WSL (IMS/RFIC) Sunday 13:00 – 17:00 BCEC Room 153C

State-of-the-Art of Low-Noise III-V Narrow-Bandgap and Silicon FET Technologies for Low-Power Applications

Half-day workshop reviewed by MTT-14, MTT-7, MTT-23.

Organizer(s):

Francois Danneville, IEMN-DHS, UMR CNRS, France; MTT-14, IMS TPC.
Paulius Sakalas, CEDIC, Dresden University of Technology, Germany; MTT-14.

This workshop aims to investigate various state-of-the-art low-noise FET technologies for low-power applications: (i) narrow-bandgap III-V HEMTs technologies (on InP or GaAs substrate) (ii) Si CMOS Technology. The first part will focus on InGaAs/InAlAs and Antimonide-Based Compound Semiconductor (ABCS) InAs/AlSb HEMTs. Devices specifically designed to operate at lower DC power consumption, or for low-noise operation, will be presented along with corresponding characterizations (models extraction). Their capability will be shown through ultra-low power MMIC (or hybrid) circuits, including low-noise amplifiers (operating at room and cryogenic temperatures) and switches in cm/mm-wave range. Strengths and limitations of such technologies will also be addressed. The second part will focus on Si CMOS technology. Millimeter-wave LNA will be presented with recent advances concerning CMOS mm-wave building blocks. Special attention will be paid on particular techniques taking advantage of CMOS technology while circumventing its weaknesses. Finally, a new scheme to optimize RF noise of MOSFETs through channel engineering will be described in detail.

Speakers:

1. Jan Grahn, Chalmers University of Technology, Göteborg, Sweden
"Narrow-Bandgap InGaAs/InAlAs and InAs/AlSb HEMTs for Low-Noise and Low-Power Applications"

The narrow bandgap high electron mobility transistor (HEMT) based upon either InGaAs/InAlAs or InAs/AlSb heterostructures has the potential for high-frequency and low-noise performance at a low DC power consumption. After a short background to low-noise and low-power transistor technologies, the optimization with respect to low-noise or high-frequency of InGaAs/InAlAs HEMTs are described. The new technology InAs/AlSb HEMT is described with respect to processing, and DC, RF and noise properties. The prospects for low-noise are discussed. Implementation of InGaAs/InAlAs HEMTs in hybrid designs has been tested for cryogenic ultra-low-noise amplifiers with state-of-the-art noise performance demonstrated at 4-8 GHz at 10 K

2. Jonathan Hacker, Teledyne Scientific
"Antimonide Based Compound Semiconductors (ABCS) for Ultra-Low Power Applications"

Ultra-low-power high-frequency amplifiers and low-loss rf switches represent critical enabling components for many applications. For such applications, Antimonide–based compound semiconductor (ABCS) InAs/AlSb HEMTs are particularly suitable because

of their combination of high electron mobility and peak velocity, along with high electron concentration in the 2DEG that results in unparalleled speed-power performance. The InAs/AlSb HEMT device's inherent low-voltage operation, with Vds below 0.5V, can reduce dc power dissipation by an order of magnitude compared with a GaAs PHEMT device of equivalent performance, and by a factor of three to four compared to an equivalent InP HEMT device. In this workshop presentation, we will review ABCS device physics, device characterization and models, and explore ultra-low-power MMIC circuits including amplifiers and switches with bandwidths from 10 MHz to 100 GHz.

3. Yasuhiro Nakasha, Fujitsu Ltd.
"InP HEMT and Si-CMOS Device and Circuit Design for mm-Wave Low-Noise Applications"

An InP HEMT device technology that provides the noise figure of less than 1.0 dB at 94 GHz and the cutoff frequency of more than 500 GHz is presented. The key to perform the ultra low-noise and high frequency performances is to use the "CAVITY" structure surrounded the gate electrode of the InP HEMT. The design method, fabrication procedures are described in the presentation. A low-noise amplifier for 94 GHz passive imaging application is also demonstrated in the presentation. To date, compound semiconductor such as InP HEMT and GaAs HEMT are in a status of triumph in low-noise applications. However, recent rapid advances in the development of Si-CMOS technology provides us realizing lower cost millimeter-wave applications. In the presentation, a Si-CMOS 60-GHz and 77-GHz amplifier and transceiver design examples are presented.

4. Ali Niknejad, University of California - Berkeley
"Recent Advances in CMOS mm-Wave Building Blocks"

This talk will highlight the recent advances in mm-wave CMOS circuit design at the Berkeley Wireless Reserach Center (BWRC). The power amplifier (PA) and LNA/mixer, critical building blocks, will receive more detailed focus. Transmission line and transformer based design and power combining will be compared. The architecture for a 60 GHz transmitter and receiver prototype will be reviewed and compared to the state of the art demonstrations. Special techniques to exploit the benefits of CMOS while circumventing its weaknesses will be discussed.

5. Francois Danneville, IEMN-DHS, UMR CNRS
"Noise Properties of Low-Power Si MOSFETs Through Different Channel Engineering"

The aim of this talk is to discuss the noise properties of n-MOSFETs characterized by a uniformly doped channel (conventional SYM-MOS) and a laterally asymmetric channel (LAC-MOS), respectively. It will begin with a discussion about the behavior of intrinsic noise current sources as a function of DC biasing variations, with special emphasis on the gate-drain noise correlation coefficient -C-. It will be further shown that the difference observed on C for LAC-MOS translates into a drastic decrease for NFmin, for intrinsic

and extrinsic (lower sensitivity of NFmin to extrinsic resistances) cases, at a lower DC drain current. The corresponding outcomes are a NFmin for LAC-MOS (Lgate = 130 nm) which competes respectively with the one of III-V pHEMT (same Lgate) and of ultra-scaled SYM-MOS (Lgate = 34 nm). The trends related to other noise parameters (Rn, Yopt) will also be discussed; results will be supported by theoretical (TCAD simulations) and experimental data.