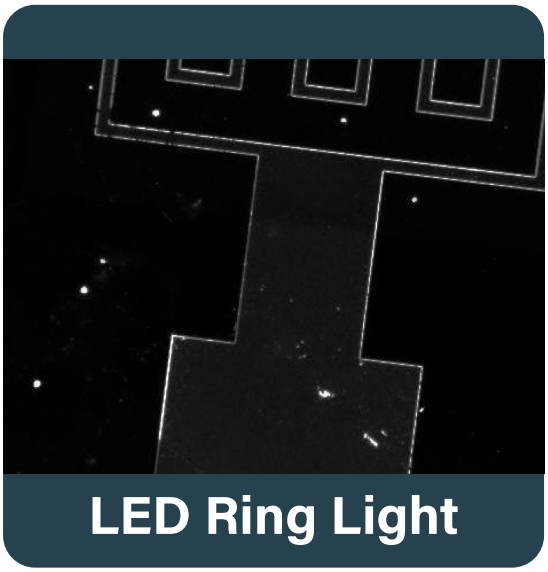
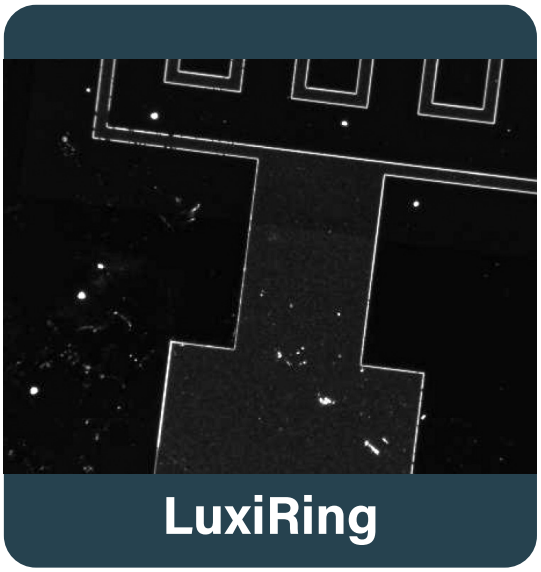
APPLICATION NOTE
HIGH-PRECISION SEMICONDUCTOR WAFER INSPECTION USING LUXIRING



LED Ring Light



LuxiRing

ABSTRACT

Accurate visual inspection of semiconductor wafers is critical for detecting micro-defects that impact device yield and performance. Standard LED illumination systems often suffer from limited lighting uniformity and uncontrolled light directionality which can hinder both human inspection and automated defect detection using AI and deep learning algorithms.

This application note presents the impact of using our LuxiRing product, a precision-engineered ring light integrating our unique proprietary LuxiBright® illumination technology, designed to deliver exceptionally high lighting uniformity and directionality without the use of additional optics. Comparative measurements demonstrate a significant improvement in illumination consistency and defect detection performance over conventional LED lighting systems.

INTRODUCTION

In semiconductor wafer inspection, illumination uniformity directly impacts the accuracy of both manual and automated quality control processes. Variations in light intensity across the field of view can create artificial contrast patterns, leading to false defect identification or missed defect detection. AI- and deep learning-based inspection algorithms are particularly sensitive to such non-uniformities since they rely on global parameters (e.g., segmentation thresholds) that assume consistent illumination.

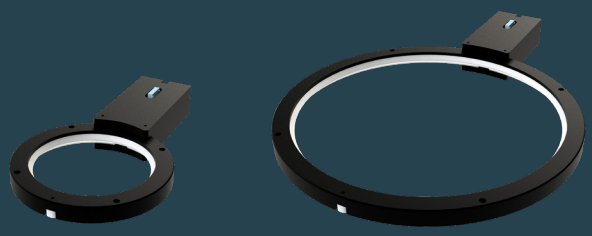
PROBLEM

Conventional LED ring lights often produce uneven brightness from center to edge leading to glare or reliance on diffusers that strongly reduces the precision and light directionality. These shortcomings compromise inspection consistency and reduce the accuracy of automated defect detection.

OUR SOLUTION

Our LuxiRing integrate our unique LuxiBright® technology that provides precise, highly directional white lighting that enhances feature visibility and maintains exceptional uniformity across the inspection field.

This is achieved without the use of additional optics such that it keeps the design compact and efficient delivering sharp and consistent illumination for both visual and automated wafer inspection.



LUXIRING Ø76 LUXIRING Ø160

MEASUREMENT OF LIGHTING UNIFORMITY

The method of measurement consists in dividing the illuminated field into four equal-area circular sectors (quadrants Q1–Q4) centered on the optical axis (Isoarea method). The average intensity in each quadrant was measured and the center-to-edge variation was calculated. This approach accounts for the radial geometry of ring lights and allows for direct comparison between different lighting systems.

The wafer surface (“the room”) was selected to have similar content across quadrants such that it ensures that the measured differences between the quadrants were due to the lighting non-uniformity and not to the variation of the features measured. The measurements were taken under identical camera and exposure settings for both LED and LuxiRing configurations.

FIGURE 1
Isaora method (quadrant Q1-Q4)

UNIFORMITY

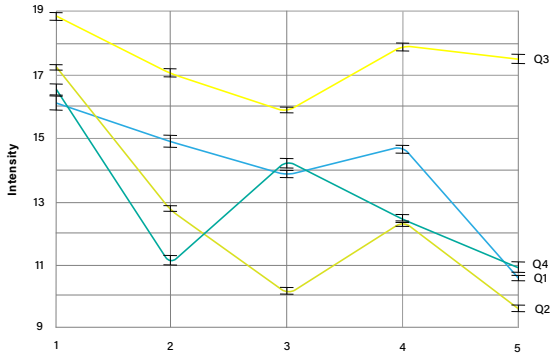


FIGURE 2
Calculation of the average intensity mesured in each quadrant

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RESULTS

Visual Impact of the lighting uniformity

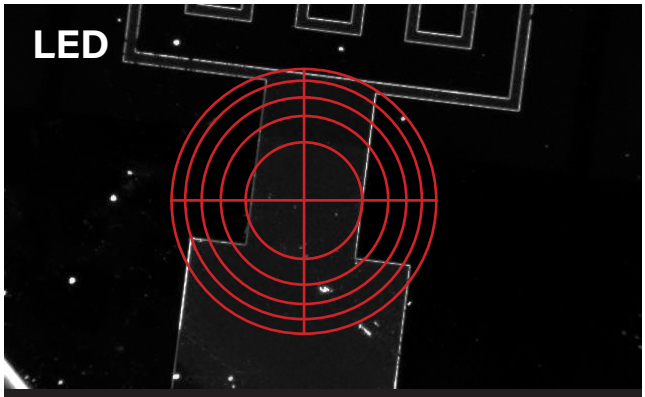

FIGURE 3
Isaora method with LED lighting

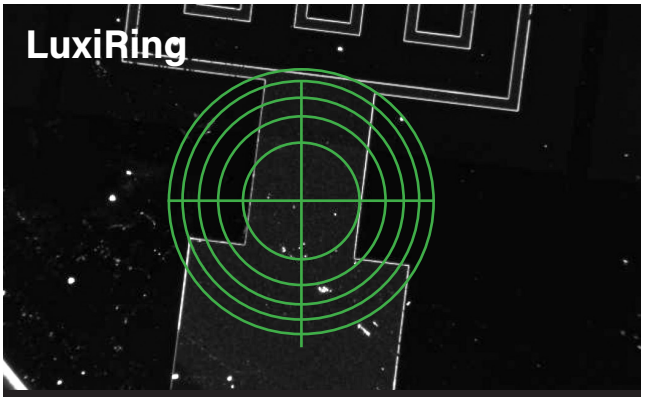

FIGURE 4
Isaora method with LuxiRing powered by LuxiBright® Lighting

Fig. 3. and 4. show a side-by-side comparison of wafer inspection images between a standard LED illumination and our LuxiRing. Under LED ringlight (Fig. 3), the illumination is uneven, producing noticeable brightness gradients from the wafer's center to its edge. These variations reduce image contrast and make it harder to discern fine defects such as dusts and edges contrast.

On the contrary, the images captured under our LuxiRing illumination (Fig. 4) display a uniform brightness across the entire field of view. This even light distribution eliminates distracting gradients, resulting in a balanced, high-contrast image that brings out subtle wafer defects with greater clarity and precision.

Quantitative Analysis of lighting uniformity

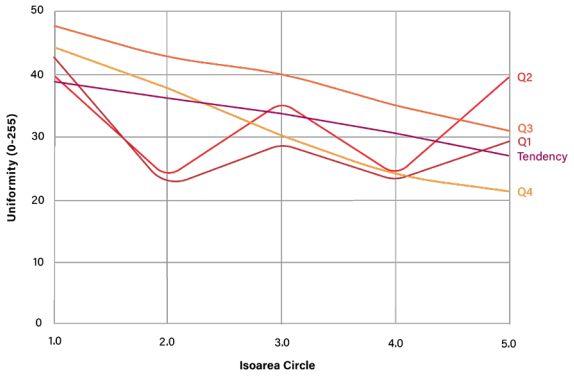

FIGURE 5
Calculation of the average intensity mesured in each quadrant with LED lighting

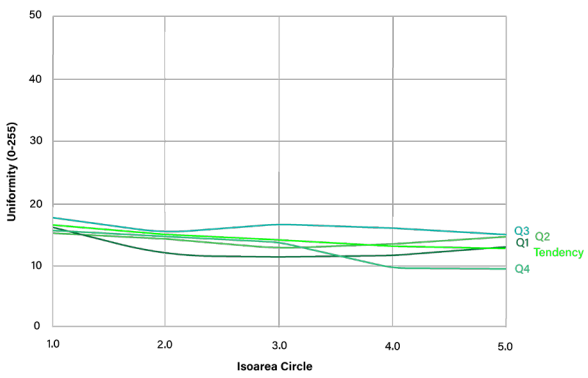

FIGURE 6
Calculation of the average intensity mesured in each quadrant LuxiRing powered by LuxiBright® Lighting

Fig. 5. and 6. shows the measurement of the lighting uniformity over the quadrants and confirm the visual observations.The image taken under the standard LED ringlight (Fig. 6) exhibits a center-to-edge intensity variation of 12 grey levels, reflecting significant unevenness in the illumination. On the contrary, the image taken under our LuxiRing (Fig. 6) achieves a variation of only 3 grey levels , representing a fourfold improvement in uniformity. This substantial gain ensures consistent image quality across the entire inspection area which is critical for both visual inspection and automated defect detection algorithms.

Visual Impact of the lighting directionality

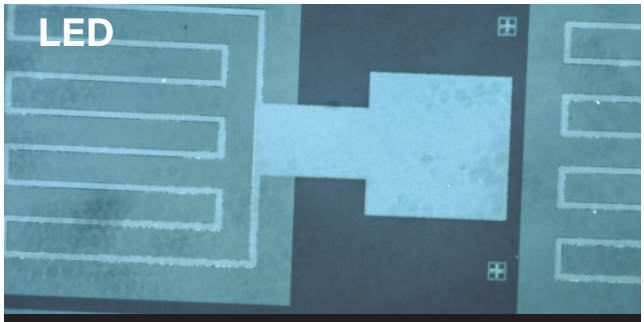

FIGURE 7
Isaora method with LED lighting

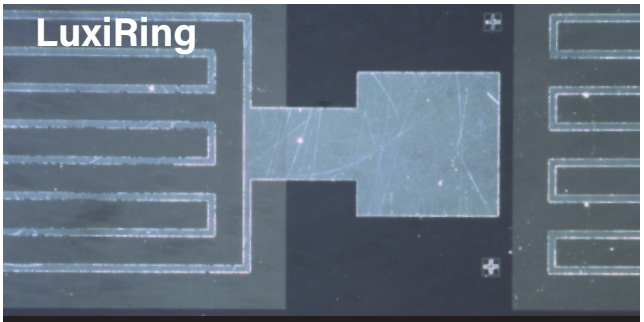

FIGURE 8
Isaora method with LuxiRing powered by LuxiBright® Lighting

Fig. 7. and 8. show a side-by-side comparison of wafer inspection images between a standard LED illumination and our LuxiRing. Under LED ringlight (Fig. 7) subtle surface defects remain hidden, while under our LuxiRing (Fig. 8) details are revealed such that scratches and dust thus enabling more accurate and reliable inspection.

Quantitative Analysis of lighting directionality

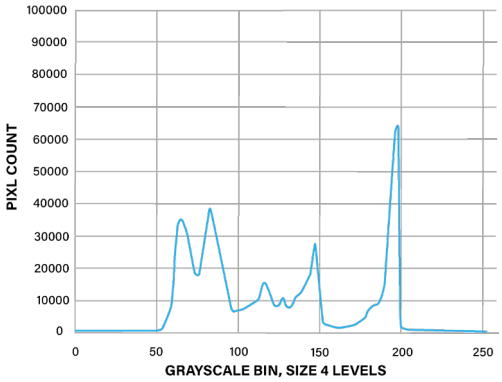

FIGURE 9
Histogram of grey levels measured under LED ringlight illumination

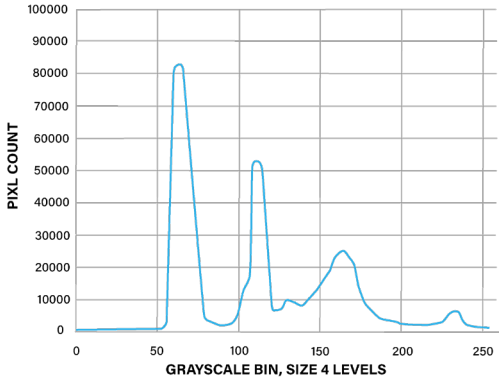

FIGURE 10
Histogram of grey levels measured under LuxiRing powered by LuxiBright® Lighting

Fig. 9. and 10. show the measurement of grayscale dynamic range and distribution over the images captured, respectfully under LED ringlight and under our LuxiRing. Fig. 10 clearly shows a pronounced shift in grey levels, indicating reflectivity from defect areas observed under visual inspection, namely scratches and dust.

CONCLUSION

LuxiRing with LuxiBright® technology delivers a transformative improvement over conventional LED lighting systems for semiconductor wafer inspection. By combining extreme illumination uniformity with precise lighting directionality, LuxiRing not only enhances the visibility of subtle features but also significantly improves the detection of fine defects such as scratches and dust.

The strong reduction in center-to-edge intensity variation ensures consistent image quality and enhances the reliability of defect detection algorithms, reducing false positives from lighting artifacts. The optimized light directionality sharpens contrast without the need for additional optics. These advances translate into higher reliability for both manual inspections and AI-based defect detection, reducing false positives and missed detections.

In short, LuxiRing sets a new standard for high-performance, precision lighting in wafer inspection, offering manufacturers a powerful tool to improve quality, yield, and process confidence.

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