ONE MICRON WAFER TO WAFER ALIGNMENT FOR 3D INTERCONNECTING DEVICE INTEGRATION

C.Brubaker [1)], T. Glinsner[2)], P. Lindner[2)], C. Schaefer[2)],

[1)] EV Group Inc., 3701 E. University Drive, Suite 300, Phoenix, AZ 85034, USA,
E-mail: Sales@EVGroup.com, Phone: +1 602 437 9492
[2)] EV Group, St. Florian, A-4780 Schaerding, Austria,
E-mail: Sales@EVGroup.at, Phone: +43 7712 5311 0

Precision aligned wafer bonding is a key enabling technology for 3D Interconnects, wafer level packages (WLP) and advanced MEMS devices. Unlike in MEMS that frequently involve double side processing, IC and CMOS wafers are always processed on a single side. Therefore wafer to wafer alignment must use alignment targets situated in the bond interface i.e. face to face. The ability to align and bond such wafers with one micron precision is becoming a critical issue for a variety of applications. This paper will report on the principal steps of the face to face alignment method and on latest results of one micron or better accuracy routinely obtained by such method with a special developed alignment system. The principal equipment designs for wafer to wafer alignment and bonding as well as its modularity for fully integration into high volume production lines will be discussed.

Face to Face Wafer Alignment Method

The SmartView™ alignment system is able to achieve one micron or better alignment tolerance using a face to face alignment method, thus eliminating extra processing steps, such as the need of backside alignment keys.

Instead of using a single microscope in between the wafers, as it has to be used in other substrate alignment platforms, the SmartView alignment system (see Figure 1) employs two microscopes for alignment. One microscope is placed above and the other below the wafer stack. The dual microscopes focus on a common axis calibrated for each alignment. Each microscope objective observes one alignment key on the surface of the wafer.

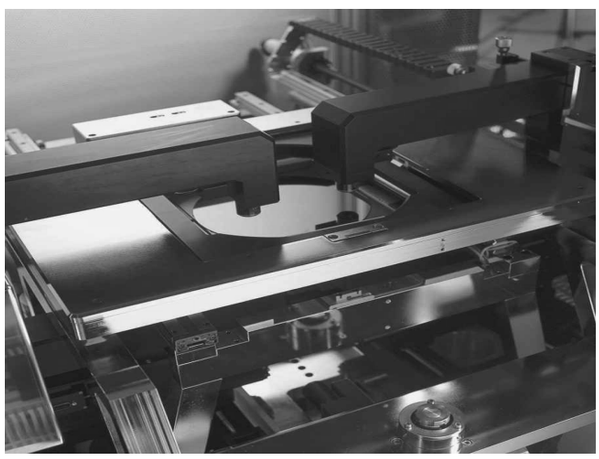

Figure 1. *Photograph of a close-up view of the SmartView aligner microscope*

The SmartView process flow is as follows:

Step 1: First the top wafer which is rotated face down after loading is observed by the bottom optics. The alignment key is found, the image is digitized and stored electronically. Step 2: The top wafer is then retracted, allowing the bottom wafer to be brought into position and then aligned to the existing digitized image of the top wafer.

Step 3: Once complete the two wafers are automatically moved into alignment by calculating the relative X and Y locations of the alignment keys on each wafer and moving the wafers into the final alignment position. Once complete the wafers are brought into contact and secured for bonding.

Wafer alignment is accomplished using encoded stage motors allowing X and Y movements in increments of 0.1 micron steps and a small axis of Z-travel controlled by three software compensated independent spindle motors to preserve planarization between the top and bottom wafers. The repeatability of the measurement system is below 0.15 microns.

Alignment Results

Figure 2 shows the typical alignment results for 200mm wafers by using the SmartView alignment system in multiple test series under production conditions. The values in X and Y direction are within 1 micron or less accuracy. The standard deviations in all series are in the range between 0.3 to 0.4 microns.

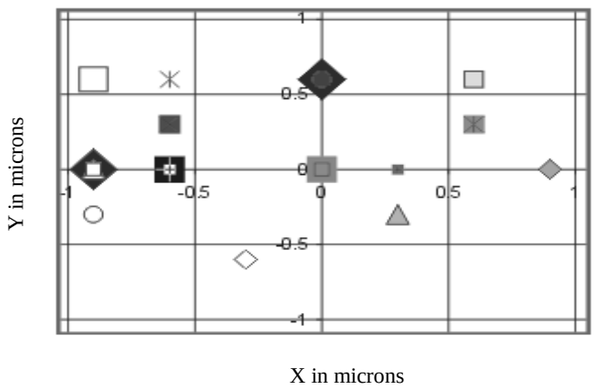

Figure 2. *Alignment Results for SmartView wafer to wafer bond alignment system*

Wafer Bonding and Integrated Align/Bonding Systems for 200mm

Present advanced packaging applications require a bonding platform that can accommodate chip to chip, chip to wafer and wafer to wafer configurations. Further key is the ability to perform the process repeatedly without compromising in precision.

For R&D the scale must apply to substrates smaller than 10mm square, through full wafers of 200mm diameter. Here stand alone 200mm wafer bonders are the choice and able to accommodate these and the subsequent criteria. For high volume production instead integrated fully automated systems are required in which the Smart View aligner is combined with an automated 200mm bonding system for up to 10 bond chambers. Both bonders in R&D as well as in fully automated integrated systems feature bond forces of up to 40kN, class1 cleanroom compatible stainless steel base designs and temperatures beyond 550°C with excellent uniformity, stability and reproducibility.