2025 IEEE Texas Symposium on Wireless and Microwave Circuits and Systems

Timothy T. Lee
2025 President IEEE-USA,
Technical Fellow
Boeing Research and Technology

The Role of Advanced Microelectronics and Heterogeneous Integration for Next-Generation 5G/6G Microsystems

With the recognized end of Moore's Law scaling due limits of photolithography, the semiconductor industry has embarked on a couple of different approaches; from the evolution of FinFETs to Gate-All-Around (GAA) devices and shortening interconnects by stacking of dies with 2.5D / 3D heterogeneous integration techniques. Together these two innovations will enable continued advances for higher performance, lower power and costs. The biggest hurdle for systems is much higher energy efficiency and power management. As for RF, millimeter-wave systems, the trends are to develop, mature and field higher power density devices based on Gallium Nitride (GaN) that are superior to older GaAs devices.

IEEE has been active in a number of technology roadmap activities that include the Heterogeneous Integration Roadmap (HIR). Roadmaps are useful to guide our focus on what is coming up within the next 3-, 5- and 10 year horizons. The biggest market driver for silicon today is for AI/ML in particular for training of Large Learning Models (LLMs). The biggest market driver for III-V is for 5G/6G, and sensing applications like radar where phased-array systems are deployed. The biggest challenges for millimeter-wave technologies is the propagation losses at the higher frequencies which result in limited range of bases-stations to handset communications. The use of phased-array architectures helps to overcome some of these challenges but is it enough? for 6G (100- to 300-GHz), the potential for 8 to 10 GHz of instantaneous bandwidth may enable even higher data-rates but with even more reduced range. From a design perspective, as we go higher in operating frequencies, the available space between radiating elements is reduced. Heterogeneous Integration that enables tight integration of antenna, RF transceivers and backend processors will pave the way to AI-enabled Integrated Sensing and Communication applications.

This talk will provide an overview of the status of microelectronics, summarize HIR roadmap, look at market drivers and discuss the potential impacts of IMT-2030 to our microwave community.

Timothy Lee is a Boeing Technical Fellow based in Southern California. He leads the development of disruptive microelectronics technologies for advanced communications networks and sensor systems for airborne and space applications. His research interests include 3D Heterogenous Integration (3DHI) technologies for chiplet/wafer stacking of digital/analog/RF silicon/III-V devices for high-performance, and low-power microelectronics for aerospace and defense application. He is principal investigator for the transition of IRAD, CRAD and university Lab to Fab research into technologies for defense systems. During his over 40 years of experience, he has held technical/managerial positions at research facilities, aerospace companies, and semiconductor foundries. He has led development of hardware for satellite communications and has built phased-array antenna electronics for commercial and US government customers. Tim has authored over 30 journal and conference papers. Tim is a very active member of IEEE and has served the community in several positions, including IEEE MTT-S president in 2015, IEEE 2020 International Microwave Symposium General Chair, IEEE MGA Operations Committee in 2021, and IEEE-USA board of directors from 2021 to 2022 to name few. He is currently IEEE-USA president-elect for 2024. He holds SMEE and SBEE degrees from MIT and a master's degree in system engineering from University of Southern California.

2025 IEEE Texas Symposium on Wireless and Microwave Circuits and Systems

Costas Sarris
Professor,
University of Toronto

The Applications of AI/ML in Future RF/Wireless Circuits and Systems

A recent report by the US Department of Energy defines the area of scientific machine learning as a core component of artificial intelligence (AI) and a computational technology that can be trained, with scientific data, to augment or automate human skills, which has the potential to transform science and energy research. In this presentation, I discuss the potential of scientific machine learning methods to the analysis and design of microwave circuits and wireless systems.

We present a 3-D electromagnetic simulator for integrated microwave circuits based on Physics-Informed Neural Networks (PINNs). PINNs directly integrate physical laws into their loss function, so that the training process does not rely on the generation of ground truth data from simulations (as in standard neural networks). I will extend this approach to multiphysics simulations of microwave components, such a MEMS. Finally, we demonstrate the potential of PINNs as fast surrogate models of complex structures that lend themselves to uncertainty, reliability and
yield analysis under fabrication and material tolerances.

Moreover, I demonstrate the impact of machine learning on the computational modeling of radio wave propagation scenarios. We build convolutional neural network models that can process the geometry of indoor environments, along with physics-inspired parameters, to rapidly estimate received signal strength (RSS) maps. Emphasis is placed on the generalizability of these models, which is their ability to learn the physics of radio wave propagation and produce accurate modeling predictions in new geometries well beyond those included in their training set

Costas Sarris is a Professor with the Department of Electrical and Computer Engineering, University of Toronto. His research area is computational electromagnetics, with an emphasis on time-domain modeling. He also works on physics-based wireless propagation models (with full-wave, asymptotic, and hybrid techniques), uncertainty quantification, and scientific machine learning.

Dr. Sarris is an IEEE Fellow. He was a recipient of the 2021 Premium Award for Best Paper in IET Microwaves, Antennas & Propagation, and the IEEE MTT-S Outstanding Young Engineer Award in 2013. He was the TPC Chair of the 2015 IEEE AP-S International Symposium on Antennas and Propagation and the CNC/USNC Joint Meeting, the 2019 and 2023 MTT-S Numerical Electromagnetics, Multiphysics and Optimization (NEMO) Conference, the TPC Vice-Chair of the 2012 IEEE MTT-S International Microwave Symposium, and the Chair of the MTT-S Technical Committee on Field Theory and Numerical Electromagnetics (2018–2020). In 2019-2024, he was the Editor-in-Chief of the IEEE JOURNAL ON MULTISCALE AND MULTIPHYSICS COMPUTATIONAL TECHNIQUES.

Naveen Yanduru
Vice President,
Renesas Electronics

Market and technology trends defining the future of wireless communications

The evolution of wireless communications is driven not only by faster connections but by the need for massive capacity expansion. With the rise of IoT, Integrated Access and Backhaul (IAB), Non-Terrestrial Networks (NTN), and data-intensive applications like AR/VR and gaming, networks must adapt to meet increasing capacity demands.

This talk will examine current and future capacity needs, highlighting key technical factors such as SNR and bandwidth and market factors such as market sizes and cost expectations. We will explore RF circuit and system-level innovations that enhance SNR and showcase advanced RF beamforming ICs and modems that enable the use of high-frequency spectrum.

Naveen Yanduru received his PhD from the University of Texas at Dallas. He brings 3 decades of experience in the semiconductor industry, progressing from engineering roles to leadership positions. He has led the development of RF front-ends, transceivers, and SoCs, contributing to the shipment of over 400 million chips across sectors including handsets, wireless infrastructure, aerospace, and defense. As Vice President and General Manager of the RF Business at Renesas, he drives innovation and market leadership in the global semiconductor space.

Previously, Dr. Yanduru held technical and management roles at Texas Instruments, Samsung, PSemi, Qualcomm, and IDT. He holds 26 U.S. patents, has authored more than 25 IEEE publications, and has served as an IEEE Distinguished Lecturer.

Kamran Entesari
Professor,
Texas A&M University

Silicon Photonics for Software-Defined Radios and Radio-over-Fiber Links

Next generation wireless communication systems are actively investigated to accommodate the expanding data traffic of the future, prompting the consideration of silicon photonics (SiP) devices and circuits as promising candidates for high-performance, cost-effective solutions.
This talk focuses on exploring two state-of-the-art RF applications of SiP technology. The first one is to utilize SiP technology as part of a microwave/mm-wave soft-ware defined radio architecture to provide wideband automatic RF channel selection and jammer rejection. A task which is extremely challenging to achieve using stand-alone integrated electronic radios at these frequencies. The second application is to utilize SiP technology to develop cost-effective remote antenna units for radio-over-fiber links at microwave/mm-wave frequencies. Radio-over-fiber links are very instrumental in deploying dense distributed antenna units to avoid obstacles for indoor wireless communication or distributing 5G/6G wireless communication nodes to expand the wireless coverage.

Kamran Entesari (IEEE Fellow) received his Ph.D. degree from The University of Michigan at Ann Arbor, in 2005. In 2006, he joined the Department of Electrical and Computer Engineering at Texas A&M University, where he is currently a Texas Instruments Engineering Professor. His research interests include integrated RF photonics, RF/microwave/millimeter-wave integrated circuits and systems, and microwave chemical/biochemical sensing.

Prof. Entesari was a recipient of the 2017/2018 Qualcomm Faculty Award, the 2011 National Science Foundation CAREER Award, the 2009 Semiconductor Research Corporation Design Contest Second Place Award, the Best Student Paper Award of the IEEE RFIC Symposium in 2014 (second place), the IEEE Microwave Theory and Techniques Society award in 2011 (third place), and the IEEE Antennas and Propagation Society award in 2013 (Honorable Mention). He is currently a Technical Program Committee Member of the IEEE IMS Symposium. He was an Associate Editor of the IEEE Microwave and Wireless Components Letters journal and Technical Program Committee Member of the IEEE RFIC conference. He has published more than 170 peer-reviewed IEEE journal and conference papers and has given numerous invited talks and workshop tutorials.