Packaging Research Center (PRC)

Georgia Institute of Technology

Dedicated to the development of microsystems packaging technologies for the twenty-first century

A National Science Foundation Engineering Research Center since 1994

The Packaging Research Center (PRC) provides a comprehensive, cross-disciplinary and multi-functional focus on the packaging issues associated with next-generation electronic systems. The Center focuses on various packaging issues and their impact on future systems as well as specific research details and is continually working to define roadmaps for next-generation packaging technologies.

Research

Introduction and Overview

The primary mission of the PRC strategic research plan is to address next-generation microsystem packaging needs in the four critical market sectors of computers, telecommunications, automotive, and consumer electronics. Given these system needs, the primary requirements are low cost, high performance, high reliability, and reduced size. The technical vision of the Center, consistent with these needs, involves integrating all of the components and packaging levels into one level of package, a "System-on-a-Package" (SOP) structure. This is analogous to the integrated circuit revolution for transistors. The PRC's goals for the next-generation of microsystems packaging are a 10x improvement in cost, size, performance, and reliability. To achieve the cost, size, performance, and reliability targets of next-generation microsystems packaging, the PRC has identified a number of required research thrusts with multiple faculty, students, collaborators, and companies associated with each thrust. These thrusts conduct research in a collaborative fashion within themselves and with each other. Figure 1 depicts the thrust areas and their organization into four major research groups, each headed by a research director.

Roadmap and Strategic Parameters

The Center's System-on-a-Package vision drives the research within each thrust and the cross-disciplinary interactions between thrusts. The PRC research community, in conjunction with industry and government organizations, has developed its own internal roadmap of strategic research parameters and needs in each of the thrust areas to act as a guide for focusing diversified research activities towards the integrated packaging vision of the Center.

Figure 1: System Drivers, Barriers, Thrusts and Research Groups

Research Barriers

The strategic parameters defined in the PRC roadmap lead to anticipated research barriers in bringing about new and fundamental technologies. Figure 2 lists the major research barriers in each of the research thrusts. These include cost, material, and process barriers, among others.

PRC Three-Tier Research Strategy

To realize the vision of highly integrated, ultra-light and ultra-thin, low-cost, high-reliability, and high-performance packaging, to meet the roadmap targets, and to successfully overcome the identified research barriers, the PRC has defined a three-tier research strategy. These three research levels are (1) the fundamental research breakthroughs occurring within each thrust, (2) cross-disciplinary or multi-thrust technical demonstrations, and (3) system-level research focused upon evolving Center-wide testbeds and functional prototypes. None of these levels of research can reach full maturity, or, in some cases, even succeed, without the others; and each of these levels builds upon and strengthens the others. The concept of this three-tier strategy and the evolutionary structure associated with these research levels and the interactions between them drives the Center's research.

Continued advances and breakthroughs at the fundamental level are being enabled and nurtured, so that these advances can be inserted into multi-thrust demonstrations and into the functional prototypes. The process demonstrations, which are often multi-disciplinary, multi-thrust test vehicles, are critical to the integrated demonstration of technologies and serve to enable researchers to explore the fundamental limits of their technologies without some of the constraints imposed on their technologies when they are integrated into functional prototypes.

Education

PRC's Education Model for the 21st Century

The PRC, together with the Georgia Research Alliance and the U.S. electronics industry, has embarked on a comprehensive educational mission: delivery of system-level and globally competitive microsystems packaging education. The PRC envisions that next-generation packaging education will need to incorporate not only fundamental science and engineering but also system-level engineering and manufacturing. A system-level education, typically at the Ph.D. level, involves incorporating concepts in concurrent design, fabrica-

tion, assembly, and test of systems, semiconductors, and packages to address market needs for cost, performance, size, and reliability of the electronic products. A globally competitive engineering education involves not only fundamental and system-level knowledge, but also a working knowledge of business, management, foreign culture and global markets. This is typically achieved at the Masters level through the recently developed Practice Oriented Masters (POM) program. The PRC is developing programs not only at the undergraduate and graduate levels, but also for pre-college students and high school teachers, and for professional engineers.

Undergraduate Education
The PRC's education program at the undergraduate level addresses shortcomings of the traditional engineering education in three ways, through: (1) the development of a "focused program of study" (FPS) tailored to the needs of the undergraduates from each discipline involved in the Center (2) the "design, build, and operate" (DBO) courses which provide practical and hands-on exposure to microsystems packaging manufacturing practice at the systems level and (3) team research.

Graduate Education
Engineering graduate students historically emerge from universities with a somewhat narrow set of skills, and many of these students lack a more global and comprehensive system-level perspective. The proposed solution to this state of affairs has been the development a new program at PRC: an interdisciplinary packaging certificate within a Practice Oriented Masters (POM) program in microsystems packaging.

The POM program is designed for those students who plan to go immediately into industry rather than seek a Ph.D. It has three major components: (1) packaging engineering courses (2) management courses and (3) an internship. The engineering component focuses on systems-level understanding and hands-on laboratory experience coupled with fundamental scientific knowledge in key packaging-related disciplines. The management component focuses on management of technology (particularly aimed at achieving national roadmap goals), entrepreneurship, and global aspects of the packaging enterprise. The internship consists of either a domestic or international employment experience.

Education of Professionals
The rapid rate of technology advances in electronics packaging makes continuing education essential for industrial practitioners. The PRC seeks to support such lifelong learning through a variety of short courses, seminars, and colloquia, as well as by organizing workshops and conferences. Many professional engineers are interested in continuing education through distance learning. Therefore, in the near future the PRC plans to offer both short courses and a variety of conventional courses using video and web-based technology.

Pre-College Outreach
The PRC recognizes that recruiting well-prepared students into any engineering program, including microsystems packaging, is a "pipeline" issue. The PRC is committed to improving the quality of its engineering graduates, and as a consequence, is also committed to improving the awareness of pre-college students and teachers of electronics careers. For that reason, the PRC provides on-campus research experience opportunities to several high school students and teachers every year.

Industrial Collaboration/Technology Transfer

The Packaging Research Center and its 35 industry partners have jointly developed a partnership plan to develop cooperatively the next-generation technologies and educate the next-generation of packaging engineers and transfer both to industry. The plan involves taking industry's need for the next-generation of systems and putting faculty, graduate students, undergraduate students, and industry engineers together to explore new scientific frontiers, demonstrate process integration, fabricate functional prototypes, and foster the educational development of a new breed of globally competitive engineers. This comprehensive collaboration plan *involves industry in every facet of the PRC*, from identification of next-generation needs to delivery of functional prototypes. The intent of the industry collaboration plan, therefore, is to ensure that university activities are consistent with industry's next-generation needs and to establish a clear path for technology transfer to industry.

Facilities

The comprehensive PRC research and educational facilities strategy is based on a three-tiered facilities philosophy.

First Tier: Fundamental Research Facilities — The PRC supports approximately 10 fundamental research laboratories. These laboratories typically are located in the buildings of the seven participating departments of the principal investigating professors, who typically manage the laboratories.

Second Tier: Small Area Prototype Research Facilities — The Small Area Prototype Research Laboratory is a 7,000-square-foot, class 1000-100 cleanroom facility. The PRC uses this facility to bridge the fundamental research activities occurring in the fundamental research laboratories and the large-area prototyping research activities of the Next-Generation Board Laboratory. It is here that researchers demonstrate the ability to integrate fundamental research innovations for Optoelectronics, Integral Passives, and Low Cost High-Density Wiring processes on a small-scale basis prior to implementation in large-area prototypes.

Third Tier: Next-Generation Prototype Research Facilities — This tier of facilities includes the Next-Generation Package Design Laboratory, the Next-Generation Board Laboratory, and the Next-Generation Module Laboratory. Combined, these facilities provide a total of 17,850 square feet of laboratory space dedicated to large-area, next-generation prototype research. These laboratories are the key elements that differentiate the PRC from other academic research programs. Here, results of fundamental research efforts are integrated into cross-discipline, functional, sub-system or system-level, proof-of-concept prototypes. The prototype research facilities also provide unique opportunities for fundamental research validation, practical hands-on education for students and industry engineers, and technology transfer of PRC innovations to industry. The PRC intends to broaden its national role by extending the use of the large-area Next-Generation Prototype Research Laboratories to the U.S. electronics industry.

Center Configuration, Leadership, Team Structure

The PRC's Director, Dr. Rao Tummala, is supported by an array of internal and external advisors and partners, including the Georgia Tech Advisory Committee (GTAC), chaired by the Dean of Engineering; an Industrial Advisory Board (IAB); and the PRC Board. A Research Director oversees four research groups, each with its own group director. There are Associate Directors for Center-wide Prototyping activities, Education, Global Collaboration, Industry Collaboration, Strategic Operations, and Infrastructure.

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