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INTELLIGENT INSPECTION

Koh Young on Cutting-Edge Inspection Challenges

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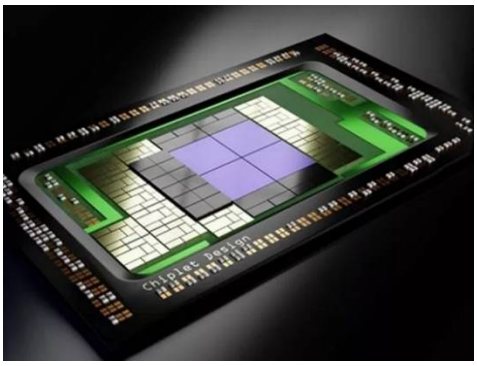
In an email-based exchange, we asked Koh Young's Brent Fischthal how UHDI and advanced packaging were challenging inspection systems. Here's what Brent had to say.

Advanced packaging seems to be accelerating the trend toward larger component packages. What are the new demands/challenges these packages put upon inspection?

The shift towards larger component packages and advanced packaging brings a host of challenges that affect the industry. These challenges include complexity, density, package diversity, and inspection methodologies, all of which necessitate a more innovative approach.



Firstly, the increased complexity associated with advanced packaging techniques introduces more intricate board designs with multiple layers and miniaturized components. Furthermore, the drive towards higher density and smaller pitch, facilitated by advanced packaging solutions such as 2.5D and 3D packaging, places significant demands on inspection machines. For instance, inspection systems must reliably identify defects like soldering issues, bridging, or voids within densely populated areas, even where access might be limited.

Moreover, the proliferation of diverse advanced packaging methods, including fan-out wafer-level packaging (FOWLP), system-in-package (SiP), and chiplets, requires inspection machines to accommodate a wider variety of package types and configurations. In addition, the variation in component heights, a common characteristic in advanced packaging due to designs like stacked die, requires the inspection system to overcome the shadowing created by these package height differences to make consistent and reliable measurements.

Besides larger component packages, OEMs, and applications such as automotive are demanding much larger volumes of finished boards, with much higher yields and increased reliability. How does this change the role of inspection equipment? Surely just making the machinery faster isn't the entire solution.

In the context of escalating production volumes, higher yields, and stringent reliability requirements, the inspection machine's role is indeed more than just speed enhancement; it becomes a multifaceted, integral component of the manufacturing process. Larger and more complex packages generate larger and more complex inspection data sets, which makes efficient data handling, storage, and analysis imperative. This enables the identification of trends, root causes of defects, and process improvements by inspection machines that collect the right data in the right amount and in the right way to allows AI-powered software tools to turn measurement-based data into actionable insights. Afterall, processed data is information, but analyzed data is insight.

Within the context of Industry 4.0 and smart manufacturing initiatives, inspection machines must seamlessly share data with other systems to enable real-time feedback and process optimization. This requires an increasingly higher degree of connectivity, interoperability, and compatibility with factory automation systems. As production volumes surge, preserving product quality is of even more importance. Inspection machines assume the role of a gatekeeper, vetting components to ensure that only those meeting the quality criteria progress down the production line. Inspection is increasingly contributing to Statistical Process Control (SPC) techniques by capturing data for predictive analysis, SPC can preempt potential issues and enable proactive preventive measures. Finally, inspection machines contribute to data-driven decision-making, generating a wealth of data which offers valuable insights into both trends and defects, which, in turn, generates process improvement efforts. This integration into Industry 4.0 initiatives fosters seamless data flow, helping improve maintenance and enhance connectivity with other systems.

In essence, the evolution of inspection means multifaceted roles: process control, quality assurance, data-driven decision-making, and defect prevention. These roles ensure that manufacturing processes remain efficient, reliable, and agile in meeting the demands of the modern industry landscape.

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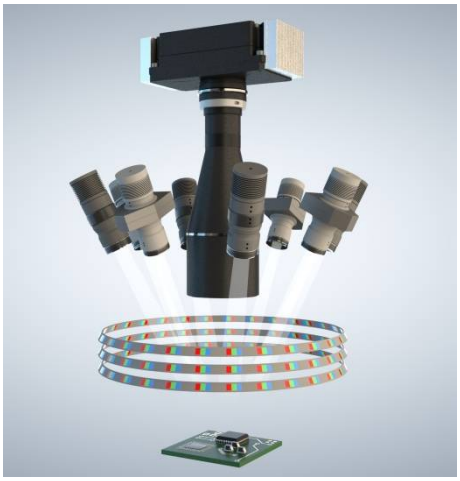
Brent, the materials themselves – the, or signal integrity, etc. – how do they affect the role of inspection?

The materials used in advanced packages and semiconductor manufacturing play a crucial role in shaping the specific inspection requirements. As an inspection system provider, we focus on understanding how these materials, especially those optimized for high-speed performance or signal integrity, affect visual inspection processes. These materials introduce unique challenges and considerations. For instance, substrates designed for high-speed applications often have intricate microstructures and delicate surface features that require high-resolution imaging systems to detect defects accurately. Additionally, materials may have varying optical properties that influence the choice of lighting and imaging techniques. Furthermore, the material's reflective or absorptive characteristics can change the contrast and visibility of defects during visual inspection.



Enter phase-shift moiré interferometry, a powerful tool for visual inspection in advanced semiconductor manufacturing. This technique relies on the interference patterns created when two regular grids or patterns overlap, with one grid being slightly displaced or phase-shifted compared to the other. By analyzing the interference patterns, phase-shift moiré interferometry can detect various defects, such as cracks, delamination, or voids in materials. Its sensitivity to minute surface variations makes it an effective technique for identifying defects that might be missed by other inspection methods. Consequently, it excels in capturing high-resolution images, analyzing surface deformations, assessing surface quality, and detecting defects, all of which are critical aspects of ensuring the reliability and performance of semiconductor components and materials. Phase-shift moiré interferometry can reveal even minor deviations in surface quality by analyzing the interference patterns, making it an effective tool to address the challenges associated with advanced packaging materials.

A deep understanding of the materials involved is essential for tailoring visual inspection systems to meet the specific demands of advanced semiconductor packages and ensuring the detection of defects and anomalies with precision and reliability.

That deep understanding of the materials: how much of that resides with the EMS engineers and operators, and how much of that is built into the Inspection equipment itself?

The choice of optimized substrate materials significantly shapes the challenges and requirements of optical inspection. These specialized materials introduce unique considerations that need tailored approaches to inspection. Substrates often feature intricate microstructures and fine surface details, demanding high-resolution imaging capabilities in optical inspection systems to precisely capture these features and detect defects. While the manufacturer needs to have some residence expertise, forward-thinking inspection equipment providers like Koh Young had help by delivering "material agnostic" solutions to help alleviate the challenges.

For example, moiré phase-shift interferometry enhances the resolution of optical systems for defect detection despite component reflectivity or substrate color by providing highly detailed surface information and improving the sensitivity of the inspection process. Systems like our Meister Series leverage moiré phase-shift interferometry to optimize lighting, imaging techniques, and contrast adjustments during inspection.

Furthermore, its advanced data analysis and interpretation tools complement the technique's capabilities, making sense of the complex optical data generated during inspection. Customization and calibration of optical inspection systems to accommodate various substrate materials are essential, ensuring accurate and reliable inspections in semiconductor manufacturing processes.