World Academy of Science, Engineering and Technology
International Journal of Electronics and Communication Engineering
Vol:18, No:10, 2024

# Advanced Techniques in Semiconductor Defect Detection: An Overview of Current Technologies and Future Trends

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**Abstract :** This review critically assesses the advancements and prospective developments in defect detection methodologies within the semiconductor industry, an essential domain that significantly affects the operational efficiency and reliability of electronic components. As semiconductor devices continue to decrease in size and increase in complexity, the precision and efficacy of defect detection strategies become increasingly critical. Tracing the evolution from traditional manual inspections to the adoption of advanced technologies employing automated vision systems, artificial intelligence (AI), and machine learning (ML), the paper highlights the significance of precise defect detection in semiconductor manufacturing by discussing various defect types, such as crystallographic errors, surface anomalies, and chemical impurities, which profoundly influence the functionality and durability of semiconductor devices, underscoring the necessity for their precise identification. The narrative transitions to the technological evolution in defect detection, depicting a shift from rudimentary methods like optical microscopy and basic electronic tests to more sophisticated techniques including electron microscopy, X-ray imaging, and infrared spectroscopy. The incorporation of AI and ML marks a pivotal advancement towards more adaptive, accurate, and expedited defect detection mechanisms. The paper addresses current challenges, particularly the constraints imposed by the diminutive scale of contemporary semiconductor devices, the elevated costs associated with advanced imaging technologies, and the demand for rapid processing that aligns with mass production standards. A critical gap is identified between the capabilities of existing technologies and the industry's requirements, especially concerning scalability and processing velocities. Future research directions are proposed to bridge these gaps, suggesting enhancements in the computational efficiency of AI algorithms, the development of novel materials to improve imaging contrast in defect detection, and the seamless integration of these systems into semiconductor production lines. By offering a synthesis of existing technologies and forecasting upcoming trends, this review aims to foster the dialogue and development of more effective defect detection methods, thereby facilitating the production of more dependable and robust semiconductor devices. This thorough analysis not only elucidates the current technological landscape but also paves the way for forthcoming innovations in semiconductor defect detection.

**Keywords :** semiconductor defect detection, artificial intelligence in semiconductor manufacturing, machine learning applications, technological evolution in defect analysis
**Conference Title :** ICCSE 2024 : International Conference on Compound Semiconductor Electronics
**Conference Location :** Tokyo, Japan
**Conference Dates :** October 03-04, 2024