Capacitance Sensors Facilitate 3D IC Construction

To boost device performance, today's semiconductor and microelectronics manufacturers are building three-dimensional integrated circuits featuring vertically-stacked silicon wafers and dies. The rationale is simple. Exploiting the Z axis avoids the power and footprint penalties associated with two dimensional processes. Implementing the rationale, however, is not so simple. Going vertical requires coplanar surfaces to make contact with all pins, pads, and pillars.

Problem

Typically, manufacturers measure the angle and gap between two planes to determine coplanarity. Bonding tool actuators rely on these angle/gap measurements to adjust components and make sure all device pins and/or solder balls reside on the same geometric plane so they mate or bond together properly, without residual stress. This process is dubbed "active parallelism compensation."

Because bonding success depends on the precision with which angle and gap measurements are made, active parallelism compensation can prove challenging and costly – especially when required resolution is in the sub-micron range.

Solution

To achieve high-resolution position control, MTI employs ASP-50-ILA capacitive displacement probes, a D-300 Digital Accumeasure capacitive amplifier, and actuator/control system. These components work together to monitor and adjust the gap/angle between the bond plane (die bonding tool) and ground plane (die or substrate).

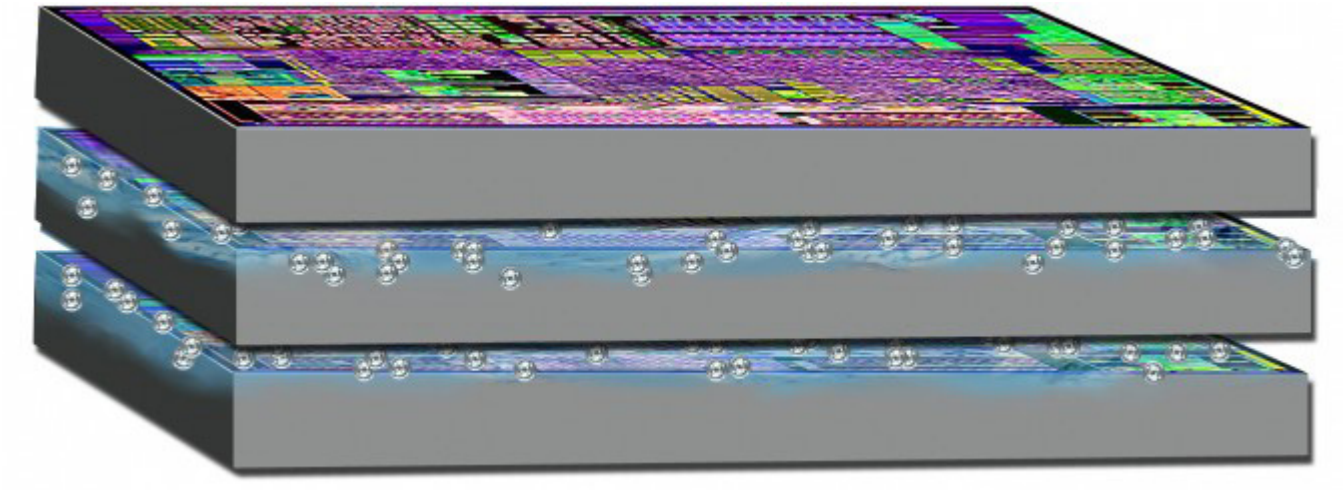
Setup involves mounting the probes to the die bonding tool; a minimum of three capacitance probes are needed to establish the planar surface. Likewise, a minimum of three actuators are required to adjust the die or substrate for coplanarity with the die bonding tool.

Gap measurements are processed by a D-300 Digital Accumeasure capacitive amplifier. The amplifier interfaces with the control system via 1000 base Ethernet or USB to monitor coplanarity and provide position control to the actuators. The amplifier and control system generate a 1,000 points/sec sample rate of the planar position.

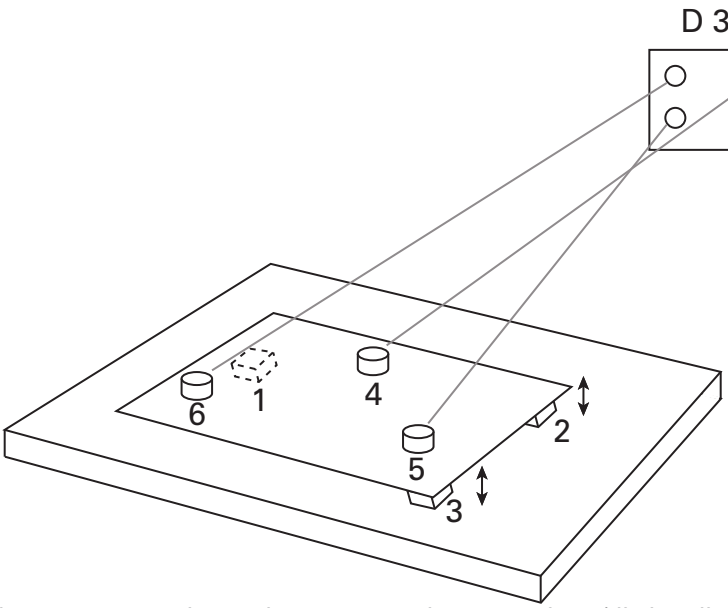
Benefits

Custom designed for the semiconductor industry, the capacitive displacement probes can be threaded, cylindrical, or flat. Constructed of materials with negligible outgassing levels, they operate in vacuum as well as elevated temperatures.

Amplifier linearity is 0.01% of range, yielding a linearity spec of (50 um/0.01% = 5 nm) and a resolution of 5 nm p-p at 100 Hz loop position bandwidth speeds. Total error encountered: 10 nm max. Additionally, Digital Accumeasure systems offer less than 100 PPM drift, rivaling laser interferometers for stability and accuracy.



Coplanarity ensures all connections are successfully bonded, minimizing the risk of field failure.



1, 2, 3 Are Piezo Flexures
4, 5, 6 Capacitance sensors for coplanarity

Three gap measuring probes mount to the upper plane (die bonding tool). A control system monitors coplanarity of the tool to the lower plane (die or substrate) and provides position control to the actuators.

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