A Shared Architecture for a Dynamic Technology Simulation Repository

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Abstract

In this paper, the design of a shared technology simulation repository is described. This system allows the download, archival, and simultaneous translation of equipment recipe and run data into a shared, revision controlled repository, as well as the automated generation of Technology Computer Aided Design (TCAD) input. Based on this system Computer Integrated Manufacturing (CIM) data and integrated circuit layout data can be combined to provide rapid technology optimization, enabling new methods of technology development.

1. Introduction

The application of TCAD in an industrial product/process development environment presents unique challenges, aside from those traditionally attacked by the academic community. This paper focuses on the management of the broad range of complex and dynamic information one must pull from the semiconductor fabrication facility (fab).

Inside the fab, the CIM system manages the information, which, as a paradigm, has matured in the semiconductor industry on a local (fab) level. However, several challenges lie ahead. Time to market is a leading criterion for success in a marketplace that requires cost effective and rapid development and optimization of new technologies. Market conditions will likely force semiconductor companies into more scalable nonlocal paradigms, some of which are already utilized today, such as contract manufacturing, remote process equipment utilization (Losleben et al. 1996), rapid development-fab to production-fab transfer, and technology licensing.

TCAD has long been accepted as a cost effective development tool for new technologies, if problem-specific calibration methods (Mar 1996 and Park et al. 1997) are used. However, to collect relevant data, TCAD often relies on human intervention, although all of the necessary data exists on computers somewhere in the fabs. A key to the continued success of TCAD is the adoption of a methodology that provides a tight link to the CIM environment of the (possibly remote) process development site. Currently, a considerable amount of time is wasted in simply looking for process recipes, and even worse, in running simulations or calibrations using incomplete or incorrect recipes. In this manual approach, human errors are inevitable and the incorporation of changes requires a great deal of engineering time.

The availability of a database that contains process and TCAD related information makes it easy for a TCAD engineer to leverage the calibration work of other individuals or groups and to avoid duplication of efforts. It also provides an essentially self-documenting system to track changes. To this end, both the feasibility of technology simulation based equipment control (Fallon et al. 1999) and a technology simulation archive (Wimmer et al. 1995) have been demonstrated. Our architecture described in this paper implements the convergence of those two concepts.

2. System overview

The purpose of this system is to provide up-to-date and revision controlled simulation projects for TCAD (Figure 1).

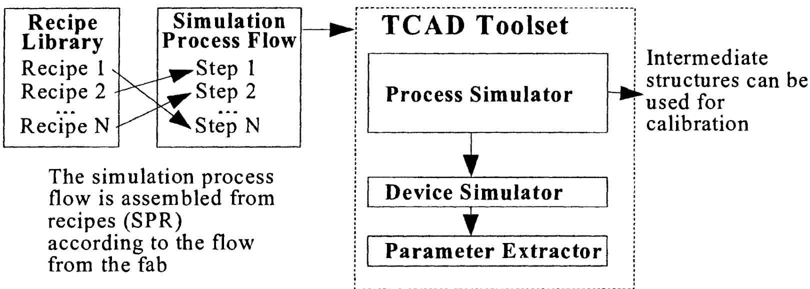

Fig. 1. The Use of Process Recipe Information in the TCAD Tool Environment.

Here, the challenge is an up-to-date library of recipes in the fab. The completeness of the recipes, the automatic downloading, and the direct translation greatly minimizes the chance of obtaining incorrect or out-of-date process flow information and vastly improves the prospect of meaningful process simulation.

3. Process Information Management

Up-to-date process flow information is readily available in a spreadsheet format from the fab's MES (Manufacturing Execution System). For the recipe library, data is extracted directly from the equipment if the MES under consideration does not have a comprehensive integrated recipe management system. Data access can be achieved via the network, through FTP to controller station, standard equipment interface, or sometimes as part of a regular back-up of recipes. In some cases *in situ* measured furnace temperature, gas flows, heater powers, *etc.* are available. For advanced process steps, these data are superior to recipe targets.

The recipes and additional data are placed into a recipe library, translated, and archived under revision control. For the process information, the SPR (Simple Process Representation) language of a proprietary input deck assembly tool (ISE 2001) is used as an intermediate representation, providing more separation between "physical" process conditions and simulator-specific options. SPR is an ASCII human-readable command language which provides macros in order to maintain the natural hierarchy of the information as it comes from the system. The recipe translation presently comprehends implantation and thermal steps but the approach described here can be extended to other computer-driven tool sets in the fab.

4. Simulation Library

The simulation library is a central part of the system, organized as a simple set of directories in a file system. The library contains a subdirectory with a collection of recipes (called the recipe library). In addition, the simulation library contains other files necessary for a successful operation of the system. The simulation library is structured as shown in Figure 2.

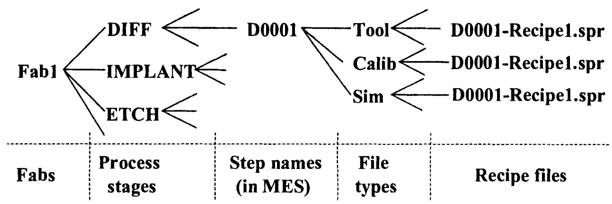

Fig. 2. The Structure of the Simulation Library.

The simulation library is revision controlled with CVS, the Concurrent Versions System, an open-source, network-transparent version control system (CVS 2001). This provides an opportunity for different engineers to collaborate while working on the library. Engineers can download recipes and update their local copies with the latest versions, or access previous versions of recipes by version number or date.

In most cases, translated recipes downloaded from the equipment are not quite ready for simulation. TCAD specific information, such as the type of physical models to be used, model parameters, etc. may have to be fine-tuned or added. Also, recipes can be optimized with regard to incompatible objectives, e.g., simulation speed or accuracy. The recipes, therefore, usually undergo calibration by a TCAD expert.

5. Assembly

The process flow, recipe information, and TCAD specific data are assembled into a complete simulation flow, again represented in SPR (Figure 3). The assembly tool, in turn, further translates process information together with layout and TCAD-specific information into process simulator input, or, possibly, other representations. All these pieces have been integrated into a proprietary TCAD simulation framework (ISE 2001). This framework also allows the use of process simulation together with other simulation elements, such as device simulation and extraction of electrical parameters.

6. Benefits

The wide accessibility of up-to-date and revision controlled TCAD data minimizes the turn-around time for the simulations and often enables simulations that would otherwise be unfeasible. In particular, the CVS repository allows to reconstruct the process flow and corresponding recipes for an earlier date although changes to the current process may have already been implemented.

Beyond TCAD, the comprehensive collection of data is also useful to other communities. Engineers in the development fab now have point-and-click access to a wide range of recipes, to time-temperature and gas flow data for all thermal steps. Engineers doing process transfers from one fab to another have access to all of the recipes on a specific tool. The overall benefit of the system becomes even more pronounced for the nonlocal paradigms of manufacturing.

The system is currently implemented at one of Motorola's R&D fabs. Recipe files are automatically downloaded from furnaces and implanters and translated. This approach is portable throughout development and production fabs with computer-driven tools and is beneficial to many engineering disciplines in the semiconductor manufacturing environment.

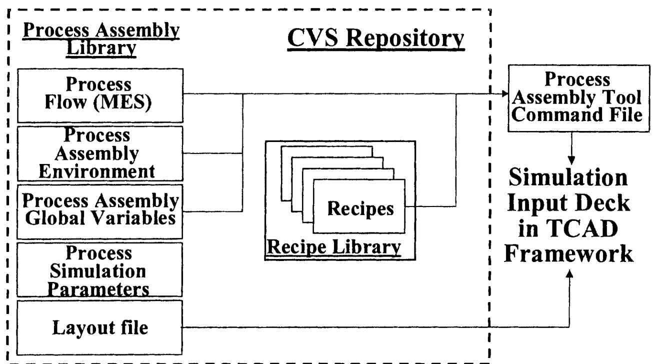

Fig. 3. Assembly of a Process Simulation Input Deck.

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