3.1 Publishable summary

Project Summary and Objectives

Among the physical limitations which challenge progress in nanoelectronics for aggressively scaled More Moore, **Beyond CMOS** and **advanced More-than-Moore applications**, **process variability** and the interactions between and with **electrical, thermal and mechanical effects** are getting more and more critical. Effects from various sources of process variations, both systematic and stochastic, influence each other and lead to variations of the electrical, thermal and mechanical behavior of devices, interconnects and circuits. Correlations are of key importance because they drastically affect the percentage of products which meet the specifications. Whereas the comprehensive experimental investigation of these effects is largely impossible, **modelling and simulation** (TCAD) offers the unique possibility to predefine process variations and trace their effects on subsequent process steps and on devices and circuits fabricated, just by changing the corresponding input data. This important requirement for and capability of simulation is among others highlighted in the International Technology Roadmap for Semiconductors ITRS. A project partner has also demonstrated how correlations can be simulated.

Within SUPERTHEME, the most important weaknesses which limit the use of current TCAD software to study the influence of both systematic and stochastic process variability and its interaction with electro-thermal-mechanical effects will be removed, and the study of correlations will be enabled. The project will efficiently combine the use of commercially available software and leading-edge background results of the consortium with the implementation of the key missing elements and links. **It will bridge the current critical gap between variability simulation on process and device/interconnect level, and include the treatment of correlations**. The capabilities of the software system will be demonstrated both on advanced analog circuits and on aggressively scaled transistors.

The SUPERTHEME Consortium

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ams AG	Austria
Gold Standard Simulations ltd	United Kingdom
UNIVERSITY OF GLASGOW	United Kingdom
TECHNISCHE UNIVERSITÄT WIEN	Austria
ASML NETHERLANDS B.V.	Netherlands
Excico France	France
HQ-Dielectrics GmbH	Germany
ION BEAM SERVICES	France

Work performed and results achieved

Within the first year of SUPERTHEME, all main components of the project progressed as scheduled and achieved important intermediate results :

- Detailed benchmark specifications have been performed by ams. These benchmarks refer to four different high performance analog sensor applications.

- Additional less formal specifications will be drawn from interactions with the SUPERTHEME Industrial and Scientific Advisory Board and with the International Technology Roadmap for Semiconductors ITRS.
- Sources of process variability at equipment level were identified by the industrial partners in the project. First quantitative data for these variations was compiled based on published and partly own data.
- The feasibility of the integration between the core software components to be used in the project was demonstrated. This referred especially to the link between equipment simulation carried out on reactor scale and feature-scale simulation of deposition and etching. The device simulation tool GARAND which enables the simulation of the impact of variations such as Random Dopant Fluctuations and Line Edge Roughness on device performance has been extended to enable the simulation of arbitrary three-dimensional device geometries which results from variation-aware process modeling. Physical device models have been improved as required for the predictive simulation of the impact of single dopants and single traps.
- The integration between variation-aware process, device, and circuit simulation was demonstrated. Especially, the impact of variations in litho-freeze-litho-etch double patterning lithography on SRAM performance was studied and presented in September 2013 at the SISPAD conference.

Expected final results and potential impact

SUPERTHEME will enable and demonstrate the simulation of the impact of systematic and stochastic process variations on devices and circuits. Software developed within the project will complement currently available commercial tools to reach this target.
The exemplary quantification of process variability at its source, which is at equipment level, will be one of the key results because such data is currently largely missing. Analog benchmarks conducted at ams will demonstrate that variations are not only important for aggressively scaled CMOS but also for several More-than-Moore applications. Software developed within the project will complement currently available commercial tools to reach this target.

The quantification of process variations at their source and the assessment of their impact on devices and circuits will considerably support the optimization of yield in semiconductor manufacturing.

Project web site

http://www.supertheme.eu

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