Printed by UP Media Group in CIRCUITS ASSEMBLY The Journal for Surface Mount and Electronics Assembly

Mapping Contact Pressures on Mechanically Attached Heat Sinks

Real time capacitance tactile pressure sensor systems evaluate low contact pressures with almost instantaneous analysis.

Gerard E. Mayers and H-S Liang, Ph.D.

Until recently, measuring low contact pressures precisely in real time between any two contacting surfaces has been difficult to accomplish. Traditional load cells or strain gauges are either unable to reach the desired psi or kg/cm^2 pressure range, too bulky to accommodate the area being tested or too time-intensive to be properly and efficiently used. Another difficulty has been the tendency of capacitance sensor systems to provide false readings due to noise in the testing environment.

With the development of real time capacitance tactile pressure sensor systems (CTPS), a technique for evaluating low contact pressures with almost instantaneous analysis in electronic packaging process-related applications now exists. Using a CTPS such as the one discussed in this article, an engineer or technician can capture very low contact pressure data, shed light on problems with mechanically attached heat sinks and confirm the predictions generated by the finite element analysis (FEA) component of the system. Engineers and technicians no longer need the trial and error process to obtain product optimization; a CTPS, even where low contact pressure information may be recorded, can efficiently and effectively obtain both pressure distribution and pressure magnitude measurements. Additionally, the problem of environmental noise has been overcome, allowing for confidence in obtaining precise information. In general, the CTPS enables mapping of applications or tests where pressure lies within 0.007 kg/cm^2 to 633 kg/cm^2 (0.1 psi to 9,000 psi).

Relevance to Heat Sinks and Similar ICs

Cisco Systems, a manufacturer of telecommunications equipment, needed a means of determining compressive pressure on integrated circuits (ICs) to ensure proper thermal contact (a minimum of 0.71kg/cm^2 or 10 psi) in a uniform manner, while also low enough for operation. The aging effect of the thermal interface materials that are part of the heat sink assembly also needed to be considered.

As the size of heat sinks increases, both cooling issues and issues with permanent mechanical mounting arise. A common problem with permanent mechanical mounts is excessive mechanical compressive stress and deformation on ASIC solder columns, causing solder joint failure. Compressive load on ASICs with ordinary mounting screws will usually cause large stress and deformation on solder joints. The deformation of an ASIC solder column has to be controlled within the manufacturer-specified allowable range over the entire product service life. A reliable, mechanical heat sink mounting mechanism that will self-correct its mounting pressure during assembly, after rework and throughout the product service life is strongly needed. The mounting mechanism should also constrain the solder column deformation.

Cisco tried using tactile pressure sensor film (TPSF), but the lowest available pressure range for the film did not meet the company's needs for its particular application. Cisco needed to both measure and interpret compressive load in real time, and it required a system that would enable it to verify design specifications, particularly in its R&D areas. The average contact pressure the Cisco team sought to verify ranged around 11 psi, and the local maximum psi was 23 (maximum allowable psi was 35). The overall pressure gradient was seen to be uniform, and the particular component being tested was an ASIC 25 mm x 25 mm ceramic column grid array (CCGA, Figures 1 and 2).

Various components in the ICs make attachment of a CTPS difficult, but the specific CTPS Cisco used provided ease of use, time-saving, post-test processing, and documentation of the results. It also captured problems before they became unmanageable and confirmed FEA results from other testing.

Specifications of a CTPS

The CTPS system Cisco used captures low to medium pressure ranges (0.007 kg/cm^2 to 633 kg/cm^2 or 0.1 psi to 9,000 psi) efficiently and accurately. The system consists of a pressure mapping pad, a data collection controller, interface hub, power supply, interface cables and software.

The thin sensing element skin, or pad, is the heart of the system. The internal composition of this skin is very flexible, enabling placement in invasive, intolerant environments and adaptation over curved surfaces. The skin itself is very durable, being utilizable for several hundred times or more before replacement is necessary. The skin ranges from a minimum pad size of 2.5 cm x 2.5 cm (1 in. x 1 in.) to a maximum pad size of 81 cm x 200 cm (32 in. x 80 in.); the maximum temperature range for the skin is 73.8° C (165° F).

With a query rate of about 60,000 sensor points/second, the information recording rate for interpretation is approximately ±10%. Another valuable aspect of the system is the ability to connect two sensing element pads to the master system, allowing a mapping of two applications simultaneously.

Use and Interpretation of the CTPS

Unlike other sensor systems that capture specific pressures within specific ranges at given moments in time, the CTPS records and interprets contact force in real time. As noted previously, the system is built around a pressure-sensing pad. Pressure sensing is available in various sizes and is detachable from the electronics, making this particular CTPS attractive for environments where the testing area is either inhibitive of normal procedures to record/interpret the test information (temperature, humidity) or where space is at a premium.

Within each specific pressure level, calculation of contact force occurrences is performed automatically, thereby enabling recording of average pressure information over a specific time interval from each sensing pixel. This information thus mapped by the sensing grid pattern can then be played back to review the entire scope of the data. Of especial interest is the ability to display up to four images simultaneously for comparison. Finally, the mapped image can be provided in 2-D, 3-D, histogramic or pressure vs. time formats for dynamic measurement, along with numerical data and comments.

The CTPS can analyze and interpret the compressive load data captured by the sensing element in real time. Other sensor systems usually require a set amount of time to capture the compressive load information and then another specific period of time to both analyze and interpret the data. The speed of the data collection is a breakthrough in the efficient gathering of force information in low pressure environments. The system’s ability to ignore environmental noise also contributes to the successful capture of compression readings.

If an engineer needs to display pressure images in variable viewpoints, the CTPS allows rotation of the data in 90° increments for the most intuitive orientation. Similarly, pressure ranges can be selected to provide optimum viewing, regardless of weight. Contact force measurement data can be displayed via a mapping image with numerical data, color bar and comments. Images themselves are importable as bitmaps to other software documentation; the data itself may be exported in formats compatible with most spreadsheet software.

Conclusion

The CTPS outlined here has potential for revolutionizing how low to medium contact pressure information is both captured and interpreted. Employing this technique allows the scientific and systematic collection and analysis of data in very low pressure ranges that was, until very recently, unattainable. Incorporating this system into an overall R&D, quality control (QC)/quality assurance (QA) or production program will aid in compliance with ISO 9001 standards. The use of this CTPS system with its information capture and analysis abilities lends statistical control and qualification to this aspect of a QC program. The time saved in understanding the contact pressures at work in heat sink and other IC production will enable improved production and release capabilities. In an R&D capacity, merits of different pressure levels can be simultaneously analyzed for comparison.

Gerard E. Mayers *is a senior information specialist with Sensor Products Inc., E. Hanover, NJ; email gmayers@sensorprod.com.* ***H-S Liang, Ph.D.****, is with Cisco Systems, San Jose, CA.*
