Future Aspects of Process and Device Simulation

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1 TCAD

Process and device simulation is commonly used for the design of new VLSI devices and processes and as an explorative tool to gain a better understanding of device and process physics. On the other hand, simulation is also carried out after the design phase to optimize certain parameters of a technology, e.g., to improve device reliability or to increase the yield. For these tasks the term "Technology Computer Aided Design" or TCAD was created.

TCAD includes both physically rigorous and simplified device and process simulation in one to three dimensions. Furthermore, links to layout-oriented CAD and to circuit simulation are required.

Depending on the particular application of TCAD tools, different demands arise: For the prediction of the behavior of new devices both accuracy and robustness are required. For statistical simulations for process control or post-design optimizations, speed is the most crucial issue, as physical models can be calibrated to an existing manufacturing process and hence do not pose a reliability problem. Independently of the progress in advanced physical modeling, the fast and simple "fitted" models will still remain in broad use; there is no unique "best model" for all simulation problems.

Modeling for simulation involves knowledge of and interfaces to a number of scientific disciplines in addition to electrical engineering and computer science. This has also had an impact on the properties and architecture of the software which has been produced by that heterogenous community.

2 Frameworks

For a long time the importance of (pure) software issues for TCAD has been underestimated. In the past few years, as these issues are attracting more attention, the major focus is on the integration of TCAD tools into a common framework.

In the Electronic CAD (ECAD) or Electronic Design Automation (EDA) field, there have always been several clearly defined layers of abstraction (see Fig. 1). Though the device count scale is open towards the high end, there is a well defined lower bound for ECAD, which is the single device. For TCAD, however, the only evident lower boundary in terms of abstraction is the physical atom.

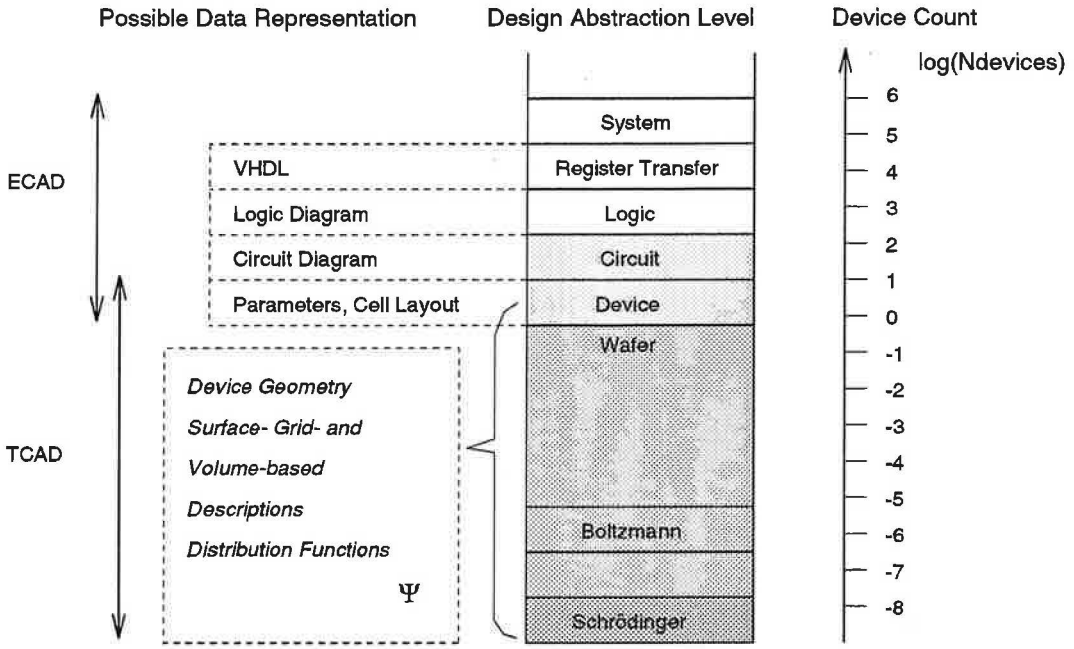

Figure 1: Design levels and device count scale in ECAD and TCAD

These considerations indicate that finding a unified data representation for TCAD is dominated by semantical problems which are closely related to the large interval (see Fig. 1) of device count to be represented, together with the lack of clearly defined intermediate abstraction levels and the multi-disciplinary background involved in TCAD.

As an operating environment for TCAD tools and engineers, a TCAD framework must provide the following key features:

- allow minimum effort integration of existing tools and facilitate the development of new tools
- allow casual users to use simulation in a black box manner
- provide enough flexibility on the task level to accomodate easily to new design tasks
- provide an extendable database for design representation
- must be "open" in terms of platform independence, availability and the use of open substandards
- provide standard functionality like visualization, interactive structure editing or postprocessing as generic tools

Facing these rather rigorous demands and the potential problems stated above, one should not expect to find an easy and fast way towards the ultimate TCAD framework. However, various attempts to go that way can be found:

In semiconductor industry there have been a number of remarkable framework efforts worldwide, like an integrated system for statistical VLSI design [1] (Japan), or AT&T's MECCA system [2] (USA).

Commercial TCAD vendors are integrating their tools and providing them with unified user interfaces, like STUDIO from Technology Modeling Associates, or MASTERPIECE from Silvaco Data Systems.

Recently, a client-server framework architecture has been presented by the Semiconductor Wafer Representation working group of the CAD Framework Initiative [6], an international standardization committee for ECAD.

We have developed VISTA, the "Viennese Integrated System for TCAD Applications". It consists of a binary database for design representation which is accessed by the tools through a layered procedural interface [3]. The simulators are controlled by an interpreting TCAD shell [4] which integrates all system components on the task level. An X11 based user interface provides a comfortable means for human interaction. An interactive device editor, generic postprocessing and visualization modules are also part of the framework. Special emphasis has been put into the use of open subystems and into the consistency of the overall system architecture [5].

3 The Future

The shrinking device dimensions will demand physical models based on a lower level of abstraction and as a consequence the "bandwith" of models used for TCAD will increase. Despite the evolution of physical models, the future of Process and Device simulation will be significantly influenced by the introduction of TCAD frameworks and its impacts: The integration of different TCAD simulation tools into a homogenous environment will allow simulation to catch up with the physical reality. This requires a semantical standardization for TCAD data representation, which is a major challenge for the future.

The importance of device and process simulation will increase in general and as a consequence of the broader use, performace, together with robustness and ease of use will become even more crucial.

References

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