Semiconductor Process Simulation

Rainer Minixhofer
austriamicrosystems AG, A-8141 Unterpremstätten, Austria

Semiconductor technology and industry has enormously advanced in the past decades. Starting from a plastic triangle, a slab of germanium, some gold foil and gold contacts (the first bipolar transistor in 1947), as of 2004 the typical transistor density per circuit is around 140 million transistors/cm² for micro processor applications, doubling every year.

Semiconductor industry is the main driving force for technology innovation and "New Economy" markets. The ongoing development of faster integrated circuits with higher device density has led to highly complex and sophisticated products which are widely accepted by the society. A modern integrated circuit cannot be developed without the massive use of computer aided design (CAD) in any step of the complex flow from the idea to the final product. This presentation concentrates on technology computer aided design (TCAD) and its use for the simulation of the semiconductor fabrication process flow.

Semiconductor process simulation aims to model the physical systems of single semiconductor fabrication steps and their sequence which form the overall process flow. This task implies the modeling of the single process steps with differential equations and solving them on mesh-grids, which represent a cross-section through the interesting area of the integrated circuit.

The final outcome is the topography of the overall structure (boundary of the cross-section consisting of different materials) and the doping distribution inside the semiconducting materials. This information can be used to model the electrical behavior of the structure in a subsequent device simulation step. Since the physical structure and the doping concentrations can be hardly obtained by experiments, process simulation gains even more value at nanometer scale process technologies.

This presentation aims to describe some aspects of the implementation of process simulators. Furthermore the benefits of process modeling are shown with a couple of examples.