Focused Research Center for Gigascale Integration

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1 Advanced Modeling and Computational Prototyping

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1.1 Modeling of Interconnect Reliability

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Integrated circuits are currently designed using simple and conservative 'design rules' to ensure that the resulting circuits will meet electromigration reliability goals. This simplicity and conservatism often leads to reduced performance for a given circuit and metallization technology. We have developed a CAD tool, ERNI, which allows process-sensitive and layout-specific reliability estimates for fully laid out or partially laid out integrated circuits. ERNI applies a set of filtering algorithms to identify highly reliable or immortal interconnect elements based on increasingly more complex analysis.

Using ERNI, interconnect trees can be extracted from layouts, and a worst-case effective jL product can be determined by assuming that all limbs of the trees are at the maximum current density allowed by the design rules. Those trees that are found to be immortal even under these worst-case conditions are eliminated from further consideration. In the next step, with current density estimates for the remaining trees, more trees are eliminated from further consideration, so that a much smaller population of mortal trees can be treated with default analytic models to make circuit-level reliability predictions.

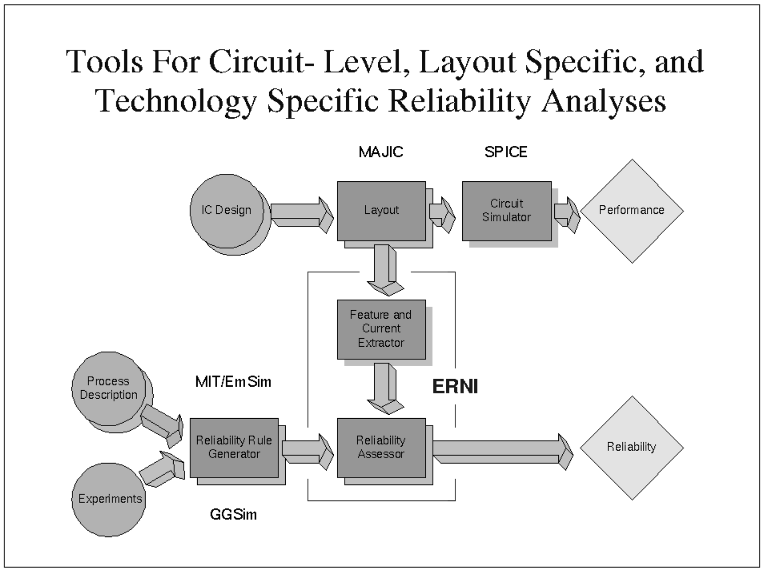

Figure 1. *Modeling of Interconnect Reliability*

2.1 Distributed Design and Fabrication of Microsystems

Project Staff
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The design, fabrication, and verification of state-of-the-art microsystems devices require an increasingly diverse, specialized, and expensive set of resources. These resources include manufacturing equipment, people, metrology tools, and computational software. Advanced microsystems research activities are even more demanding, frequently requiring unique equipment and processing capabilities.

Such capabilities are of particular importance in the development of new technologies, where both equipment and expertise are limited. Distributed fabrication enables direct, remote, physical experimentation in the development of leading edge technology, where the necessary manufacturing resources are new, expensive, and scarce. Computational resources, software, processing equipment, and people may all be widely distributed; their effective integration is essential in order to achieve the realization of new technologies.

We are developing software components of a flexible system architecture capable of supporting distributed, collaborative miscrosystems design, fabrication, and testing. Process engineers and product designers access processing and simulation results through common interfaces and collaborate across the distributed manufacturing environment.

A distributed semiconductor process repository allows users to retrieve and examine process flows from multiple process libraries across the network. The repository programming interfaces are encapsulated by a distributed object model as specified by OMG CORBA standards. Application clients and repository services may be implemented in any language supported by a CORBA-compliant Object Request Broker (ORB) and interoperate across a local or wide-area network. Process objects and services may be located at various sites, transparently to application clients. The process representation object model supports both simulation and fabrication and has been extended to support statistical process variation information from process history.

Applications under current development include optimized MEMS design, distributed process control and diagnosis, and remote MEMS metrology via a gigabit optical network.

2.2 Labnet Software

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University microfabrication laboratories are facing many new challenges and opportunities: facilities are becoming more expensive and difficult to manage; resources and expertise need be shared and made available to a wider community; education and research are becoming more dependent on multi-institutional collaboration. Given the above challenges, there is a growing desire for a new distributed information infrastructure, that will allow remote collaboration, access to remote sites' data and sharing of end-user software applications, in the face of differences between remote sites in computer platforms, operating systems, and technical resources. Past research has been done within this application domain but most working systems are too tightly coupled to their local facilities, suffer from portability problems and have never addressed the issue of data distribution and remote site interaction.

The Labnet Software Project was initiated in recognition of a need for universities to share the development and support effort needed to develop and maintain new distributed laboratory information systems. Joint development work among MIT, Stanford University and the University of California at Berkeley is in progress and working toward the goal of using the system in a production environment at all schools.

Currently, Stanford University has taken the lead on the development of the core modules of the system, with MIT and UCB contributing specific pieces of the system. An initial successful deployment of the core system has been done within Stanford's production environment, leading to increased user feedback and testing. The intended goal is to have the core system installed at MIT within the year and to completely replace the existing software system, used within the MTL fabrication facilities, within the next 1-2 years. In addition to the main goal of having a working information system for the university's fabrication facilities, the following are the general technical goals and guidelines of the project:

- Assess and adopt the use of relevant emerging technologies such as The Object Management Group's (OMG) Common Object Request Broker Architecture (CORBA), OMG's Interface Definition Language (IDL), Sun Microsystem's Java language, eXtensible Markup language (XML), and standard database access interfaces such as Java DataBase Connectivity (JDBC).
- Create an infrastructure that will enable collaborative distributed design and fabrication (including object-oriented distributed programming interfaces and web-based user interface capabilities).
- Develop abstract specifications of programming interfaces both to data and services, easing the burden of future additions and changes to the software infrastructure.

2.3 Process repository

Semiconductor Process Repository

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A system was created to facilitate distributed process research and design. This allows users to retrieve and examine process flows from multiple process libraries across the network.

A distributed process repository interface was developed. The repository application programming interface (API) is encapsulated by an OMG CORBA distributed object model and defined by an Interface Description Language (IDL) specification. The process object model used to encapsulate the process repository API is based on the Semiconductor Process Representation (SPR) Information Model. The IDL specification is programming language-neutral; application clients and repository services may be implemented in any language supported by a CORBA-compliant Object Request Broker (ORB) and interoperate across a local or wide-area network. Process repositories may be distributed; process objects and services may be located at various sites transparently to application clients. Applications and services may interoperate using entirely distinct ORB implementations if a common protocol such as the Internet InterORB Protocol (IIOP) or appropriate bridges are available.

The present SPR IDL development includes the Base Information Model. This standard process representation interface provides a common facility to communicate fabrication processes. The fabrication process information organizes processes into smaller subprocesses. At each level, the process can be described from different views. These include the 'effect' of a process on the wafer, the 'environment' around the wafer during the process, and the 'equipment' settings during the process. Each view contains parameters that describe some aspect of the wafer, environment, or equipment during some interval of time. Dynamic attributes (property lists) are also supported for maximum extensibility. The base SPR IDL has been extended to include specific effects and parameters with statistical information.

A distributed software architecture for semiconductor process design has been defined and implemented in Java with the OrbixWeb Object Request Broker (ORB). The implementation communicates with any ORB adhering to the Internet Inter-ORB Protocol (IIOP). A persistent storage mechanism has been implemented using Object Design ObjectStore PSE (Persistent Storage Engine) for Java.

Other services to manage, query and find distributed objects are being developed. Their interfaces are based upon the Object Management Group's (OMG) CORBA services specifications. A Life Cycle service for creating, deleting, copying, and moving distributed objects has been developed. Work has begun on implementing a Query service and a Trader service. Together, the services will be essential for the development of distributed and shared applications for semiconductor process research and design.

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