A Novel New Approach to Acoustic Inspection using SpinSAM Technology

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A look at how some of the latest acoustic inspection technology developments and the continued use of AI are addressing the exacting quality control needs of manufacturers.

IN TODAY'S SEMICONDUCTOR manufacturing industry – in particular the inspection process – there are clear and common productivity and quality control pre-requisites that rank high among the needs of manufacturers. If you're one such company operating in the semiconductor production ecosystem, then it's likely that your needs for inspection and testing will mirror those of others in the same industry. Higher throughput, greater accuracy in defect detection, higher resolution, smaller machine footprint and continuous uptime are all desired.

For wafer inspection specifically, among the different technologies that exist – including X-ray (**FIGURE 1**), infrared, optical (**FIGURE 2**) and acoustic (**FIGURE 3**), – not all are created equally, and some have better attributes than others depending on the application. When it comes to X-ray based solutions, thanks to its smaller resolution (typically one micron or less), X-ray is better suited to sampling. Infrared options that use an IR detector have their own drawbacks and struggle to operate in scenarios involving highly doped wafers, while optical solutions inspect the wafer surface, and cannot see inside.

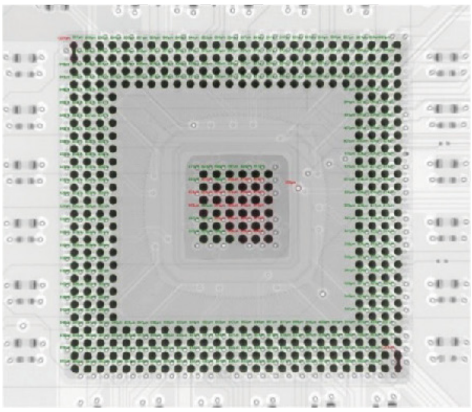

Figure 1. X-ray identifying defects.

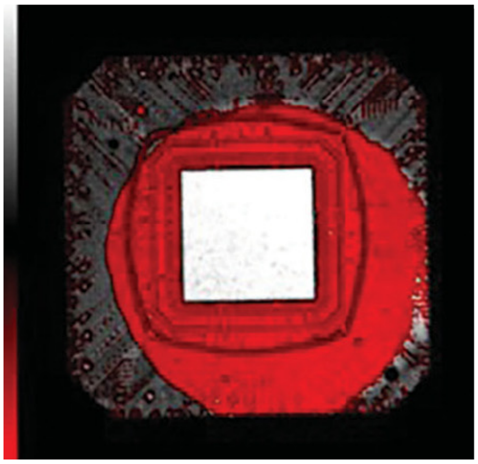

Figure 2. Acoustic identifying defects.

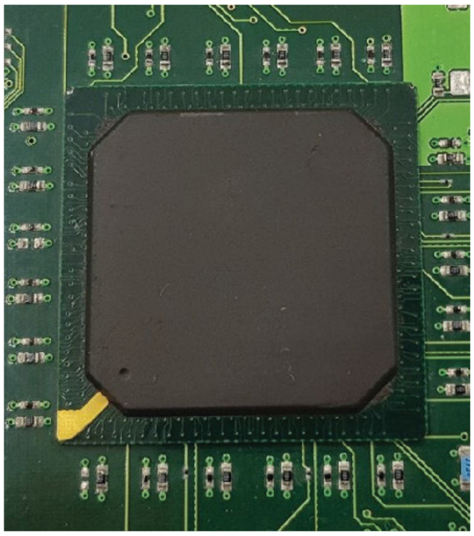

Figure 3. Optical identifying defects.

For acoustic inspection, at least with traditional scanning methods, there's an issue with the use of water. Since the sample is submerged in a tank or bath when the transducer scans it, any crack or other defect in the surface could lead to water entering the sample. This process also necessitates a constant changing and filtering of the water to ensure high purity and safeguard against the unwanted introduction of particles, as well as a drying time upon the wafer's removal from the water. Additionally, in instances where two wafers have been bonded together but have failed to properly anneal prior to scanning, separation will often occur, demonstrating another limitation of the traditional method. All of that adds to a long and laborious process for manufacturers to endure. However, our new, innovative SpinSAM™ Acoustic system

Figure 4. Waterfall technology.

uses waterfall technology (**FIGURE 4**) that limits the exposure to water versus some competitors that are using water bath or immersion scanning. Nordson offers waterfall on all Acoustic systems, as an option on the lab systems, and standard on production systems.

Suffice to say, there'll always be tradeoffs and it ultimately comes down to the specific needs of your own inspection process. The good news is that ongoing developments within some of the more advanced and breakthrough acoustic inspection technologies deliver improved yields, processes and productivity for wafer semiconductor manufacturers and address their current – and even future – needs.

A spinning formula

Among the more needle-moving of acoustic options on the market is our own, proprietary SpinSAM Automated Microimaging (AMI) technology (**FIGURE 5**), engineered to address the stringent and specific inspection requirements for semiconductor mid-end manufacturing.

Figure 5. SpinSAM Acoustic Microimaging (AMI) system.

Perfectly suited to applications that include bonded wafers (**FIGURE 6**), Chip-on-Wafer, stacked wafers, MEMS, and over-molded wafers, the small footprint system boasts an advanced spin scan method that has been purposely designed to undertake 100% inspection of wafers (**FIGURE 7**) and achieve maximum units per hour without sacrificing precision.

To put that into context, we're talking about inspection of 41 wafers per hour, which is a throughput of around four to five times that achievable via competitive offerings.

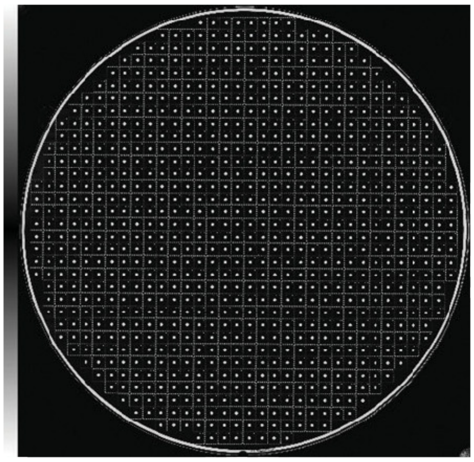

Figure 6. Bonded wafer.

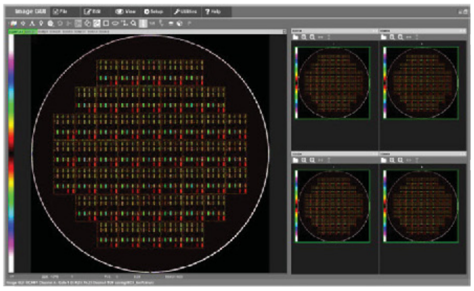

Figure 7. Wafer in software app.

Something that many of our customers are excited about is the technology's wafer edge scanning (**FIGURE 8**) capability. In nutshell, this provides the capability to pinpoint the position on the wafer that needs to be scanned – say the last 10 millimeters at the wafer's edge, where there can be a higher concentration of defects. This 'perimeter scan' is something that really moves the dial when it comes to time-efficiencies and productivity, because users can choose a higher resolution exactly where they need it. This is simply not possible with a raster scan (**FIGURE 9**) versus the spin scan (**FIGURE 10**) because it would have to cover the whole wafer and amounts to a more time-consuming process that impacts throughput.

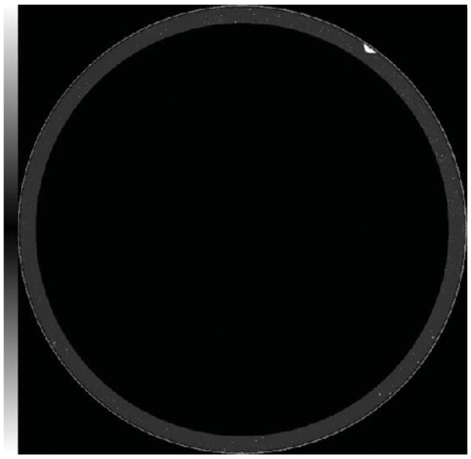

Figure 8. Edge scan.

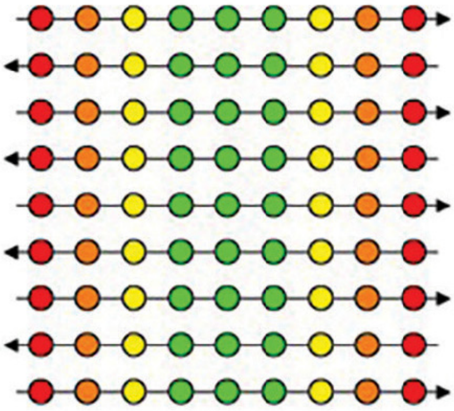

Figure 9. Raster scanning.

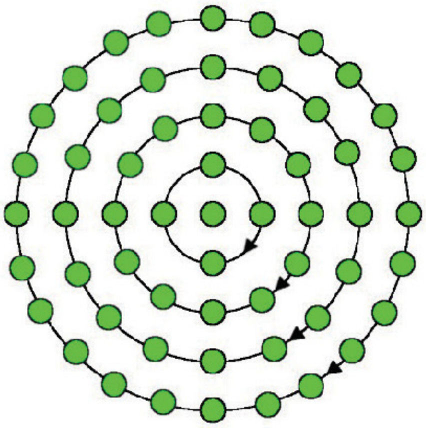

Figure 10. Spin scanning.

In conjunction with this, an innovative Global Tool Matching feature (**FIGURE 11**) ensures that SpinSAM can detect the smallest defects with new levels of precision, while allowing the same settings to be used across different SpinSAM systems. This ensures uniformity across the inspection process and means that matching results are guaranteed, regardless of where the machine sits in the world.

Among its other feature-rich

Figure 11. Global tool matching.

attributes and something that we believe is unique within SpinSAM is its modular design. That's to say that, unlike other systems that share an XYZ axis – two transducers attached to the same motor that follow each other – in our case each scanner operates independently, so one wafer could be scanning at 100 microns, while the other is scanning at 50. This enables manufacturers to efficiently spin scan (**FIGURE 12**) up to four wafers simultaneously with four matched transducers, while enjoying wafer inspection over the widest frequency range ever achieved in a production environment.

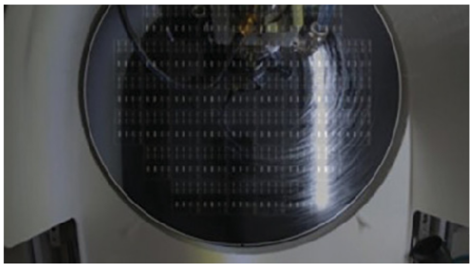

Figure 12. Transducer over wafer.

But that's not all, in an industry where machine uptime is critical – not least because floor space is so expensive – and unwanted downtime can quickly rack up costs of thousands of dollars an hour, every second counts, so continuous operation is vital.

The SpinSAM AMI system has efficient Mean Time to Repair (MTTR), which means that regular maintenance can be scheduled while the machine can keep running. Because of its modular design, the operator can remove one (**FIGURE 13.**) of the four scanners to swiftly address any necessary repairs, while the other scanners continue to do their job. Like that, the inspection process does not need to be entirely halted and throughput can still run smoothly at 75%.

Figure 13. MTTR.

The *AI*m of the Game

Looking ahead, just as the technology continues to break new ground on a seemingly daily basis, Artificial Intelligence (AI) – and more specifically machine learning (ML) – is already raising eyebrows within our own industry given its huge potential to revolutionize aspects of the inspection process. At Nordson, we have been deploying various inspection and metrology systems incorporating various levels of ML, Deep Learning (DL) and AI for many years and our solutions continue to get more sophisticated.

With an ever-increasing need for faster memory, I believe that a key driver for AI within the semiconductor market will be high-bandwidth memory and the ability for greater stacking of chips, which represents a really good application for SpinSAM.

Another aspect perfectly suited to AI within acoustic inspection is with image analysis, currently a laborious process. As it is, this requires an operator to generate an image, adjust the focus, the transducer, the resolution, where they're looking and how deep they want to look. Not only that, but once these complex samples are produced, it's very difficult and massively time-consuming to manually fine tune and get the adjustment to locate the right layer. Indeed, the whole process can easily take up to a couple of hours of an operator's time.

Looking ahead, I think that process could evolve over the longer term with the help of AI, where it would look at the building blocks of the A-scan image and analyze the data in the waveform to determine where it should be looking. Using AI to do this could lessen time from two hours to two minutes – eliminating the subsequent expense and downtime that results from the need to bring in an engineer to spend hours setting up an acoustic microscope.

Ultimately, with the continued advances in the development of transformative technologies like SpinSAM, and the way in which we continue to leverage AI and ML, semiconductor manufacturers can count on Nordson to deliver superior performance to improve their yields, processes and productivity.

About the author

Bryan Schackmuth is the Product Line Manager for Acoustic technologies at Nordson Test & Inspection. Nordson TEST & INSPECTION offers its SMT & Semiconductor customers a best-in-class product portfolio, including Acoustic, Optical and both Manual and Automated X-ray Inspection systems, X-ray Component Counting systems and Semiconductor measurement sensors. Nordson TEST & INSPECTION is uniquely positioned to serve its customers with best-in-class precision technologies, passionate sales and support teams, global reach, and unmatched consultative applications expertise.