Lithography in Advanced Packaging

MKS' Motion Control platform provides speed, accuracy and repeatability to a critical advanced packaging process.

Introduction

As electronic consumer devices continue to become smaller and lighter with increased performance, advanced packaging pushes the limits of innovation in the semiconductor industry. Advanced packaging continues to evolve to keep pace with industry needs to reduce package size, decrease power consumption and increase chip connectivity, while improving reliability, performance and multi-function integration. As advanced packaging processes and 3D integration drive back-end adaptations of front-end processes, MKS' extensive experience as a front-end manufacturing supplier helps us understand, anticipate and support the changing needs of the back-end packaging environment. MKS, a long standing solutions supplier for front-end semiconductor fabrication, has partnered with our customers, solving their most challenging advanced packaging problems, and leveraging our technical innovation, experience and passion.

MKS products solve key Lithography challenges

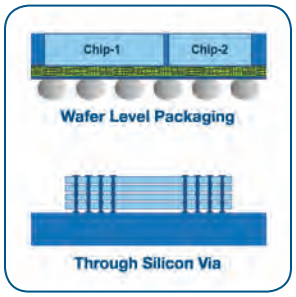
including fast step and settle, reduced process variability and high repeatability with performance solutions in:

- Motion Control
- Active Isolation

Chip packaging technology that meets industry expectations of size, power, yield and cost continues to evolve with new advanced packaging chip methods including 2.5D and 3D glass and silicon interposers. These new and unique processes to interconnect and integrate chips into final assemblies present new challenges in deposition, etch, lithography, inspection, singulation and clean for both front-end foundries and back-end packaging suppliers.

New Challenges in Lithography Processes

Redistribution Layers (RDL), Under Bump Metallization (UBM) and bump and pillar formation are key processes enabling high density interconnects used in 2.5D and 3D advanced packaging. In order to meet the quality and high throughput needs of the industry, the wafer stage must step and settle quickly with limited vibration transference to flash illumination optics. The stage must function with little process variability in absolute accuracy and be repeatable within a small process window due to stacking of multiple lithography layers on the same die. This level of accuracy and repeatability is needed from die to die within a single wafer and from machine to machine on the manufacturing floor to ensure high quality ICs.



Challenges specific to lithography include:

- Surface accuracy positioning
- Fast step and settle with vibration control
- Movement accuracy within a defined process window
- Repeatability

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MKS Solutions

Lithography uses a step, settle, and illuminate process to create features used in 2.5D and 3D advanced packages. These process steps are repeated on a single die to create multilayer features, die to die on a single wafer, wafer to wafer on the same machine and ultimately machine to machine on the manufacturing floor.

The complex 2.5D and 3D structures of advanced packages require multiple reticles and a significant increase in the number of exposures to build up the structures which can reduce process throughput. One way the industry has tried to mitigate lower throughput is by increasing die size, resulting in a reduction of elapsed lithography time by processing fewer die per wafer. However, larger sized die require a greater degree of positioning accuracy on the surface. MKS' advanced Z Tip Tilt (ZTT) and theta stage with high accuracy and dynamic capabilities enable perfect alignment and accuracy between the die and the die surface. The ZTT stage provides autofocus capability to dynamically maintain the wafer in the correct Z position. These capabilities support using larger die in advanced packages by resolving the alignment and accuracy issues.

Another way to increase throughput is to increase the speed of wafer movement between flash illuminations. MKS' air bearing motion stage has a typical acceleration of 1-2g with a jerk time of a few milliseconds for moving masses in the XY direction. Quick movement over a short distance can create oscillation of the optics column resulting in illumination delays as the wafer settles. MKS' Motion Control system provides quick step and settle of the stage while simultaneously managing the active isolation and synchronizing it with the stage's motion profile to avoid base motion as well as residual acceleration. The fast stage movement speed and limited vibration transference to the flash illumination optics enables an overall faster processing time resolving the throughput issue.

The lithography process requires precision, accuracy and repeatability wafer to wafer and machine to machine to ensure end device reliability. Without repeatedly precise, accurate positioning of features, multiple die cannot be stacked and interconnected to create a fully functioning and reliable device. MKS' Motion Control solutions provide a high level of movement accuracy and repeatability, within ±100nm on a 300mm wafer, within a defined process window. Our strong metrology capabilities allow us to calibrate stages with a high degree of accuracy, increasing the reliability of our stages through stable and high positioning repeatability. This high level of repeatability within a small area supports multilayer build-up of 3D structures without negatively impacting yield of stacked devices. This also ensures the same level of accuracy can be achieved wafer to wafer and machine to machine removing any yield concerns due to incorrect positioning of 2.5D and 3D structures.

The adoption of panel processing is another way the industry is trying to increase advanced packaging throughput. In response to this changing dynamic, MKS has developed the DynamYX® DATUM® stage capable of supporting 500mm panel sizes with similar step and settle, vibration isolation and positioning accuracy and repeatability.

Nanoimprint lithography is an alternate method for creating advanced packaging structures which uses a dispensed resist or liquid which is then stamped and UV cured. For this alternate process, absolute accuracy is not as critical because the process uses fiducial markings to enable adjustment to the proper location. Instead, due to the forces of the stamping process, stiffness of the surface is important to ensure there is no warp of the stamped features. MKS' DATUM stage provides the level of stiffness needed to ensure good imprint of the structures on the die. The DATUM stage uses the same fast step and settle technology to ensure sufficient throughput.

MKS' Motion Control solutions provide fast, precise and repeatable movement while controlling optics excitation resulting in higher throughput and better yield of 2.5D and 3D advanced packages.