One-dimensional carrier profiling of blanket and confined semiconducting structures

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Required background: physics (solid-state, semiconductor physics), engineering (metrology)

Type of work: 50% experimental, 50% theoretical

The performance increase of Complementary Metal Oxide Semiconductor (CMOS) devices at every new technology node has required to shrink their dimensions to the nanoscale and to introduce new high-mobility channel materials (Ge, SiGe, III-V). More recently, these devices have also moved from planar to three-dimensional architectures. In this context, it is urgent to develop a characterization technique able to accurately determine the incorporation and activation of dopants in the ultra-shallow doped regions of the transistors, i.e. the source, drain and extensions. This project aims at tackling this critical issue by combining two established techniques, i.e. Secondary Ion Mass Spectrometry (SIMS) and microhall (MH).

SIMS is the established technique for one-dimensional dopant profiling. In a nutshell, SIMS is based on the layer-by-layer sputtering of the sample with the help of a low-energy ion beam. The fraction of the sputtered atoms which are ionized is accelerated by an electric field to a mass spectrometer, where each species is separated and counted. Unfortunately, SIMS does not capture any electrical information about the sample as it measures the total dopant profile, i.e. including the inactive portion. In this project, we propose to incorporate multiple MH measurements during the sample sputtering to determine the active doping concentration at different stages of the profiling.

This project will essentially consist of two tasks. *Task I* will deal with simple blanket structures of doped Si and more advanced SiGe, Ge and III-V materials. MH measurements will be run either on the sputtered surfaces or on dedicated metallic pads to improve the electrical contacts. *Task II* will extend the technique to confined three-dimensional volumes. For this purpose, dedicated structures have been fabricated, where fin arrays of dimensions compatible with SIMS have been electrically connected in parallel such that their electrical resistance can be measured. In both tasks, the candidate will focus on the MH measurements and simulations. Calculations will indeed also be needed to understand the impact of the contact geometry and of the confinement on the free carriers and currents inside the investigated structures.

This work will be done in the characterization group of imec disposing of a multitude of characterization techniques in support of this project. It will also be done in very close collaboration with the process engineers of imec and its industrial partners.