



## LECTURE: Millimeter-Wave to Terahertz Circuit/System Designs Based on Deep-Scaled CMOS

*Dr. Mau-Chung Frank Chang*

### CONTENTS:

The continuous scaling of CMOS technologies has opened up new opportunities for developing highly integrated circuits and systems based on deep-scaled CMOS in the spectra range from mm-wave to Terahertz. This talk will highlight the impact of such device scaling to mixed signal circuit/system designs from 60GHz to 1.3THz and share various design examples based on unique approaches developed in our UCLA High Speed Electronics Laboratory (HSEL).

We will first address methods of signal generation, amplification and modulation for high performance and energy efficient transmitters and then share our solutions to high linearity and broadband signal receiving, mixing and demodulation for highly integrated and portable digital radio, radar and image systems. We will also discuss design issues concerning ultra-high speed and low power data converters (ADC/DAC) for supporting aforementioned System-on-Chip developments.

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**12:30-14:00h**

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### Prof. Mau-Chung Frank Chang

Dr. Mau-Chung Frank Chang is the *Wintek Endowed Chair and Distinguished Professor* of Electrical Engineering and the Director of the High Speed Electronics Laboratory at University of California, Los Angeles (UCLA).

Before joining UCLA, he was the Assistant Director and Department Manager of the High Speed Electronics Laboratory at Rockwell Science Center (1983-1997), Thousand Oaks, California. In this tenure, he successfully developed and transferred the *AlGaAs/GaAs Heterojunction Bipolar Transistor (HBT)* and *BiFET* (Planar HBT/MESFET) integrated circuit technologies from the research laboratory to the production line (now Conexant Systems and Skyworks). The *HBT/BiFET* productions have grown into multi-billion dollar businesses and dominated the cell phone power amplifiers and front-end module markets (currently exceeding one billion units/year). Throughout his career, his research has primarily focused on the development of high-speed semiconductor devices and integrated circuits for RF and mixed-signal communication and sensing system applications. He was the principal investigator at Rockwell in leading DARPA's ultra-high speed *ADC/DAC* development for direct conversion transceiver (*DCT*) and digital radar receivers (*DRR*) systems. He was the inventor of the multiband, reconfigurable *RF-Interconnects*, based on FDMA and CDMA multiple access algorithms, for *ChipMulti-Processor (CMP)* inter-core communications and inter-chip *CPU-to-Memory* communications. He also pioneered the development of world's first multi-gigabit/sec *ADC*, *DAC* and *DDS* in both *GaAs HBTs* and *Si CMOS* technologies; the first 60GHz radio transceiver front-end based on *transformer-folded-cascode (Origami)* high-linearity circuit topology; and the low phase noise CMOS VCO ( $FOM < -200\text{dBc/Hz}$ ) with Digitally Controlled on-chip Artificial Dielectric (*DiCAD*). He was also the first to demonstrate CMOS oscillators in the Terahertz frequency range ( $1.3\text{THz}$ ). He was also the founder of an RF design company G-Plus (now SST Communications) to commercialize WiFi 11b/g/a/n power amplifiers, front-end modules and CMOS transceivers.



Dr. Chang has authored or co-authored over 280 technical papers, 10 book chapters, authored 1 book, edited 1 book and holds >20 U.S. patents. He was a co-editor of the *IEEE Transactions on Electron Devices* (1999-2001) and served as the Guest Editor for the *IEEE Journal of Solid-State Circuits* in 1991 and 1992, and for the *Journal of High-Speed Electronics and Systems* in 1994.

He was elected to the *US National Academy of Engineering* in 2008 for the development and commercialization of GaAs power amplifiers and integrated circuits. He was elected as a Fellow of IEEE in 1996 and received IEEE *David Sarnoff Award* in 2006 for developing and commercializing HBT power amplifiers for modern wireless communication systems. He was also the recipient of 2008 *Pan Wen Yuan Foundation Award* and 2009 *CESASC Career Achievement Award* for his fundamental contributions in developing AlGaAs/GaAs heterojunction bipolar transistors. His recent paper "*CMP Network-on-chip Overlaid with Multiband RF-Interconnect*" was selected for the *Best Paper Award* in 2008 *IEEE International Symposium on High-Performance Computer Architecture (HPCA)*. He received Rockwell's *Leonardo Da Vinci Award (Engineer of the Year)* in 1992; National Chiao Tung University's *Distinguished Alumnus Award* in 1997; and National Tsing Hua University's *Distinguished Engineering Alumnus Award* in 2002.

Dr. Chang received his B.S. in Physics from National Taiwan University in 1972, his M.S. in Materials Science from National Tsing Hua University in 1974, and his Ph.D. in Electronics Engineering from National Chiao Tung University in 1979.