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Terahertz Integrated Circuits: Large Spectrum On Small Chips

Prof. Ruonan Han

Department of Electrical Engineering and Computer Science

Massachusetts Institute of Technology

Date: Thursday, June 18, 2015

Time: 5:30 Reception, Dinner (Optional) 6:00 pm, Lecture 7:00

Place: American Center for Physics, One Physics Ellipse, College Park, MD 20740

Directions: Map

Free parking.

All IEEE members and guests are welcome to attend.

Cost: Lecture and reception free, optional Dinner $10

Please RSVP (Dinner only) to Roger Kaul, r.kaul@ieee.org by June 17th

Abstract:

Terahertz radiation has enormous applications in biomedical, security and communication areas. Non-ionizing THz sensing, as a non-invasive diagnostic solution, has shown great potentials in the assessment of burn injury, measurement of corneal hydration, defect detection in non-metallic materials, etc. Spectroscopy in THz range can be used in the identifications of explosives and noxious gas, as well as the breath analysis for health monitoring. Every two years, the transmission data rate triples in wireless links , and doubles in wireline links. Carriers near or within the THz range will soon become indispensable to meet the challenges in the big data era.

Monolithic on-chip integration of THz systems has emerged as a promising solution to trigger the wide applications of the THz wave. Compared to other technologies, THz integrated circuits (THz ICs) have the advantages of low cost, small form factor, room-temperature operation, and high integration capability. These have made THz IC the key enabler for the future portable and affordable THz devices and equipment.

To push the limits of the THz electronics performance, and demonstrate unique capabilities using the integrated-circuit approach, in this talk, we present our efforts across the levels of device engineering, nonlinear theory, electromagnetism and system architecture. In particular, we show an interesting "wave-synthesis" method to consolidate the above disciplines into highly compact and versatile circuit structures. For the prototypes of such approach, we present a 260-GHz CMOS radiator array with 1.1-mW output power, a fully-passive 480-GHz CMOS frequency doubler with 0.2-mW power, as well as a SiGe transmitter with a 3.3-mW radiated power at 320GHz—this, as well as the related DC-to-THz radiation efficiency of 0.54%, are the highest among all silicon-based THz sources. In addition, we also utilize the strength of silicon chips in large-scale integration, and demonstrate capabilities such as electronically-scanned 280-GHz focal-plane imaging array, 260-GHz pulse generation, as well as the first fully-integrated phase locking for THz radiation. These open

up new opportunities in handheld spectrometers, heterodyne imagers, and so on.

Speaker:

Professor Ruonan Han received his Ph.D. degree in electrical and computer engineering from Cornell University in 2014. Prior to that, he received his B.Sc. degree from Fudan University in 2007 and M.Sc. degree from the University of Florida in 2009. He worked as a summer intern at Rambus Inc. in 2012. In 2014, he was appointed as the E. E. Landsman (1958) Career Development Assistant Professor by the Department of Electrical Engineering and Computer Science at Massachusetts Institute of Technology. He is a core faculty member in the Microsystem Technology Laboratories.

The research of Prof. Han is focused on millimeter-wave and terahertz integrated circuits and microsystems. The development of electronics at his group aims to revolutionize the sensing technologies in biomedical diagnosis, homeland security, and industrial quality control. His research efforts also target at key challenges from the next-generation wireless/wireline communications. Prof. Han is the recipient of the IEEE Solid-State Circuits Society Pre-Doctoral Achievement Award, and the IEEE Microwave Theory & Tech. Society Graduate Fellowship Award. He also won the Best Student Paper Award (2nd) at 2012 IEEE RFIC symposium, the ECE Innovation Award and Director's Thesis Research Award at Cornell University.