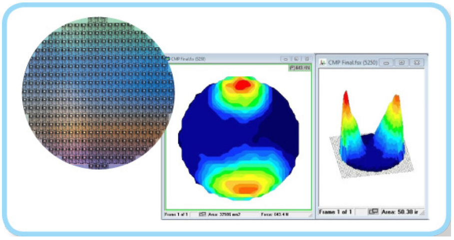
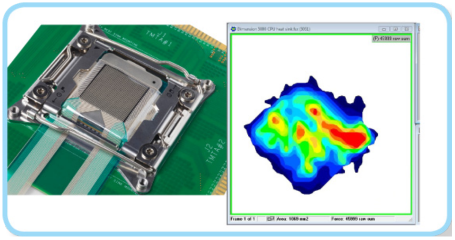
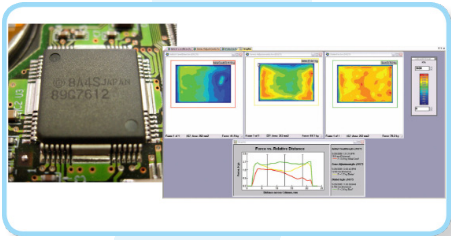
Tekscan®

Insight from Pressure Mapping into Semiconductor Quality and Manufacturing

Measure Interface Pressure to Increase Reliability & Yields







INTRODUCTION

The purpose of this eBook is to present you with an overview of the Semiconductor Industry and how Pressure Mapping technology can validate design and manufacturing. The eBook presents examples of the contributions that Pressure Mapping has made in helping the Semiconductor Industry to gain insight needed for various applications and processes in this field.

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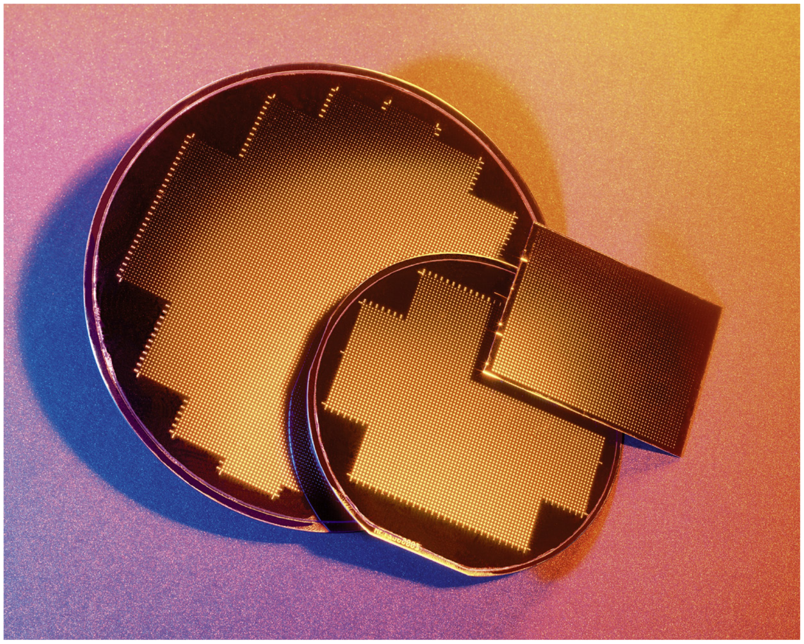
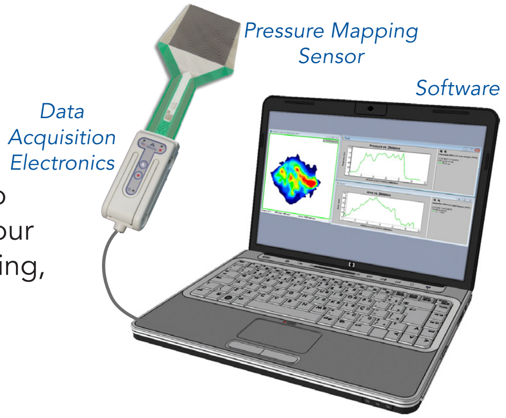
1. SEMICONDUCTOR INDUSTRY OVERVIEW

Whether making components for integrated circuits or photovoltaic devices, precision manufacturing is required for semiconductors and electronics. All steps in the fabrication process, including cleaning, etching, and polishing, need to be fine-tuned when the evenness of finished product is measured in microns. As the $300 billion semiconductor industry continues to grow, throughput and cost become driving factors for production. This leads to larger wafers, which can introduce new challenges for quality control.

When integrating electrical components to a printed circuit board (PCB), the reliability of connections becomes critical to the functionality and performance of the system. Intermittent component connections can lead to total failure, while a weak connection to a heat sink can lead to diminished performance or breakdown. Manufacturers need reliable designs and assembly processes to consistently make quality products, especially if it is an automated process. It is even more important for electronics producers to maintain quality in the communications era.





Pressure Mapping System

2. What is Pressure Mapping?

Pressure Mapping systems measure interface pressure between two surfaces, utilizing a thin and flexible sensor. The resulting data, and our analysis tools, offer insights to enhance product design, manufacturing, quality, and research. Pressure Mapping systems are made up of three components: 1. Pressure Mapping Sensor, 2. Data Acquisition Electronics, and 3. Software.

Paper Thin Sensors

Pressure Mapping sensors consist of a unique piezoresistive material sandwiched between two pieces of flexible polyester, with printed silver conductors on each half. The result is an extremely thin 0.004" (0.1 mm) sensor, which can be manipulated to fit in a broad range of applications, with minimal disturbance to the behavior of the system being tested.

Paper Thin Sensor - 0.004" (0.1mm)

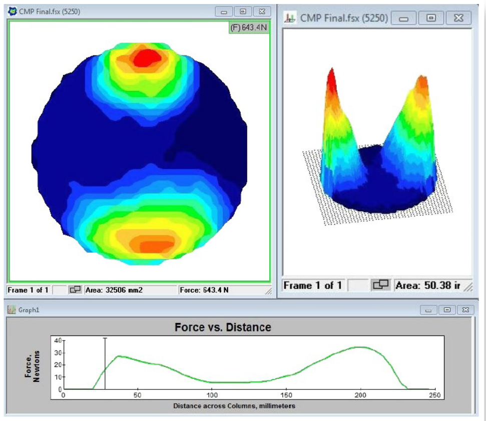
Data Acquisition Electronics

In order to obtain the pressure data, our scanning electronics scan the thousands of sensing points within each sensor. The data is instantly relayed to the software on your PC via a USB cable. Our sensors can be scanned at up to 1,600,00 sensing elements/second.

Data Acquisition Handle Plugs into Computer

Software that Provides Insights you can't Get Anywhere Else

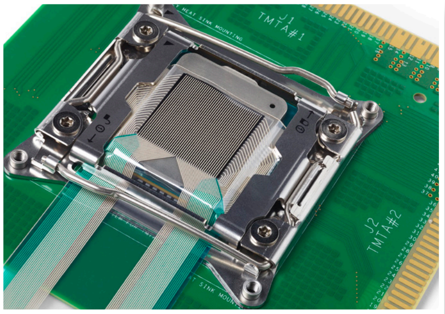
Pressure Mapping software provides the tools for more comprehensive and higher quality analysis than ordinary pressure sensing technologies. The software displays the pressure distribution data, in multiple formats, for superior analysis. Data and imagery of the pressure distribution are shown in real-time, with the ability to record, play back, and save dynamic movies. The user has the option to create and customize graphs from the corresponding movie's data, or export as an ASCII files for use with other programs.



Pressure Mapping software easily shows where high and uneven pressures exist along the two lobes.

3. SEMICONDUCTOR APPLICATIONS USING PRESSURE MAPPING

HEAT SINK



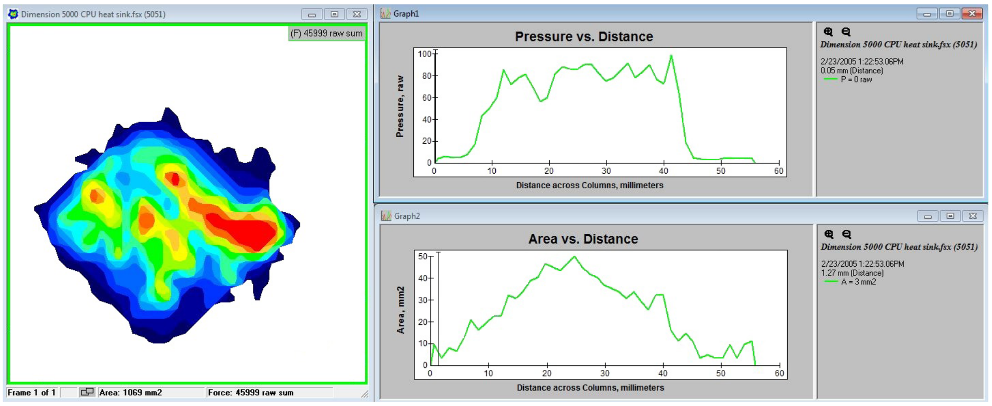
Heat Sink with Pressure Mapping Sensor

High density, active electronics emit energy that can raise their temperature, leading to failures and decreased performance. For the heat sink to properly dissipate heat from the components they are secured to, even contact must be achieved between the part being cooled and the heat source.

To make sure there is proper thermal transfer, the pressure between a heat sink and the source need to be high and even. This can be difficult to achieve, due to the mechanically "stiff" nature of the heat sink and hard surfaces involved; where contact may be achieved well at one or two points, larger regions of potential contacts have gaps.

VALIDATE HEAT SINK AND MOUNT CONTACT

Uniform pressure distribution during the mounting of a heat sink is important for the performance. Using pressure mapping during the mounting process allows a user to see the actual pressure distribution and any potential complications due to poor and uneven contact pressure between the heat sink and mount.



(F) 45999 raw sum

Frame 1 of 1

Area: 1069 mm2

Force: 45999 raw sum

Dimension 5000 CPU heat sink.fsx (5051)

2/23/2005 1:22:53.06PM
0.05 mm (Distance)
P = 0 raw

Dimension 5000 CPU heat sink.fsx (5051)

2/23/2005 1:22:53.06PM
1.27 mm (Distance)
A = 3 mm2

2D pressure display of a heat sink being mounted. Higher pressures are shown in red along the right corner, where the heat sink and source are not even.

The above image shows the 2D pressure display of a heat sink. Higher pressures are evident along the right corner, indicating that the contact area between the heat sink and the heat source is not uniform. This could lead to potential problems with cooling and performance.

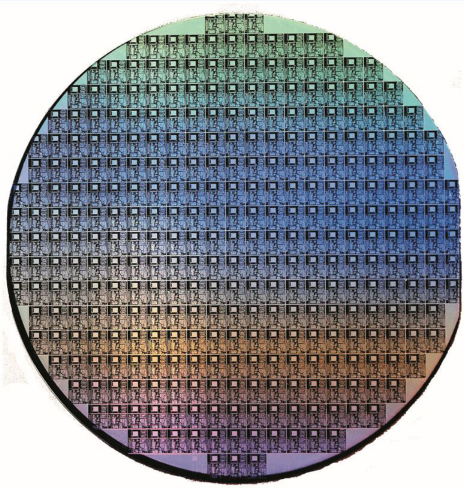
The paper-thin sensors can be easily inserted between the heat sink and heat source to perform evaluation, while having a minimal impact of interface dynamics. Measurements can be done as the heat sink is being mounted, to see where uneven pressures may exist. Adjustments can then be made to the heat sink and heat source, and new measurements can be taken to make sure even contact is made.

Using pressure mapping with heat sinks helps to improve the design and assembly process, minimize validation-testing time, and reduce failures. This leads to improved reliability and yields.

CMP Wafer Polishing

In CMP (chemical mechanical polishing) systems, equipment state measurements, such as characterization and parallelism of polishing heads, is a key step in the semiconductor process. Particle residue will be left behind if the polishing head is not suitably conditioned with a consistent roughness.

CMP is an important manufacturing process in the semiconductor industry. Improving non-uniformity during the polishing process is a critical goal for manufacturers of wafers. An uneven polishing head can cause cracks in the wafer and create product waste.

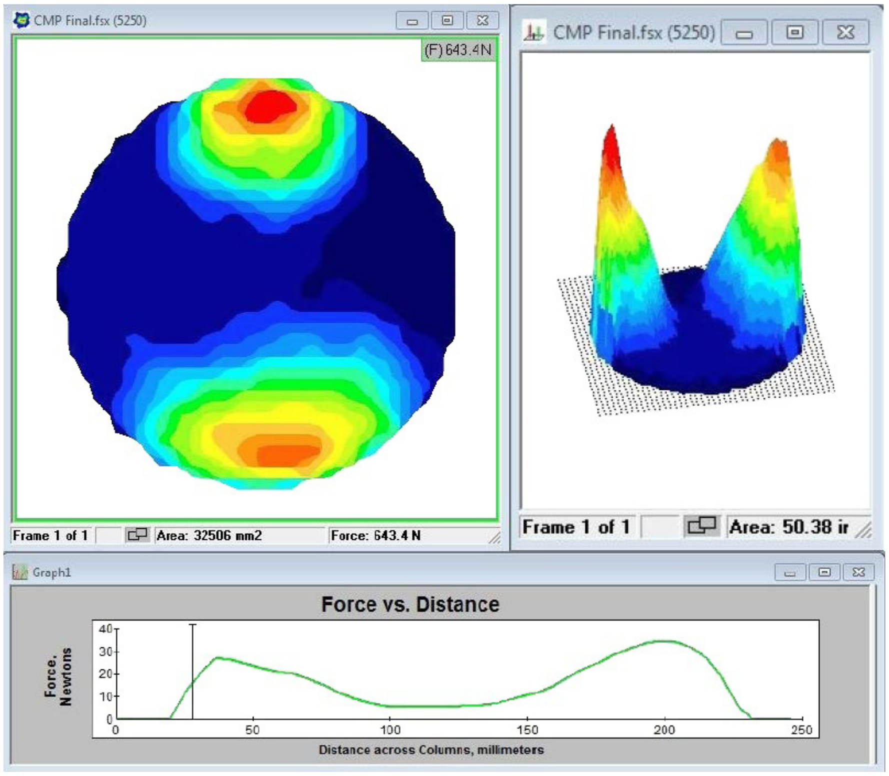


Semiconductor Wafer

Pressure Mapping Shows Parallelism of CMP Wafer

Pressure Mapping can measure the pressure distribution during the various stages of CMP wafer polishing. Tekscan's pressure mapping sensors can be inserted into the CMP polishing machine to measure the pressure distribution along the entire wafer in real-time.

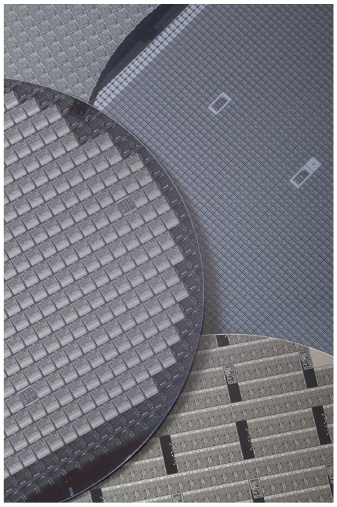
The software will display the parallelism or pressure variation problems during the polishing process. Machine adjustments can then be made, and new measurements taken, to ensure an even pressure.



2D and 3D pressure display of Semiconductor Wafer Polishing. Higher pressures are shown on the two lobes of the polishing head indicating uneven pressures being put on the wafer from the polishing head.

The figure above shows non-uniform pressure distribution on the wafer during polishing, with higher pressures applied on the two lobes of the polishing head. The material removed is likely due to an uneven pressure on the wafer from the polishing head.

WAFER BONDING



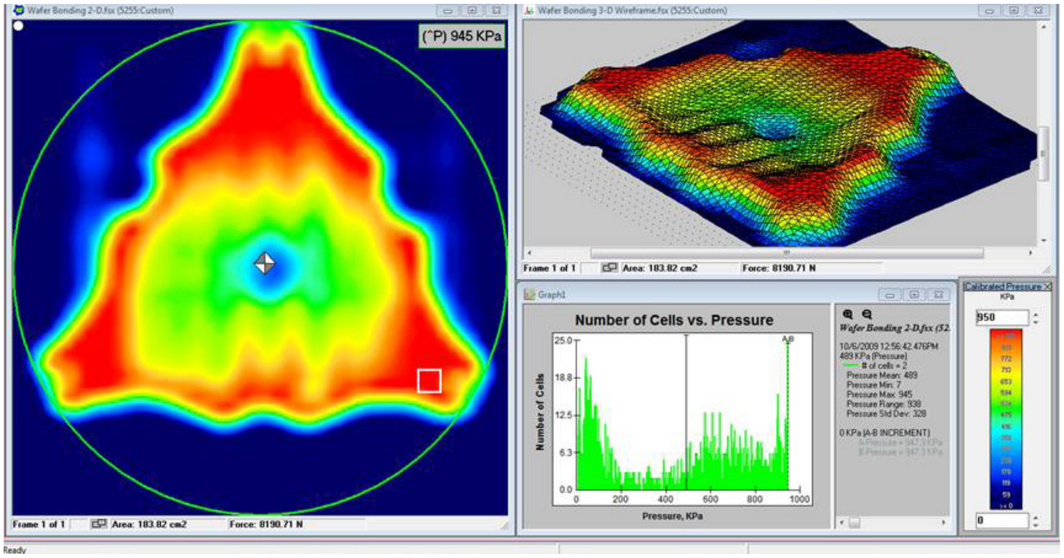
Semiconductor Wafers

During the wafer bonding process, it is necessary to have flat plates apply an even amount of pressure. Over time and increased use, these plates start to become uneven, making it difficult to detect slight pressure variations across the surface.

PRESSURE MAPPING SHOWS NON-UNIFORMITY DURING WAFER BONDING

With Pressure Mapping both static and dynamic pressure impressions can be taken before, during, and after machine adjustments are made. This allows the user to see how changes in the pressure can affect planarization and contact area. Measuring these key process steps and equipment states enables engineers and machine operators to establish product quality standards.

If the optimal pressure is not achieved, adjustments can be made to optimize the clamping fixture design, quantify forces, or determine the ideal protocols such as torque patterns and procedures.



Wafer Bonding 2-D.fsx (52

10/6/2009 12:56:42.476PM
489 KPa (Pressure)
# of cells = 2
Pressure Mean: 489
Pressure Min: 7
Pressure Max: 945
Pressure Range: 938
Pressure Std Dev: 328

0 KPa (A-B INCREMENT)
A Pressure = 947.3 KPa
B Pressure = 947.3 KPa

2D and 3D pressure display of Semiconductor Wafer Bonding. Higher pressures are shown in red indicating uneven pressures being put on the wafer from the bonding process.

The figure above shows uneven pressures along the wafer during the bonding process. The high pressures shown in red are points where the pressures are much higher indicating a non-uniform bonding. Adjustments must be made to the fixture to create even pressures along the entire wafer.

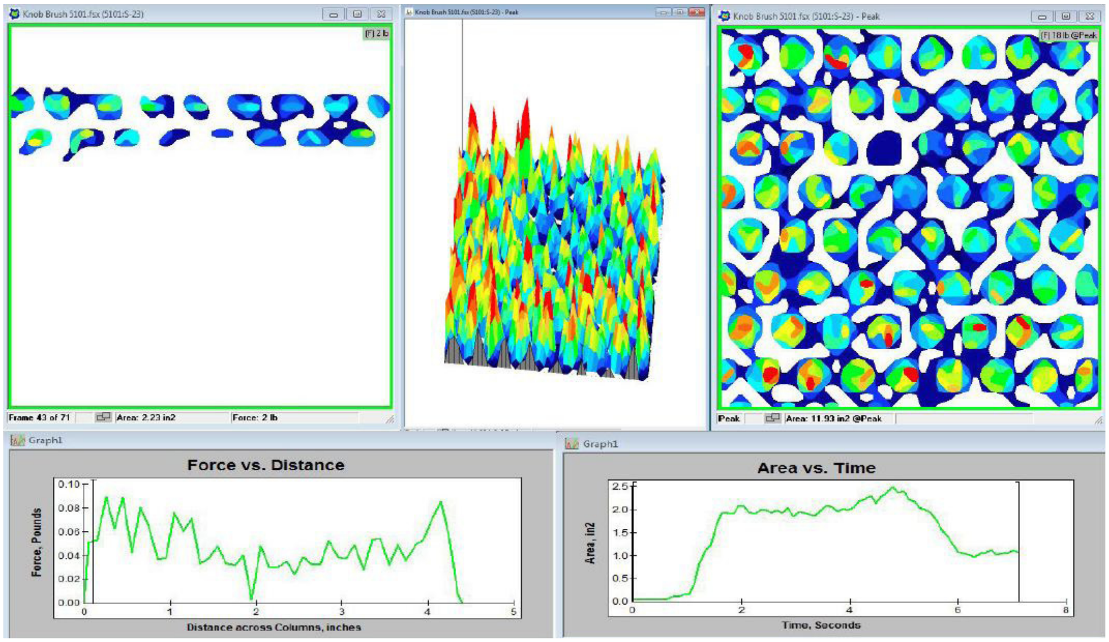
POST-CMP PVA BRUSH TESTING

PVA Brush Roller over Pressure Mapping Sensors

Polyvinyl alcohol (PVA) brushes are used in the semiconductor process during the post-CMP cleaning stage. During PVA brushing post-CMP cleaning particle removal is done through direct contact between the soft PVA brush and the wafer surface. The brush asperities engulf the wafer surface contamination, while the brush rotates to remove the particles from the wafer.

PROPER BRUSH-TO-WAFER CONTACT PRESSURE WITH PRESSURE MAPPING

Ensuring proper brush-to-wafer contact pressure and contact area is crucial in achieving clean and particle free wafers. Pressure mapping and tactile pressure sensors provide immediate feedback on the effectiveness of the brush. This is done by measuring the real-time contact pressure distribution and area. The pressure mapping software displays any pressure inconsistencies that could cause particles to not be removed from the wafer.

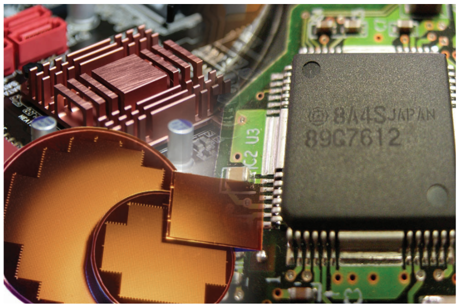


2D and 3D pressure display of a PVA Brush Roller. Uneven pressures are clearly evident along the middle of the brush where more pressure is being applied.

The above image shows 2D and 3D displays of the pressure output of a PVA Brush roller used during semiconductor wafer post-CMP process. Uneven pressures were clearly identified along the middle of the brush. Using this information, the brush can be adjusted to fix the pressure distribution, making it more even. New measurements can be taken to ensure an even contact pressure across the entire brush.

Utilizing pressure mapping during post-CMP PVA brush process helps to ensure a consistent wafer cleaning performance and improved consistency, which helps reduce machine set-up time and increase product yields.

PRECISION CLAMPING



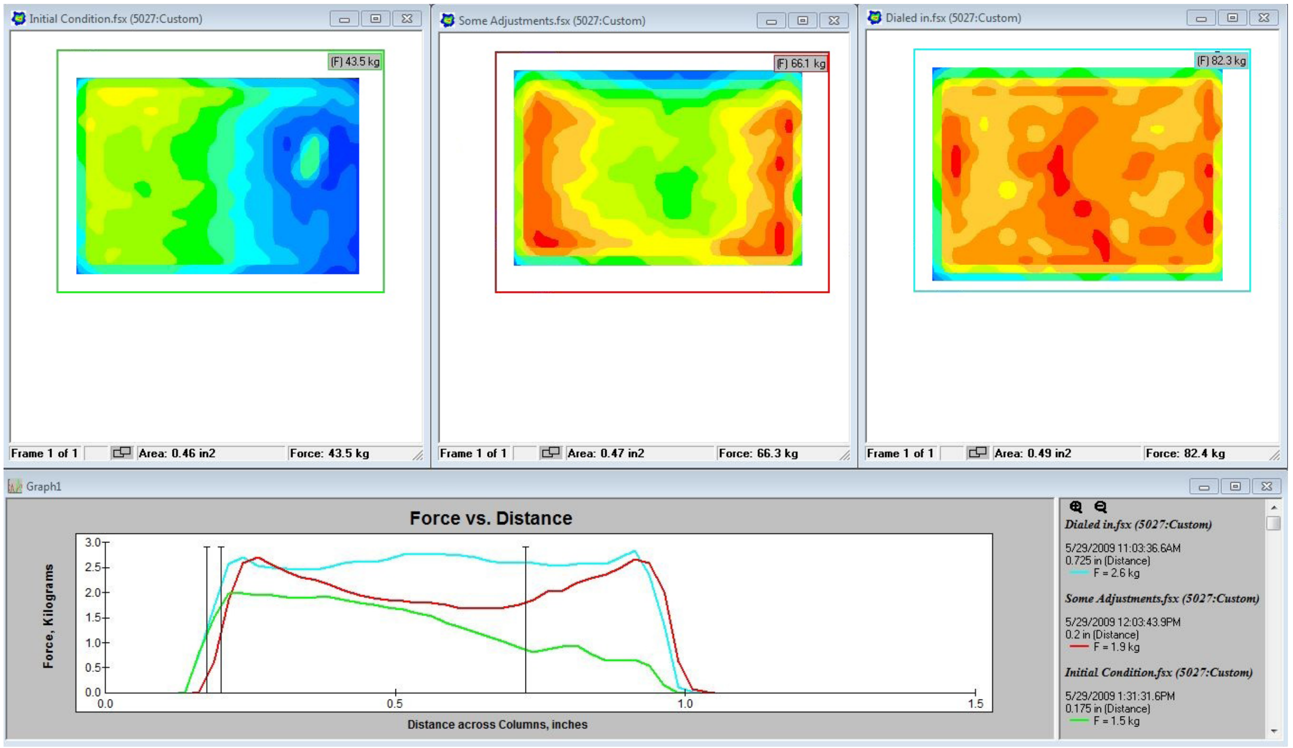
Semiconductor Precision Clamping

Unknown clamping forces during computer chip and heat sink mounting or wafer probe testing can cause considerable product defects and quality issues. This can lead to lower yields, increased costs, and product waste.

EVALUATE PRESSURE DISTRIBUTION DURING THE ENTIRE CLAMPING PROCESS

Pressure Mapping is a key diagnostic and machine set-up tool for clamping fixtures. The ultra-thin sensors can be placed between any two mating surfaces, such an integrated circuit on a PCB or a probe and wafer. Pressure Mapping allows both static and dynamic pressure impressions to be taken before, during, and after machine adjustments, allowing the user to see how changes in pressure can affect planarization and contact area. Measuring these key process steps and equipment states enables engineers and machine operators to establish product quality standards.

If the optimal pressure is not achieved, adjustments can be made to optimize the clamping fixture design, quantify forces, and determine ideal protocols such as torque patterns and procedures. Pressure Mapping systems can be used to optimize pressure distribution prior to a testing sequence or production run, saving valuable company time and money.



Initial Condition.fsx (5027:Custom)

(F) 43.5 kg

Frame 1 of 1 | Area: 0.46 in2 | Force: 43.5 kg

Some Adjustments.fsx (5027:Custom)

(F) 66.1 kg

Frame 1 of 1 | Area: 0.47 in2 | Force: 66.3 kg

Dialed in.fsx (5027:Custom)

(F) 82.3 kg

Frame 1 of 1 | Area: 0.49 in2 | Force: 82.4 kg

Graph1

Dialed in.fsx (5027:Custom)

5/29/2009 11:03:36.6AM
0.725 in (Distance)
F = 2.6 kg

Some Adjustments.fsx (5027:Custom)

5/29/2009 12:03:43.9PM
0.2 in (Distance)
F = 1.9 kg

Initial Condition.fsx (5027:Custom)

5/29/2009 1:31:31.6PM
0.175 in (Distance)
F = 1.5 kg

Progressive iterations of tooling, process, and/or fixturing adjustments, yield more even pressure distribution across the area of interest.

4. CONCLUSION

Throughout all aspects of semiconductor manufacturing, detailed testing and inspection are necessary to yield high quality and well-functioning products. Pressure Mapping from Tekscan enables engineers and machine operators to quickly and accurately perform real-time pressure measurements during the various stages of the semiconductor process. The data provided by a pressure mapping system provides a unique insight into a system or product's performance, which is invaluable in system and process design. It also provides the information necessary to maintain high quality products, improve reliability, and improve yields.

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[4] Philipossian, A., Mustapha, L., (University of Arizona, Tuscon). Effect of Mechanical Properties of PVA Brush Rollers on Frictional Forces during Post-CMP Scrubbing. Journal of the Electrochemical Society, 151 G632-G637, 2004.