INTEGRATED CIRCUITS DESIGN AND TEST LABORATORY

Dr. W. Robert Daasch, Co-Director and Professor
Dr. Branimir Pejcinovic, Co-Director and Associate Professor
Electrical and Computer Engineering
Maseeh College of Engineering and Computer Science
Portland State University
PO Box 751
Portland, OR 97207
Office: 503.725.5409, Fax: 503.725.3807
daasch@ece.pdx.edu

Summary of Research

The Electrical and Computer Engineering Department's Integrated Circuits Design and Test Laboratory (ICDT&L) at Portland State is equipped with $3.6 million of state-of-the-art semiconductor testing equipment and approximately $500 thousand of supporting software. The Integrated Circuits Design and Test Laboratory is a Maseeh College of Engineering Spire of Excellence. The Laboratory is the home to seven-year industry and academic collaboration in integrated circuit design and test.

ICDT Laboratory Credence Test Facility is the only university homed test facility with Level2 correlation with semiconductor manufacturers.

Semiconductor testing is required because there is an imperfect transfer of an idea for a circuit design to the reality of an integrated circuit device. Current technologies can produce a device with over ten million transistors and ten million wires packed into an area less than the size of a dime. This level of complexity ranks the semiconductor device as the most complex engineering structure made in human history. The research challenge addressed by the IC Design and Test Laboratory is the design of next generation circuitry and new algorithms and procedures that will identify in less than ten seconds of test time as fearsome transistor or a single wire imperfectly manufactured. Without new testing methods or new design alternatives that are more testable the test time will increase, end-user costs will increase, or product reliability will decrease. Each is an unacceptable outcome because a competitive semiconductor industry is central to the Oregon as well as the United States economy. Semiconductor products are fully integrated into the daily lives of the citizenry in communications, health and safety, and

entertainment.

The reduction of semiconductor device critical dimensions to nanometers and angstroms has a profound effect what physical models can be used to understand device behavior and the effect of defects can have on the device. The physical properties of one hundred to two hundred atom clusters are quantum mechanical. A quantum mechanical view of semiconductor devices is different from bulk, deterministic, material properties. Keeping in mind the shear numbers of devices involved and the length of time an integrated circuit is used by the end customer, semiconductor test poses a unique interplay between the physical sciences and engineering.

The Integrated Circuits Design and Test Laboratory is a Maseeh College of Engineering Spire of Excellence. Going forward the laboratory is uniquely positioned to be a regionally relevant and nationally prominent research facility by combining the talents of students, faculty and leading industry researchers and resources of the laboratory, Portland State University and the leading semiconductor companies worldwide.

Potential for Commercialization and Job Creation

The IC Design and Test Laboratory pioneered the creation of joint intellectual property agreements with Oregon companies and Portland State University. In contrast to the rigid two-class definition of intellectual property (i.e. yours and mine) innovative agreements initiated by the IC Design and Test Laboratory define a third class of intellectual property that permits the private industry and the university to hold or exercise joint property rights. These agreements between the partner company and Portland State University retain maximum flexibility within the law to develop market and commercialize the results of the collaborative research.

The IC Design and Test Laboratory is also the host to the first high-technology startup located on the Portland State campus. The agreements between the startup and the Laboratory served as the prototype for the Portland State University Business Accelerator. The Laboratory research facilities are a key incentive for this startup and potentially other startups to locate on the Portland State campus. The relationship between the Laboratory (through Portland State University) and the startup is the direct result of the 2001 Ballot Measure 10 that permitted the state (i.e. PSU) to receive stock "in exchange for technology created in whole or in part by a public institution of post-secondary education (Oregon Constitution, Paragraph 2, Section 6, Article XI)." Laboratory researchers collaborate with the founders and principal scientific staff on research projects with the goal advancing ideas and initial findings to products and growing Oregon businesses.

A measure of success of the ICDT&L is technology transfer. The smooth flow of results from the research laboratory to common practice or industry production is central to the Laboratory mission. For example, less than two years after initial research results demonstrated the potential value of new statistical analysis of semiconductor test data 99% of wafers manufactured by LSI Logic are tested using ICDT&L methods. The economic benefits of technology transfers are difficult to assess. Since deployment, one

estimate is that the use methods originally developed in the ICDT&L save the company over $1 million/year in production and engineering costs.

Total Research Funding

The Laboratory was founded in 1998 as a response to Senate Bill 504"to improve and expand engineering facilities" in the Portland metropolitan area. The research expenditures to 2004 and private industry contributions (equipment, staff training and maintenance) total $4 million. The details of the support are in the following table.

Research Expenditures

Source	Date	Amount (thousands)
Intel	1998-2003	$125
LSI Logic	1999-2004	$460
Semiconductor Research Corporation	2000-2004	$260
Sharp Research Laboratories	2000-2004	$70
Octavian Scientific	2002-2004	$48
Tektronix Foundation	2002-2003	$100

Industry Collaborations and Donations

Source	Date	Amount (thousands)
Credence Systems Corporation	1998-2004	$2,500
LSI Logic	1999-2004	$150
Electroglas Corporation	2001-2004	$300
Cascade Microtech	2000-2004	$40

Student Involvement

Student research assistants are the key to research progress in the ICDT&L. For the academic year 2004-2005, six PhD students, four MS students and three undergraduates are working on sponsored projects in the Laboratory. The contributions the graduate students make to the ICDT&L far exceeds their modest research stipends. Research assistants are involved in every phase of research planning, execution and analysis of the experimental outcomes. They play a key role in when working with industrial partners by informal give-and-take sessions and formal presentations. Since founding of the laboratory, the research students have e prepared and presented nearly two-thirds of the conference presentations and one-third of the journal articles.

In the last three years, the laboratory publications have received Best Paper awards in semiconductor test at the IEEE International Test Conference and at the IEEE VLSI Test Symposium. The research was presented to the International Symposium of Test and Failure Analysis as an invited presentation (only 2.5% papers presented at ISTFA are invited) and ICDT&L research was the lead article in the special issue of IEEE Design

and Test on next generation defect based testing.

Working with state-of-the-art equipment students at all levels contribute to ICDT&L research mission.

In 2002, a team of three undergraduate students were assigned a six-month project under the direction of an industrial colleague and the Laboratory Director. The initial feasibility study quickly yielded promising results and the project expanded to include an implementation plan as well. At the end of the six-month study, a new method was specified and researched, a publication with the undergraduates as contributing authors and the prototype handed off to the research sponsor. Because of the rapid technology transfer in less than 1 year over 90% of all semiconductor wafers manufactured at the facility are tested with the new ICD&T Laboratory designed method.

Laboratory graduates continue to contribute to the field after completing their degrees. Graduates hold engineering positions (some at advanced grades because of their studies and hard work at ICDT&L) at many leading semiconductor companies in the United States and Europe including; Credence Systems, Intel, LSI Logic, Maxim, Mentor Graphics, and Philips.

Websites
Integrated Circuits Design and Test Laboratory: http://icdt.ece.pdx.edu
W. Robert Daasch: http://ece.pdx.edu/~daasch
Dr. Branimir Pejcinovic: http://ece.pdx.edu/~brano