IST Project no. 027152

ATOMICS

Advanced Front-End Technology Modeling
for Ultimate Integrated Circuits

Project Presentation

1 Contract Number

027152

2 Project acronym

ATOMICS

3 Project name

Advanced Front-End Technology Modeling for Ultimate Integrated Circuits

4 Priority / Priority Component

Information Society Technologies / Nanoelectronics

5 List of participants

Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.v.	Germany
Centre National de la Recherche Scientifique	France
CSMA Limited	UK
Mattson Thermal Products GmbH	Germany
STMicroelectronics SA	France
Synopsys Switzerland LLC	Switzerland
University of Newcastle	UK

6 Total cost

€ 4,366.563.--

7 Commission funding

€ 2,479,736.--

8 Project main goals

Technology-computer-aided design (TCAD) is an indispensable tool for development and optimization of new generations of electronic devices in industrial environments. It was estimated in the International Technology Roadmap for Semiconductors that TCAD reduces technology development costs by 35% with a tendency to rise. However, to continue to be that useful for the 32 nm technology node and beyond, the capabilities of TCAD have to follow the paradigm shifts to processes and materials considered for such nanodevices.
The objective of this project is to extend the capabilities of TCAD as outlined below to the materials and doping processes used at the 32 nm node and beyond. The models developed will be implemented and integrated into Sentaurus Process to be of immediate value to the semiconductor industry and validated with respect to their needs.

9 Key issues

The key issues of the project are, in short, to fix the shortcomings of the currently existing front-end process models and to establish the models required to support development and later optimization of nanodevices at the 32 nm technology node and beyond. This includes in particular

1. To establish the currently missing quantitative models for the activation/deactivation of dopants in silicon, in particular for the combination boron/fluorine, for arsenic, antimony, and phosphorus during processes with low thermal budgets (low-temperature annealing, spike and flash annealing). Research will include the influence of pre-existing point defects as well as the generation of point defects during deactivation since they may affect activation and diffusion in neighboring regions.

2. To establish the currently missing quantitative models for the formation of extended defects and their influence on the concentration of intrinsic point defects in unstrained, thin layers of silicon (SON, SOI), in strained silicon, and in SiGe layers. While defect formation in SOI and SON is expected to be understood and to need only experimental corroboration, original experiments are required in strained silicon and SiGe layers.
3. To establish quantitative models for the effects of SiGe composition and strain on the electrical activation and diffusion of dopants. This work is expected to summarize and considerably extend the currently existing state-of-the-art.
4. To perform original experiments in strained layers to investigate possible anisotropies of the diffusion in two-dimensionally strained layers. The experimental set-up will be based on an original test structure which allows investigating the hitherto inaccessible lateral diffusion of dopants.

10 Technical approach

The achievement of the ambitious goals laid down above is based on original experiments and the development of physically based models. The consortium partners are carefully selected for the unique and complementary expertise and experimental capabilities which they bring into the project.
The main contributions to sample processing come from the industrial partners STMicroelectronics Crolles (STM-France) and Mattson Thermal Products. STM-France will carry out all ion implantation processes and all growths of silicon/germanium layers, Mattson Thermal Products will carry out all annealing processes from millisecond annealing to spike and soak annealing. With CSMA, one of the leading European characterization laboratories joined the consortium and will carry through all secondary ion-mass spectroscopy measurements. Electrical profiling with nanometer resolution will be possible by cooperation with Univ. Surrey where a differential Hall-measurement technique was developed. In addition to chemical and electrical profiling techniques, world-wide leading capabilities in electron microscopy are provided by CNRS-LAAS/CEMES. Model development, the main objective of the project, is covered by the three research institutes IISB, University of Newcastle, and CNRS-LAAS/CEMES, and by the industrial partner STM-France. Synopsys will provide the consortium with Sentaurus Process as common software platform, support model development and implementation by the partners, and integrate the models developed into the commercial model library for Sentaurus Process.

11 Expected achievements/impact

Development of new device concepts, especially when going from microelectronics to nano-electronics, requires already in the design phase that various alternatives are tested and validated. A technological validation of all possible concepts is inadmissible because of the enormous financial costs and because time is very precious when striving for a good position in the market or even market leadership. Therefore, technology-computer-aided design (TCAD) tools are extensively used by semiconductor companies during front-end development for pre-selection of technological options and optimization. The physical concepts and models developed within ATOMICS for future materials like silicon-on-insulator, silicon-on-nothing, strained silicon, and silicon-germanium and for future processing techniques like millisecond annealing strategies will help TCAD to meet future industrial requirements and to keep pace with technological needs. As a consequence, ATOMICS will help to reinforce competitiveness, economic growth, and sustainability of the European semiconductor industry.

12 Project start and duration

February 1, 2006 to July 31, 2009 — 42 months

13 Coordinator contact details

Dr. Peter Pichler
Fraunhofer Institut für Integrierte Systeme und Bauelementetechnologie
Schottkystrasse 10, Germany
Phone +49(9131)761-227, Fax +49(9131)761-212, email peter.pichler@iisb.fraunhofer.de