Compact transistor modeling for advanced GaN technologies by merging machine learning and system identification techniques.

State-of-the-art GaN transistor models range from black-box models (using machine learning), with limited or no physical interpretation, up to physics-based compact models that give insight into the influence of scaling rules and technology parameters. The latter is of interest as to provides insight into scaling and gives feedback to technology researchers.

Current state-of-the-art compact GaN transistor models (e.g., the ASM-HEMT model) have a large number of physical and tuning parameters that need to be extracted from a large number of measurements, originating from various measurements setups. This includes DC, linear S-parameter, and nonlinear large signal RF measurements, while taking thermal and trapping effects into account. This model extraction can be seen as a machine learning problem as it has a large parameter- and dataset. However, neither the uncertainty on the extracted parameters, nor the correlation between different effects / parameters are quantified. This lack of uncertainty quantification also hampers the design of the test structures and measurements to be used to increase the accuracy of the model.

The PhD envisions to bridge the gap between (big-data) machine learning techniques and (statistics-based) system identification modeling to extract the large parameter set in GaN modeling from the big measurement dataset. This includes:

- selecting and improving the algorithms to extract the model parameters using statistics-based system identification / machine learning techniques,
- quantifying the uncertainty and the correlation between the different parameters in a statistically relevant way,
- optimizing the test structure and experiment design, and
- demonstrating the performance of the techniques on measurements and simulations of test structures and power amplifiers designed for testing purposes in state-of-the art GaN technology.

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

Type of work

This research will be done in collaboration with

- the imec Advanced RF group for the design of the GaN design structure, the DC, linear and nonlinear RF measurements of the GaN transistors, and the ASM-HEMT modeling.
- the VUB/Dept. ELEC for merging the machine learning and the system identification techniques to extract the uncertainty and the correlation between the different parameters. This will also provide the foundation for the optimal experiment design.

It includes

- 30% researching the theoretical challenge to merge (big data) machine learning and (statistics base) system identification for GaN modeling,

- 30% researching the implementation of Python machine learning modeling environment,
- 20% circuit simulations for validation in ADS and/or Cadence environment,
- 20% experimental validation of the transistor models through GaN designs.

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