Enhancement mode RF Transistors in GaN-on-Si Technology

Gallium nitride high electron mobility transistors (GaN HEMTs) offer a compelling combination of high-frequency operation, power handling capability, and efficiency - making them the preferred choice for a wide range of RF applications, where performance, size, and power efficiency are critical factors. Using cost-effective and sustainable integration of GaN HEMT on silicon (Si) substrate, imec is developing GaN-on-Si RF HEMTs relevant for 6G-and-beyond wireless communication. The goal of this PhD is to develop enhancement transistors in the 6-24GHz band (FR3) with industry-relevant specifications.

One of the challenges for such transistors is to achieve E-mode, i.e. make the threshold voltage positive. To this end, innovations at material level include (i) back barriers (e.g., AlGaN, C-GaN, InGaN) in the epitaxial stack, and (ii) employing thin (sub-50 nm) GaN channel. To alleviate the performance losses associated with the above architecture, imec has recently demonstrated regrown source/drain contacts with record low resistivity [1]. In parallel, work is ongoing to reduce the current leakage associated with thin barriers, using high-K gate dielectrics. Still, the state-of-the-art E-mode devices require numerous areas of improvement which is the scope of this PhD.

The candidate is expected to identify the present challenges to achieving E-mode RF transistors, and propose innovative material and device strategies, for example:

- Investigating various GaN-on-Si buffer architectures and transistor configurations (MOSHEMT, MISHEMT) - using TCAD-based simulation tools.
- Characterizing the various RF stacks grown at imec in state-of-the-art 200 mm metal organic chemical vapor deposition (MOCVD) reactor, with in-house and external metrology facilities.
- Developing stacks with thin (graded) GaN channel, various back barriers and capping layers, optionally with highly doped (n^+) source/drain regrowth.
- Improving the state-of-the-art process flow for RF transistors.
- Proposing material & device solutions to mitigate thermal losses in next-gen RF transistors.

Desired background:

Candidates are expected to have a Master's degree in Electrical Engineering, Material science, Physics, Nanoscience and Nanotechnology or equivalent, with a solid background in semiconductor physics and excellent quantitative, analytical and communication skills.

Scope of work:
Literature study: 20% Epitaxy: 30% Modelling: 25% Integration: 25%

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[1] H. Huang et al., https://doi.org/10.1088/1361-6463/ad5dc9
[2] S. Banerjee et al., https://doi.org/10.1002/pssa.202400069