types of physics provide coupling and exchanges of energy among complementary mediums and modes. Examples include integrating piezoelectric and semiconductor materials to couple acoustic and electronic traveling waves, integrating ferromagnetic and piezoelectric materials to couple acoustic and magnetic domains, incorporating ferroelectric materials to change and tune piezoelectric orientation, and the strain tuning of magnetostatic waves. Devices using these effects provide the potential for miniature high-Q tunable resonators and filters, nonreciprocal devices, and single-chip analog signal processors. This workshop will provide perspectives on the physics and application potential for these technologies.
Monday—IMS/ARFTG	WMA	Half day	**Modulation Characterization Enabling Design of High-Efficiency and Linear PA Systems** *Marc Vanden Bossche and Zoya Popovic* **Abstract:** RF PAs play a dominant role in the system performance of wireless transmitters. PA designers are faced with the intractable goal of providing simultaneous high linearity and efficiency as communications standards adopt ever-higher modulation orders and bandwidths. Traditional PA design begins with a nonlinear transistor model based on continuous waveform measurements. When the PA is measured under the desired modulated signals, degraded performance compared to simulation is commonly observed. Commercial adoption of phased arrays increases the disparity between traditional simulation and realistic measurements; coupling between antenna elements affects the PA performance in ways not accounted for in simulation. This workshop presents the next steps in improving designs by using modulation characterization to optimize the global realistic performance of a system of PAs. The goal is to provide theoretical and practical background that can be applied directly at the lab bench. The workshop includes a practical demonstration using a commercial GaN device.

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Day—Conference	Code	Duration	Title/Organizers/Abstract
Monday—IMS/ARFTG	WMB	Half day	**Innovative and Compact Methods for Over-the-Air Characterization of Active Antenna Array Systems** *Thomas Deckert and Okay Schierhorn* **Abstract:** Active array antennas have become mature technology in communication and radar applications. The spatial radiation characteristics are typically measured "over the air" using anechoic chambers and positioning gear to perform far- and near-field measurements. These approaches have long been used by engineers to characterize classic passive antennas, while measurements of RF front ends and baseband circuitry could be performed conductively, bypassing the antenna. Since frequencies continue to increase to sub-THz frequencies, designers need to integrate antennas with beamforming chips, making a separate characterization of antennas and RF chips impossible. Additionally, the classical methods do not scale well to high test volumes that will come with active antennas becoming more ubiquitous because they are slow, large, and mechanically challenging, all driving up the test cost significantly. This workshop highlights key advancements on alternative multiprobe testers, near-field sockets, and quantum sensing probes to overcome these limitations.
Monday—IMS	WMC	Full day	**Artificial Intelligence (AI) and Machine Learning (ML) for RF PA Design and Digital Predistortion (DPD)** *Anding Zhu and Rui Ma* **Abstract:** AI and ML have transformed technologies across all sectors and are offering solutions to many complex problems. In RF design, many AI/ML-based solutions have been proposed. This workshop brings researchers from both academia and industry to discuss how newly developed AI/ML algorithms can be used in RF PA design and DPD. The topics include using multidimensional search algorithms to automate matching network synthesis, postlayout generation using fully automated optimization methods, AI-based signal control technology, and deep learning-based inverse design in mm-wave PAs. We will also discuss the latest development of DPD algorithms using ML, including DPD model simplification, long-term memory effect compensation, model extraction data selection, closed-loop adaptation, and neural network-based DPD for linearizing multiband MIMO phased-array transmitters.
Monday—IMS/ARFTG	WMD	Full day	**Device Thermal Noise Metrology: Needs, Challenges, and Opportunities** *Tom McKay and Leonard Hayden* **Abstract:** The availability of high-volume extremely low-noise-transistor very large-scale integration technologies with minimum noise figures as low as 0.2 dB (Te,min 14 K) at cellular, Wi-Fi, and satcom frequencies challenges existing noise metrology practice. State-of-the art device noise metrology systems are unable to provide system architects and technology developers the ability to clearly discern the performance of one device technology over another at these low noise levels. Recent investments by the European Union and U.S. government in semiconductor manufacturing, including RF, microwave, and mm-wave applications, underscore the need and opportunity for further public–private collaboration in this area. This workshop begins with motivation for extremely low-minimum-noise-figure technology from applications in low-Earth orbit satcom and remote sensing, followed by technology developers' experience with existing metrology practice, and culminating with discussions on ways forward with commercial vendors and the National Institute of Standards and Technology.

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Monday—IMS	WME	Full day	**Microwave/RF Sensors for Near-Field and Long-Range Sensing Applications** *Mohammad Zarifi and Valentina Palazzi* **Abstract:** This workshop will provide a comprehensive overview of the latest results on the sensing, monitoring, and characterization capability of RF/microwave-based devices operating from 30 MHz to 300 GHz. Microwave-based sensors have demonstrated great potential for the nondestructive and nonionizing monitoring of physical parameters and characterization of materials in liquid and solid phases. The main advances and results in this multidisciplinary subject, involving chemistry, material science, and microwave engineering, will be illustrated. Microwave resonator sensors, RFID sensors, and antenna-based sensors for nondestructive, nonionizing, and contactless sensing and characterization applications will be covered to provide the audience with an in-depth understanding of the subject and the potential synergies among different approaches.
Monday—IMS	WMF	Half day	**Emerging Synthesis-Based Design Techniques for Filters in Advanced Communication Systems** *Giuseppe Macchiarella, Ming Yu, and Fabien Seyfert* **Abstract:** The evolution of communication technologies in recent years has required more and more performing subsystems and devices. This workshop is focused on the latest solutions devised for the filtering subsystems required in the latest-generation communications systems. Developing these subsystems is challenging and expensive, and it increases the time to market for new equipment. The scope of the workshop is to show how a synthesis-based approach may beneficially affect new filter development (as an alternative to the brute force optimization of full-wave models). In the first part of the workshop, five presentations show novel synthesis solutions for filters used in modern and future communication systems. In the second part, the goal is to involve interactively the audience, showing the synthesis of some previously introduced filters, using in-house-developed software. This interactive moment is conceived to highlight the benefits of a synthesis-based design approach and familiarize attendees with this technique.
Monday—IMS	WMG	Half day	**Recent Advances in Industrial Microwave Power Applications** *Zoya Popovic, Vadim Yakovlev, and Malgorzata Celuch* **Abstract:** Applications of microwave power span an increasing number of research and industrial sectors. They include the widely known microwave heating, cooking, sterilization, vulcanization, and so on. The microwave sintering of particulate materials, microwave plasma generation, and microwave acceleration of chemical reactions for applications such as waste treatment are among the new disciplines showing the potential for new efficient technologies. Additionally, traditional S-band magnetron high-power sources are being challenged by semiconductor technologies that have some advantages but are still more costly. The workshop has speakers from industry who will compare existing technologies and discuss the most recent applications and multiphysics tools used to address them. One academic talk will discuss the main fundamental challenges through a few examples, such as the pyrolysis of mixed waste.
Monday—IMS/ARFTG	WMH	Full day	**Microwave Measurements in Extreme Environments for Emerging Applications in Computing, Energy, and Life Sciences** *Kamel Haddadi, Mitch Wallis, and Luca Pierantoni* **Abstract:** Microwaves have a vital role to play in a diverse collection of emerging application areas far beyond wireless communications and conventional microelectronics, spanning from quantum computing to energy storage to medical diagnostics. To unlock these potential applications, reliable microwave measurements are critical. Quantitative functional data are required at each step of development to transform conceptual designs into fully engineered, validated, and optimized products. While microwave measurement techniques are generally well established, new applications that are emerging today present new measurement challenges. This workshop will explore the current state of the art in microwave metrology techniques that are extended to new and novel measurement

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			environments and scenarios. The event will bring together researchers from across academia, industry, and government laboratories who work in varied application spaces. While these emerging applications may appear disparate, convening experts for detailed discussions of their microwave measurement challenges may uncover previously unseen connections and commonalities.
Monday—IMS	WMI	Full day	**Quantum Circuits, Methods, and Algorithms in EM and Microwave Applications** *Johannes Russer, Vladimir Okhmatovski, and Zhen Peng* **Abstract:** In recent years, significant advances have been made in quantum computing, quantum sensing, and quantum communications. Circuit quantum electrodynamical models provide tools for modeling quantum devices. Superconducting electronics exhibit special quantum properties and, when monolithically integrated, extend the possibilities for integrated microwave circuits and devices, deeply rooted in microwave engineering, to a quantum level. For RF microwave engineers, this signifies an extension and transfer of microwave engineering concepts to the quantum realm. Using quantum circuit electrodynamics, key devices in microwave quantum engineering can be modeled. On the other hand, within quantum computing, new quantum-based algorithms can also harness problem-solving in EMs. In recent years, the remarkable progress made in quantum computing hardware has defined a new noisy intermediate-scale quantum computing era. By exploiting fundamental properties of quantum mechanics, these quantum computing systems have the potential to deliver a significant speedup against classical computing hardware for solving hard EM problems.
Monday—IMS	WMJ	Full day	**History and Recent Advances in Reflect Arrays for Satcom, 5G/6G, and Imaging Systems (Also Known as Intelligent Reflecting Surfaces)** *Gabriel Rebeiz* **Abstract:** Reflect arrays, invented in the 1980s, have been predominantly used for satellite communications, high-speed imaging systems at 24 GHz (airport security systems), and mm-wave radars. Recently, they have been proposed as programmable reflecting surfaces for 5G communication systems and renamed "intelligent reflecting surfaces." This workshop presents the previous work in this area and the new work being done from 24 GHz to 300 GHz. Some of the new work is geared toward large reflecting surfaces for 5G/6G, some toward THz imaging systems, and some toward space applications. What is important is that with new low-loss Si technologies and the high level of integration offered by Si, one can now demonstrate large low-power low-loss reflecting surfaces. The new reflect arrays are expanding this classic steerable antenna technology to a wide range of application areas spanning 5G, 6G, frequency-modulated continuous-wave radars, and THz systems.
Monday—IMS	WMK	Full day	**Transitioning From Microwave to mm-Wave Acoustic Wave Devices: Future Road Map and Challenges** *Jordi Verdu and Pedro de Paco* **Abstract:** The complexity of the requirements in advanced 5G and forthcoming scenarios has a direct impact on the design of acoustic wave filters. The latest developments have pushed acoustic technology to an unprecedented situation that requires facing the incoming challenges from different perspectives. Taking this into account, the workshop aims to present the latest developments related to synthesis methodologies, linear and nonlinear modeling, reconfigurability, and new orthogonal markets that may consider the use of acoustic wave resonators. The affiliation of the presenters will lead to talks with a more industrial focus but also with an academic approach, which may contribute to a more enriching discussion.

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Day—Conference	Code	Duration	Title/Organizers/Abstract
Monday—IMS	WML	Full day	**Recent Advances in Low-Phase-Noise and High-Stability Microwave Oscillators** *Alexander Chenakin and Paul Khanna* **Abstract:** This workshop will address the timely subject of low-phase-noise and high-stability microwave oscillators that are key building blocks of virtually any RF/microwave system. State-of-the-art low-noise and high-stability microwave oscillators are particularly important in high-speed telecommunications, wireless spectrum management, and high-resolution imaging systems. The overall performance of most microwave subsystems depends on, and is often limited by, phase noise fluctuations in oscillators. With respect to phase noise and stability performance, designers primarily rely on ovenized crystal oscillators. However, recent advances in using other physical principles and materials are expected to enable oscillators with performance never imagined before. Various oscillator types, techniques, new materials, and their main characteristics will be reviewed.
Friday—IMS	WFA	Half day	**Microwave Challenges and Solutions for Quantum Computing** *Michael Hamilton and Alirio Boaventura* **Abstract:** Quantum computing platforms are actively being scaled up to a level that can outperform tomorrow's most powerful classical supercomputers to solve certain impactful complex computations related to materials, energy, and climate. Despite the tremendous progress made over the past decade in the science and engineering of an array of quantum computing systems, many challenges remain. One of the current promising candidate platforms for scaling up uses superconducting qubits that are controlled and read out using conventional microwave electronics operating at room temperature. Future versions of these systems are envisioned to bring more of the microwave electronics nearer the quantum processor but will require innovation to overcome the associated microwave challenges. The engineering challenges of realizing practical large-scale and densely integrated quantum information processing systems present quantum microwave engineers with new challenges and opportunities. This workshop will address current challenges and solutions being explored to realize scaled superconducting microwave quantum information processing systems.
Friday—IMS	WFB	Half day	**Packaging and Interconnects for Superconducting Applications** *Matt King, Robert Jackson, and Wolfgang Heinrich* **Abstract:** There have been significant advances in the application of quantum technologies, with several examples demonstrating the feasibility of what a few decades ago were only theories. However, key challenges still remain as a barrier to fully realizing the advantages brought by quantum technologies. One of the main challenges to overcome is scaling up quantum systems by several orders of magnitude. For instance, as the leading approach in quantum computing relies on superconductors and microwave signal processing, exploring options in packaging and interconnects for superconducting applications in the 4-K and milli-Kelvin range is necessary. This workshop offers the opportunity to hear from multiple speakers who are actively working in the areas of microwave packaging and interconnects for superconducting application to face the challenges ahead.

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TABLE 2. The IMS workshops. (*Continued*)

Day—Conference	Code	Duration	Title/Organizers/Abstract
Friday—IMS	WFC	Half day	**Frontiers of mm-Wave Phased Arrays** *Hasan Sharifi and Laleh Rabieirad* **Abstract:** With the development of high-performance semiconductor nodes and emergence of 5G and 6G systems, significant advances have been achieved in electronically scannable mm-wave phased arrays. The continued performance improvements of advanced node CMOS and scaled SiGe heterojunction bipolar transistors have enabled the development of highly integrated mm-wave phased arrays for low-cost, small-size, and low-dissipation applications. As a result, we have made great advances in RF front ends, antenna arrays, and high-speed analog-to-digital converters. On the other hand, the recent development of THz III-V high-electron mobility transistors has enabled phased arrays at previously inaccessible frequencies. This workshop will discuss some of the highlights of major advances in mm-wave phased arrays in four invited talks by industry and academic leaders. The range of these topics will show how the varying application spaces impose requirements that flow down through the system architecture and component designs to the semiconductor technologies.
Friday—IMS	WFD	Full day	**D-Band and Sub-THz Technologies, Circuits, and Systems for High-Data-Rate Communication, Sensing, and Imaging** *Telesphor Kamgaing, Ali Farid, and Alberto Valdes-Garcia* **Abstract:** The large available spectrum at mm-wave frequencies above 100 GHz offers wideband channels with tens-of-GHz-wide bandwidth. This enables the development of wireless and waveguide communication systems with unprecedented data capacity. The small carrier wavelength (λ) permits compact arrays with many antennas. This paves the path for compact radio imaging systems with very high resolution. The goal of this workshop is to review the most recent advances in wireless, waveguide, and radar systems at the D-band and beyond. Selected experts from academia and industry will discuss end-to-end components and challenges associated with novel mm-wave massive MIMO arrays, large-scale phased arrays, high-data-rate waveguide systems for data centers, and radar and sensing systems with very high resolution above 100 GHz. The topics addressed will include semiconductor technology, mm-wave wireless transceivers, antenna arrays, waveguide channels, and fully packaged modules.
Friday—IMS	WFE	Full day	**RF and mm-Wave Biomedical Radar Technologies** *Changzhan Gu, Chung-Tse Michael Wu, Fu-Kang Wang , Nils Pohl, and Changzhi Li* **Abstract:** In the past few years, the COVID-19 pandemic has drawn attention to health. RF and mm-wave radar has been regarded as an emerging technique for the contactless monitoring of health conditions, particularly the health of a subject's respiratory and cardiovascular systems. Radar has evolved from a complex high-end technology into a relatively simple low-cost solution penetrating industrial, automotive, and consumer market segments. The adoption of short-range radars for consumer applications requires reliable system performance in a small form factor, low power, and low cost. The advancement of Si and packaging technology has led to a small form factor that can be mounted on devices and aesthetically concealed without affecting system performance. This workshop covers multiple aspects of how to leverage short-range radar sensing for biomedical applications, including metamaterial bioradar, clinical evaluations, gait analysis, monitoring impaired people, system design principles, and MIMO bioradars.