Inspection in Advanced Packaging

MKS provides a wide range of technologies to solve inspection challenges for advanced packaging

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, leveraging our technical innovation, experience and passion.

MKS products solve key Inspection challenges

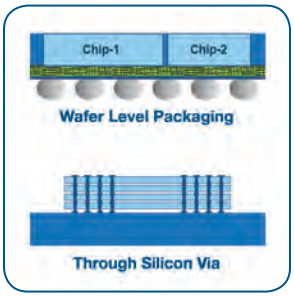
including precise illumination, fast step and settle, reduced process variability and high repeatability with performance solutions in:

- Motion Control
- Lasers
- Optics
- Integrated Optical Subassemblies

Chip packaging technology that meets industry expectations of size, power, yield, and cost continues to evolve with new advanced packaging chip methods including 3D and 2.5D 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 Inspection

The complex structures used to create 2.5D and 3D advanced packages have increased the need for more sophisticated inspection in back-end of line. Defect detection of wafer bumps, post via fills, redistribution layers and other surface related defects is critical to ensure only known good die are used in the packaging process.



To identify defects, the image generated must be precise, have high resolution and low noise. This requires a light source that provides precise and consistent illumination, a motion stage that can move quickly from location to location accurately and settle quickly, and an optical system at or near the diffraction limit of performance with high accuracy, low defect surfaces and efficient, long lifetime thin film coatings.

Challenges specific to Inspection include:

- Sufficient sample illumination
- Precise X, Y and Z movement within low tolerance
- Low jitter at high speed
- Optical images to ensure accurate defect identification

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MKS Solutions

Defect inspection is becoming critically important in back-end packaging as 2.5D and 3D structures gain traction in the market. The interconnect mechanisms of advanced packages include complex structures like bumps and pillars, through-silicon vias (TSV), and redistribution and under bump metallization layers. To ensure good reliability of the end packaged IC, inspection of these complex structures must be done repeatedly during the manufacturing process.

Illumination of the wafer or die is critical to identifying if a defect exists in the material or structures that could lead to a non-functioning IC. Lasers act as the light source, providing bright illumination through high power. However, the high power that helps illuminate can damage the wafer or die. MKS' Quasi-CW Vanguard® Laser solves this problem by delivering 13ps low energy pulses at a high repetition rate of 80MHz, insuring the wafer or die isn't damaged during illumination. Fast laser pulsing not only helps prevent wafer damage during illumination, it helps increase inspection throughput due to faster speed. Vanguard's consistent high quality UV beam parameters enhance the quality of precise detection, consolidating the throughput with reliable data collection.

Imaging of the pattern or structures on the wafer to compare against what it should be requires precise movement and control of the sample in XYZ dimensions. The motion stage has to move quickly to help increase throughput, must limit the amount of jitter at high speed, and needs to move in a straight line with little variability. 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. This quick movement over a short distance can create jitter leading to 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 resulting in 1mg of residual acceleration. The fast stage movement speed and limited jitter enables overall faster processing time, improving throughput. MKS' advanced Z Tip Tilt (ZTT) and Theta Stage with high dynamic and accurate positioning provides autofocus capability to dynamically maintain the wafer in the correct Z position with ±25nm.

MKS' motion control solutions provide a high level of movement accuracy within ±100nm on a 300mm wafer surface, with high stability on a defined process window. Our strong metrology capabilities allow us to calibrate our stages with a high degree of accuracy, increasing the reliability of our stages through stable and high positioning repeatability.

To accurately identify defects, the optical components and subsystems must be high quality to produce high resolution, high signal and low noise images. MKS has a long history and expertise in the types of optics needed for this application, producing precision optics, thin film coatings, and assemblies for laser and broadband imaging systems. All of this experience combines to ensure not only are the optics of the highest caliber for defect identification, but they also help focus the laser beam to ensure precisely controlled illumination of the subject under inspection.

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® Ultra-High Performance Air Bearing Stage capable of supporting 500mm panel sizes with similar step and settle, vibration isolation and positioning accuracy and repeatability.

MKS' Motion Control, Lasers, Optics and Integrated Optical Subassemblies help enhance image quality during inspection by producing precision UV light without damaging the substrate, controlling the movement and position of the sample under inspection within a narrow window in XYZ dimensions, and provide optics free of subsurface defects enabling better defect detection in 2.5D and 3D advanced packages.