Advanced Packaging

Exploring New Frontiers in Power- and Nano-Electronics

BY CEMAL BASARAN

The Electronic Packaging Lab at the University at Buffalo has earned a reputation for its cutting-edge work in developing computational and experimental measurement tools for facilitating the development of the next-generation microelectronics packaging. While we continue to focus on that area, we are turning our attention to power electronics and nanoelectronics, applying our capabilities in computational modeling and reliability testing to critical problems associated with nanoscale electronics and operating power electronics in harsh environments.

Douglas C. Hopkins, Ph.D., an expert on power electronics system integration, currently is leading our efforts to develop a power electronics package with a silicon carbide semiconductor mounted on a silicon carbide composite structure, compared to a silicon semiconductor mounted on Al203. This device can be pushed to operate at 400°C and above. Our mission is to perform a complete virtual product development to test the reliability of the device and certify materials that can be used to attach the device for high-temperature operations. The final product is a 60-kW power converter for the U.S. Navy that can operate at extremely high temperatures and vibration levels.

Working with a power electronics company, we are designing a dense system to be contained within a 1 × 1" package. Our team is investigating methods to mount the SiC device in a way that will enable running the device at extremely high temperatures and getting 10× the amount of power out of it. A challenge is how to maximize and manage heat gradients within such a small package. In our lab, we measure the reliability of devices and materials under very high temperatures, vibrations and very high current density levels. Our team has developed a computer modeling system that can test the reliability of the packages under extremely harsh conditions — accurately simulating various conditions of heat, high current density and vibration at the same time. Such modeling can provide huge savings for companies in terms of development costs, product testing and time-to-market. Using the micromechanical properties of materials, computer modeling can construct mathematical models of their thermomechancial behavior and fatigue life in a unified manner.

When a package is able to manage very high current density and high temperature, obviously, devices can be made lighter and smaller. But just as important, they can be placed much closer to the point of load. For example, in a related project with the Navy, our lab is developing power devices that can be mounted close to a ship's propulsion system and its weaponry — areas where temperature and vibration are a major concern. Developing reliable power electronics under these conditions is complex because when you combine thermal cycling and vibration at high temperatures, materials become liquid.

Our lab is also developing flip chip and BGA packaging technologies for power electronics and nanoelectronics, where high current density and high temperature gradient are the major obstacles to further miniaturization. We have been able to measure the deformation field in a solder joint under very high current density levels and also develop a constitutive model to predict the strain and damage evolution due to high current density (Figure 1). When our Navy- funded project is complete, it will be possible to design a solder joint small enough to carry 10^6 Amp/cm^2.

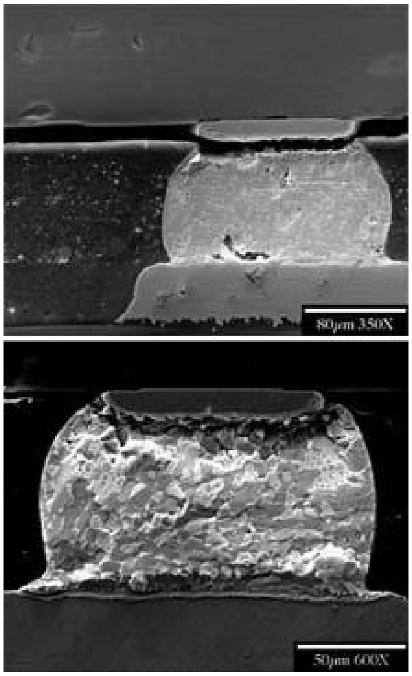

Figure 1. These images show flip chip solder joint failure under high current density.

Not all of our testing is done via computer simulation, however. Alexander Cartwright, Ph.D., an expert in lasers and photonics, is leading efforts to develop ways to detect and measure solder strain at the nano level. We have developed a technique to measure solder strain at 27.5 nm. The technique uses continuous wavelet image processing to improve the sensitivity of moiré interferometry, which uses He-Ne laser beams to measure the displacement field of a package as it is exposed to simulated service conditions. Phase shifting controls where the light is on the material, and we measure its movement and take images of the material's fringes. Wavelet transform processing then removes the noise from the image — providing a much clearer image that now can be read by a computer, as well as very accurate stress and strain measurements. This technique brings you down to the nano level, where small changes in deformations can be measured.

In the future, we hope to apply our technologies to help design packages in sensors used for environmental and chemical sensing within fuel cells, and also for use in the automotive and aerospace industries.

CEMAL BASARAN, *Ph.D, director of the University at Buffalo's Electronic Packaging Lab and an associate professor of engineering in the School of Engineering and Applied Sciences, may be contacted at the University at Buffalo, The State University of New York, 102 Ketter Hall, North Campus, Amherst, NY 14260; (716) 645-2114; e-mail: cjb@buffalo.edu.*

Advanced Packaging September, 2004
Author(s) : Cemal Basaran

| Add RSS Feed

More September, 2004 Articles > Search Archives >

Advanced Packaging Article Categories:

Industry News SEMICON News

New Products

Advanced Packaging Current Issue Table of Contents

Search Industry Specs >

Search Industry Jobs >

Magazine & E-Newsletter Subscriptions >

Return to Previous Page

Webcasts

Trends in Wafer Bonding for MEMS and 3D Integration
Original broadcast on
September 18, 2008

Building Blocks and Roadmaps for 3D Integration
Original broadcast on
June 26, 2008

Advances in 3D Packaging: Focus on Lithography
Original broadcast on
April 30, 2008

more

Sponsored White Papers Library

Recently Added White Papers

Breakthrough Package-Level Lead-Free Alloy Addresses Board-Level Alloy Challenges (05/04/2009, Henkel Corporation)

Challenging Flip Chip Applications No Problem for New Underfill Technology (03/31/2009, Henkel Corporation)

more

Featured White Papers

Breakthrough Package-Level Lead-Free Alloy Addresses Board-Level Alloy Challenges (05/04/2009)

more

Home | About Us | Contact Us | Corporate Website | Privacy Policy | Courage and Valor Foundation | Site Map
View all PennWell sites | View all PennWell events
Also Visit: Solid State Technology | Surface Mount Technology | Lightwave