Die Singulation in Advanced Packaging

Increased production yield by remediating stress and micro-cracks and improving die edge quality during Singulation and Wafer Grinding

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 evolved 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 Instrument's 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.

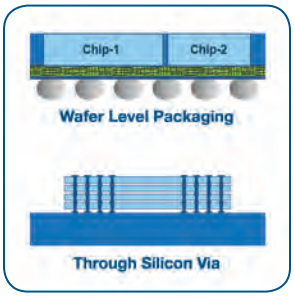
MKS products solve key Die Singulation challenges including stress relief and micro-crack propagation with high performance solutions in:

- RF Power
- RF Plasma
- Lasers
- Microwave Plasma
- Remote Plasma

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 Die Singulation Processes

Thinner and smaller die used in 2.5D and 3D integration to reduce device package size and increase performance is creating new challenges in die singulation. Die singulation includes back side grind, scribe, dice and separation.



Due to the thinner nature of the wafers for advanced packages, curl and cracking occurs from routine handling. Back side grind induces stress creating wafer warp, and surface and sidewall micro-cracks are induced by traditional mechanical dicing methods. All of this impacts yield. Alternate singulation methods including the combination of laser scribe and mechanical dicing and the extension of Deep Reactive Ion Etch (DRIE) technology are alleviating some of the challenges of cutting thinner die and are gaining traction.

Challenges specific to die singulation include:

- Stress and wafer warp post grind
- Process induced low die strength
- Poor edge and surface quality induced by dicing

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MKS Solutions

3D advanced packages use thin wafers that crack and curl from handling stress with more interconnects at tighter pitches per die. These factors drive the use of Die Attach Film (DAF) which increases rigidity of the wafer, eliminates paste creep that contaminates bond pads, and provides a consistent adhesive height thickness making stacking of die more precise, reliable and repeatable. MKS Lasers can cut through DAF, providing an improved edge quality of the adhesive, eliminating burring that can occur with mechanical dicing, resulting in better and more reproducible interconnections of stacked die.

Thinner wafers for 2.5D and 3D advanced packages develop stress, warp and decreased substrate strength induced by the back side grinding process. MKS' Microwave Plasma solutions release induced stress and restore the Si substrate material using activated gas radicals instead of ions. By using lower temperature radicals to affect electron vibration of bonds in the substrate, MKS technology provides enhanced material restoration capability, reducing substrate stress while increasing overall die strength, resulting in increased yield. The excellent restorative properties of MKS' Microwave Plasma Subsystem provide stress free die.

Mechanical scribing of low-k dielectric material induces micro-cracks and delamination of layers due to the brittle nature of the materials. MKS UV and ultra short pulse width lasers provide non-contact scribe of low-k material without causing cracks or wafer damage by controlling power delivery, pulse width and wavelength. MKS' Lasers, when tightly focused on the wafer surface, increases throughput by using short pulse width, high peak power and high repetition rate to ablate the low-k material, creating narrow, grooved streets.

Depending on the scribe, dice and separation methods being used, there are various degrees of micro-cracks and fissures that develop on die edges and side walls during the process. This results in poor yields and potential early device failure. MKS' RF and Microwave Plasma Subsystems act on the die chemistry through the use of different species reactions, promoting smoother side walls, repairing edge cracks and improving die strength, resulting in higher yield and reliability.

The grinding process is evolving to include multiple grind methods in the process flow to achieve the required wafer thinness and plasma use in this application is increasing. MKS' RF and Microwave Plasma Subsystems are used to remove the final micrometers of silicon after mechanical back side grind. Plasma Si removal reduces the risk of over grinding and destroying the wafer. MKS' RF Plasma solutions provide fast etch rates, decreasing throughput time, while MKS' Microwave Plasma solution provides a more uniform finished surface at low process temperatures, maintaining integrity with the backside tape and/or wafer carrier.

MKS' UV and ultra short pulse width Lasers are used to fully dice wafers and increase the number of die by creating narrower streets and reducing the Heat Affected Zone (HAZ) resulting in less wafer area loss. Compared to the stealth dicing method that creates fissures within the wafer material which are then manually broken, MKS Lasers provide a precise, non-contact method that fully cuts through the wafer, resulting in few micro-cracks and more precise die shapes with less variation resulting in better reliability of stacked die. Laser dicing removes the rectangular die shape constraint of mechanical and stealth dicing, thereby enabling new die shapes to meet the changing needs of the market.

Plasma dice using Deep Reactive Ion Etch (DRIE) technology is gaining traction with wafers thinner than 100µm thick, displacing more mainstream mechanical and laser dice technologies. Plasma dice allows for singulation through the entire wafer depth, reducing cracks and micro-fissures that may form from mechanical dice and separation. Plasma's lower thermal profile, when compared with traditional lasers, removes the need for heat affected zones enabling thinner streets resulting in more die per wafer. MKS' RF Generators with Dynamic Frequency Tuning handle rapid impedance changes in the DRIE process—as fast as 50µsec—delivering reliable, consistent power to the load, resulting in a more efficient etch process with unvarying and to repeatable rates. MKS' RF Generators also quickly adapt to changing impedance levels caused by etching through different material layers ensuring better process uniformity and control.

MKS' RF Power, Lasers, Plasma and Microwave Plasma Subsystem solutions provide improved yield and higher throughput by solving problems such as stress, edge quality and micro-cracks created from singulation of thinner die used in 2.5D and 3D advanced packages. Leverage MKS' technical innovation, experience and passion to solve your most challenging applications in die singulation and advanced packaging.