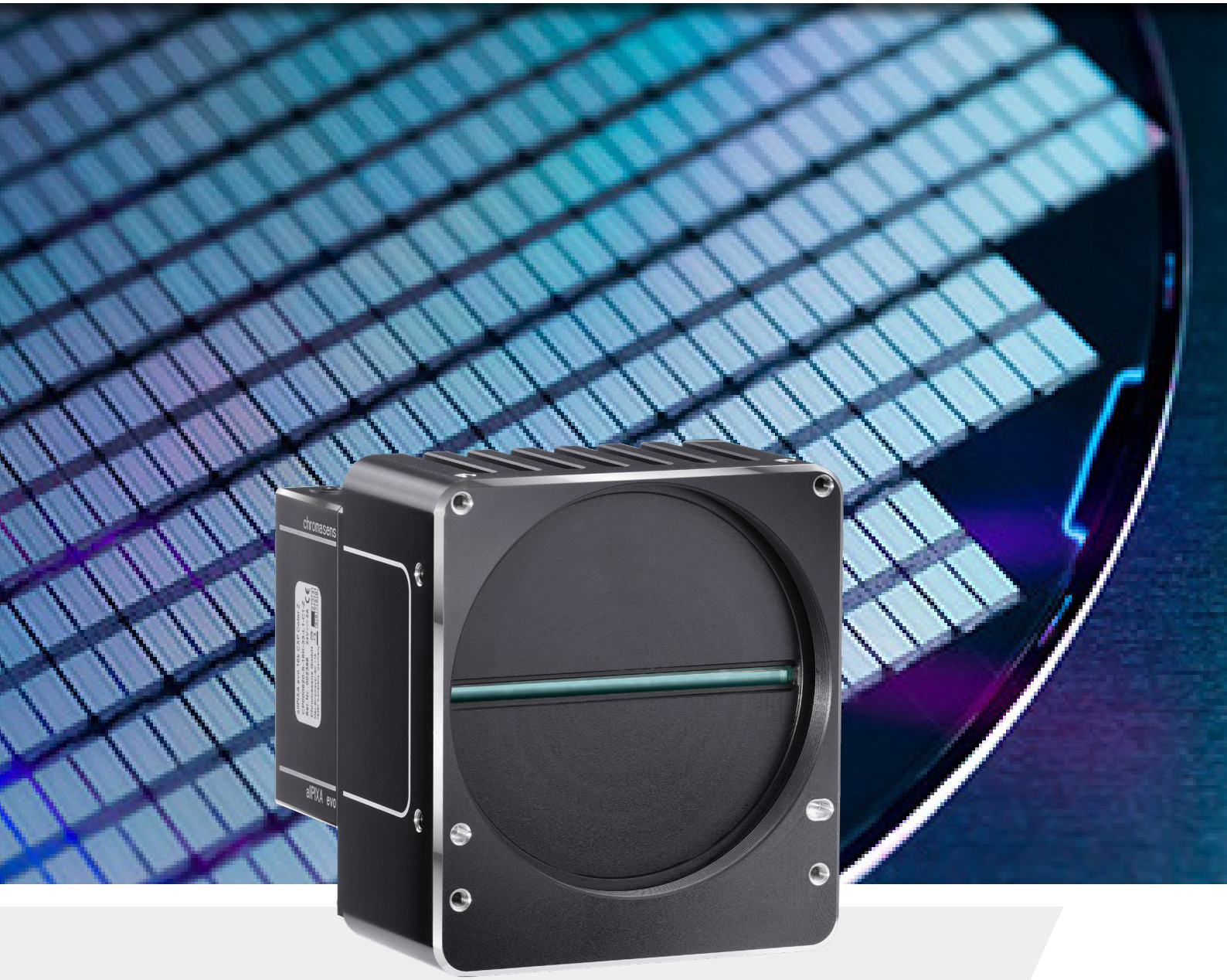
Allied Vision



// WHITEPAPER

Advanced Vision Technology For Efficient Wafer Inspection

Maximizing Throughput, Minimizing Defects

CoaXPress

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Executive Summary

Reliable detection of macro defects with fast line scan cameras and optimized lighting

This white paper addresses the critical challenge of efficient wafer inspection in semiconductor manufacturing, where maximizing throughput while minimizing defects is essential for production yield and cost efficiency.

Modern semiconductor production demands inspection methods that balance high-speed processing with exceptional defect detection sensitivity. The document presents advanced machine vision technology as the key solution for reliable macro defect detection throughout the wafer production lifecycle - from bare substrates to finished components.

Key Takeaways

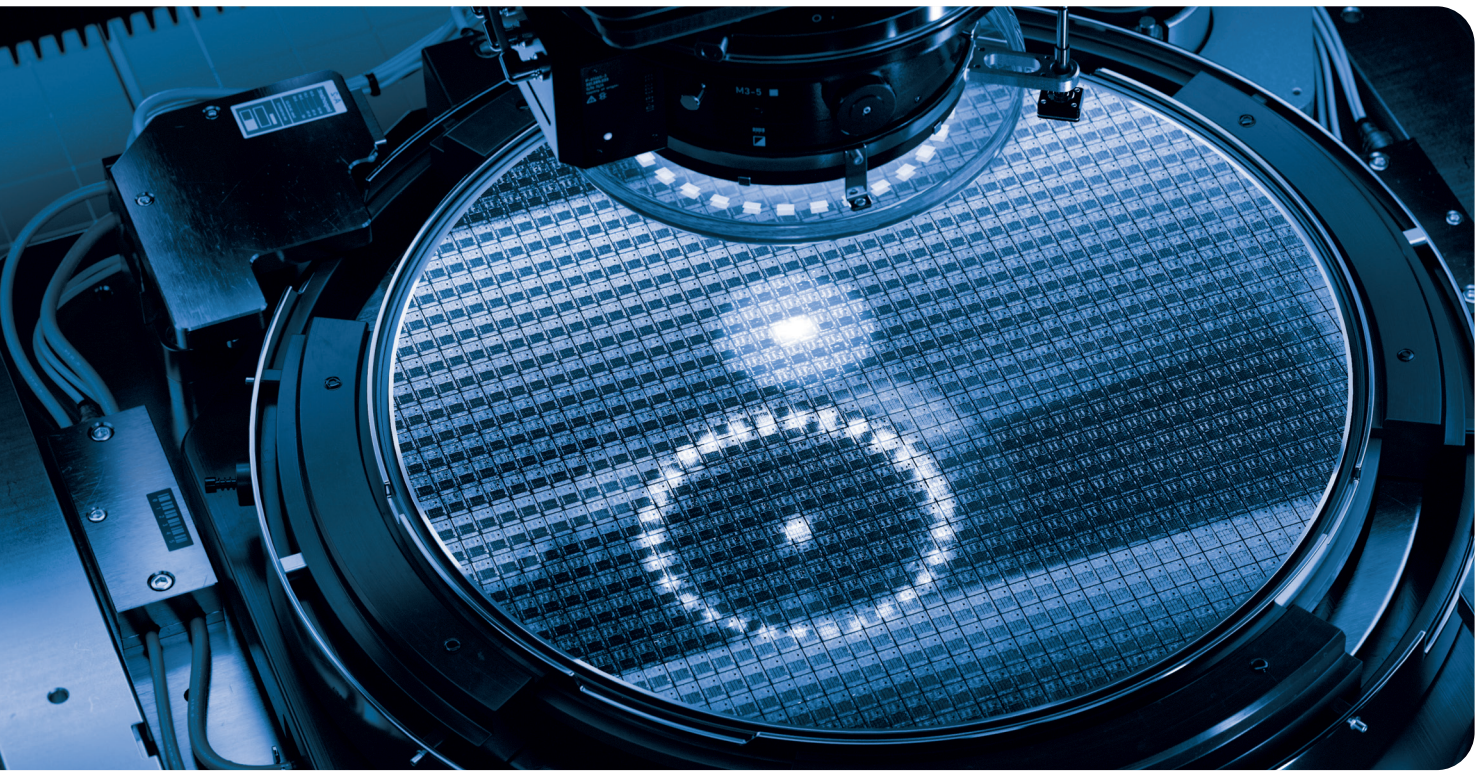
// Macro defects (particles, contamination, scratches, coating irregularities) significantly impact wafer quality and must be detected early to avoid costly downstream processing of defective components.

// Line scan camera technology enables high-resolution imaging at production speeds, with scan times under 10 seconds for 300mm wafers and detection capability for defects as small as 5-15µm.

// Allied Vision's integrated solutions combine high-performance allPIXA evo line scan cameras (offering up to 32k resolution and 70kHz line rates) with specialized Corona II lighting systems (bright-field, dark-field, and coaxial) to optimize defect visibility.

// These technologies allow manufacturers to maintain high production rates while ensuring quality through comprehensive inspection that detects critical defects with minimal false positives/negatives.

This white paper provides valuable insights for semiconductor manufacturers seeking to implement efficient, high-precision wafer inspection systems that meet the demands of modern production environments.



Challenges In Semiconductor Production

Developments in the field of electronic components continue to progress rapidly. The market and consumers demand features such as the miniaturization of products while increasing performance. At the same time, these advancements are expected to come with ever lower energy consumption.

These trends lead to increasingly complex challenges for manufacturers of semiconductor components on two levels. On the technical side, ever-smaller components and structures, combined with higher production speeds, require extremely high precision in manufacturing accuracy. At the same time, semiconductor manufacturers must keep a close eye on the cost-efficiency of their processes to remain competitive. Their goal must be to maintain low error rates and produce as little waste as possible.

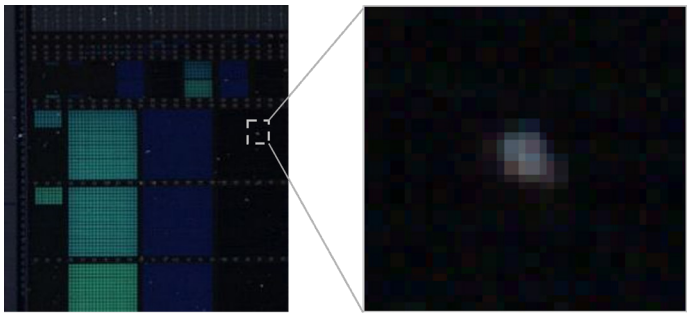
Hiring more or better-trained personnel is generally not a sustainable solution: skilled workers are hard to find and expensive. Additionally, humans are more error-prone than automated processes. These challenges can therefore only be addressed through the intensive use of high-performance automation systems. In this context, machine vision plays a critical role in quality control.

This white paper aims to highlight the technical possibilities of machine vision in the semiconductor industry and to present solutions for one of the main application fields in this area: the efficient inspection of wafers during production.

Machine Vision As A Key Technology For Macro Defect Detection

Anyone aiming to manufacture wafers cost-effectively must ensure high yield in production. It is therefore essential to detect yield-reducing defects as early as possible in order to adapt further processing and avoid unnecessary cost from performing production steps on already defective components. Wafers are inspected at many stages—from the bare wafer substrate to the final component — for deviations from defined quality standards.

One important category of potential defects in semiconductor components includes so-called macro defects. Macro defects can manifest in various forms, which can be difficult to detect and classify. They can occur on bare wafers, on the back of a wafer, but also as irregularities on structured or coated wafers.



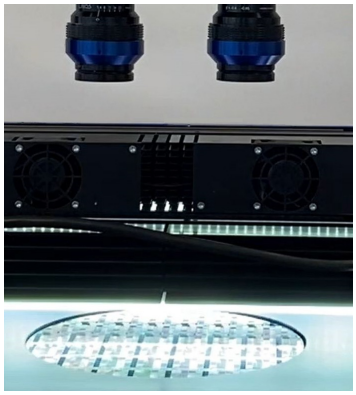
Dark field image *Dust particle*

Some examples for macro defects are particles or contaminations as well as surface scratches. Faulty processes during the chemical mechanical polishing can result in scratches, residues or unpolished areas. Etch process monitoring needs to make sure to identify residues, corrosion or pattern defects.

Large area defects such as coating irregularities, bad contacts or missing structures are further macro defects that need to be reliably identified. Features like coating integrity, cleanliness and surface quality are also details that need to be verified during outgoing quality control procedures.

Keeping up with the high volumes of wafer production requires fast and efficient inspection methods to maintain production rates. The detection methods used must also be sensitive enough to detect defects while minimizing false positives and negatives, which can be a delicate balance to achieve. Wafers must be carefully handled and prepared for inspection to prevent additional defects or damage, which can further complicate the inspection process.

Machine vision systems play a crucial role in reliably detecting such macro defects. When properly selected and implemented, these systems can keep pace with high production speeds and identify defects with high accuracy. The demands on quality inspection and control require the entire wafer to be examined at high resolution and within a short time frame.



Wafer scanner set-up with two line scan cameras and combined light

Application Specific Requirements

a) Camera Technology

The decisive component of a vision system is the camera used. Ideally, all macro defects on wafers can be captured with one single camera system. This leads to the following basic camera requirements:

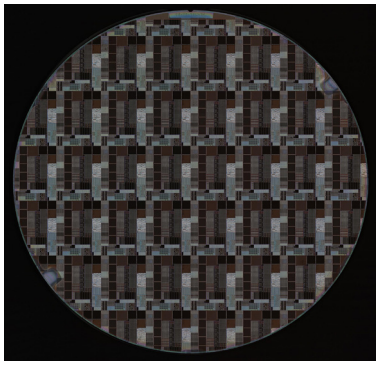
// **Scan width:** 300 mm are a common size for today´s state-of-the-art wafers. Cameras with a scan width of more than 300 mm are therefore useful to cover full 300 mm wafers.

// **Speed:** A scan time of less than 10 seconds per 300 mm wafer should be possible in order to meet the requirements for economical production processes.

// **High resolution:** To aim for high wafer quality, typically defects in the range from 5 µm to 15 µm need to be detectable.

// **Color capturing:** Detecting coating irregularities requires color cameras.

Line scan cameras have proven particularly effective in high-speed processes where even minor defects have to be detected. With this technology, images are captured line by line and then assembled into a complete image. This makes it possible to produce high-resolution images of wafers in a very short time, which serve as the basis for automatic detection of macro defects. Modern line scan cameras are equipped with high-end sensors that meet the highest standards for resolution and speed.



Example image of patterned wafer captured with coaxial light

- ☑ Line scan cameras with trilinear sensors improve the resolution by acquiring three colour samples per pixel.
- ☑ Multi field imaging based on line scan cameras allows for multiple images in one pass, thus saving cost and time.

Typical advantages of line scan cameras for wafer inspection are:

- ☑ They offer a cost-efficient solution for high resolution imaging.
- ☑ High line scan rates allow for high transport speeds.
- ☑ Using line scan cameras ensures that the angle of illumination is exactly aligned and adjusted.
- ☑ Compared to area scan cameras, line scan systems deliver a better light homogeneity.
- ☑ Line scan cameras reduce the image distortion to just one dimension.

Allied Vision's alIPIXA evo cameras have M72 (evo 8k) or M95 (evo 16k/32k) lens mount where a wide range of lenses and adapters are available

b) Illumination

The quality of line-scan images also depends critically on the selected illumination. To capture images with sufficient contrast at high acquisition speeds, high light intensity and the most uniform illumination possible are required. In addition, different types of light are needed to detect different kinds of macro defects. Therefore, when selecting line lighting, it must be ensured that appropriate bright-field, dark-field, or coaxial lighting is used depending on the application, to clearly highlight any defects.

Selecting the right illumination for a macro defect detection system requires experience and a high level of expertise. Some of the criteria for optimal selection are:

// Depending on the application, a combination of different lights might be the perfect solution to detect different defects.

// The type of macro defect is crucial when choosing the colour of the illumination. Devices with different colored light can be the foundation of efficient solutions.

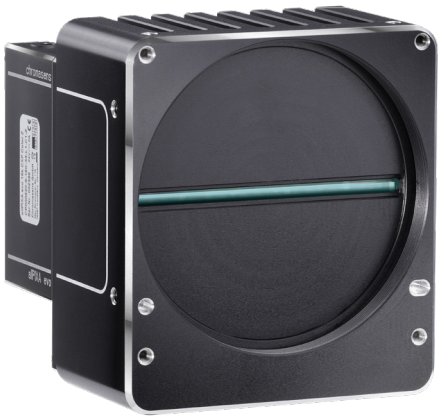
// High speed processes require illuminations with high intensity to acquire images with meaningful information.

// High homogeneity of the selected illumination is a key prerequisite for reliable results.

Components For Your Vision Solution

a) allPIXA evo line scan camera series

Allied Vision is an innovative technology partner for developing cost-effective and high-performance machine vision systems for the semiconductor industry and many other areas of application. The allPIXA evo high-performance line scan camera series has proven to be highly efficient in this field of application. With their combination of high resolution — 16k or 32k — and speeds of up to 70 kHz line rate, these cameras are ideally suited to meet the demands of modern wafer inspection. Delivering resolutions up to 16k for color images and 32k for monochrome, both models provide precise results at high throughput.



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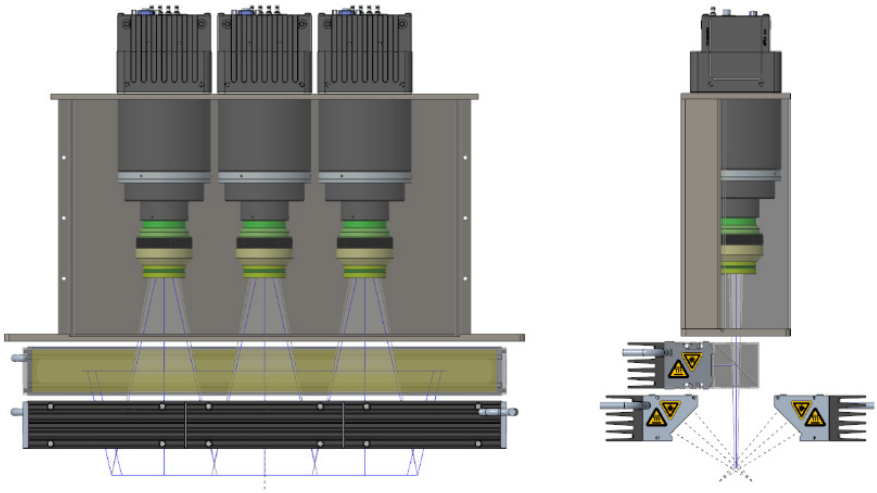
The allPIXA evo 16k camera features a next-generation line scan sensor with a pixel size of just 5 µm. Thanks to its 80 mm sensor width, a wide range of lenses is available for this camera. For monochrome images with even greater detail, the allPIXA evo 32k is the ideal choice. Its sensor consists of two offset 16k lines that combine to produce a 32k monochrome image. This sensor also has an 80 mm width but achieves a virtual pixel size of 2.5 µm, enabling the reliable detection of even extremely small macro defects.

To capture the complete geometry of a 300 mm wafer at high resolution and fully cover a field of view of this size, multiple cameras arranged side by side may be necessary. allPIXA evo cameras are equipped with a unique feature that allows direct synchronization between multiple units. The result is perfectly aligned composite images from several cameras, simplifying subsequent image processing.

Another unique feature of the allPIXA evo line scan cameras is their multi-field imaging capability. This technology uses the integrated multi-channel flash controller to synchronize up to four light sources with the camera's line trigger in a rapid sequence. As a result, up to four images are captured in a single pass, each taken under different lighting conditions. This approach reduces the number of cameras required, simplifies the inspection process, and contributes to the overall optimization of process cost.

Advantages at a glance:

- ☑ High resolution in colour: tri-linear 16k
- ☑ Very high resolution in monochrome with 32k
- ☑ High speed: capturing a 300 mm wafer in a few seconds
- ☑ Encoder input at camera
- ☑ Perfect multiple-camera synchronisation with Master-Slave feature
- ☑ Multi-field imaging feature
- ☑ Fast and reliable interface CoaXPress



Example setup: two allPIXA evo 16k cameras covering 320 mm scan width with a resolution of 10 µm and Corona II combined light: dark field and coaxial light

b) Corona II coaxial lighting solutions

As a complement to allPIXA evo line scan cameras, the Corona II family of bright-field, dark-field, and coaxial lighting solutions are an ideal fit. These LED lighting modules are designed for use in multi-field imaging applications and are based on a patented reflector technology along with smart diffusers. Corona II illuminations produce extremely bright, homogeneous light. They are available in a wide range of colors and various types of white light, making them exceptionally well-suited for semiconductor and wafer inspection applications. The combination of allPIXA evo cameras with Corona II lighting is therefore perfectly equipped to make all types of wafer defects clearly visible, even under challenging conditions, such as highly reflective surfaces.

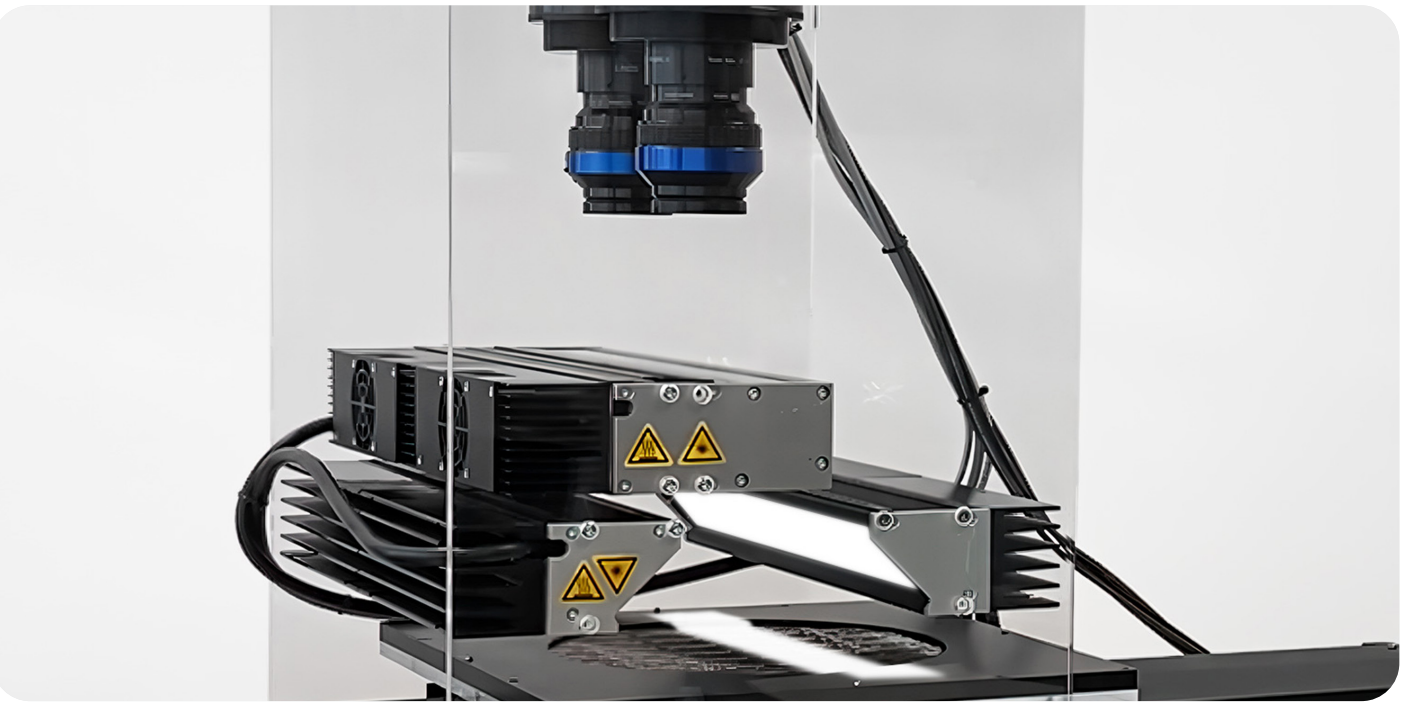
Advantages at a glance:

- ☑ High efficiency with reflector technology
- ☑ Different focal lengths for dark field
- ☑ Bright field with different colours for high flexibility
- ☑ Fast and reliable interface CoaXPress
- ☑ Smart diffusors for perfect homogeneity
- ☑ Length of lights ideally suited for 300 mm wafer

Corona II bright field light comes with different diffusors for very homogenous light and intensities up to 300.000 cd/m²

c) Customization For Specific Requirements

As Allied Vision manufactures a broad range of lighting and camera devices, they are able to offer customized solutions since many years. Their customized systems include camera, optics and lighting and meet the exact requirements for reliable solutions in the semiconductor business and many other industries. The available installation space and the stability of the overall system as well as simple and safe installation is considered. This results in systems that meet customer requirements and are also cost-optimized solutions. As the systems are pre-adjusted and 100% tested, they can be installed in a machine with minimal effort and risk.



Wafer scanner set-up with two allPIXA evo 16k line scan cameras and combined light: Corona II dark field and coaxial light

Conclusion

Electronic components form the basis for the functionality of virtually every product used in daily life. Vehicles of all kinds, communication devices, energy generation systems, data processing systems, or the entire consumer electronics sector are just a few of the countless areas that would be unimaginable today without powerful electronics.

The semiconductor industry has been one of the fastest-growing sectors worldwide for years. To succeed economically and thrive in such highly contested environments, companies must produce high-quality products efficiently and optimize their manufacturing processes.

As in many other fields, the machine vision technology plays a particularly important role in the semiconductor industry. Allied Vision offers state-of-the-art cameras and lightings as well as customized systems that secure your competitiveness and help you to assert yourself in this competitive but promising market.

Get In Touch

Do you have any questions about using machine vision solutions in the semiconductor industry? Our experts are happy to assist you.

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