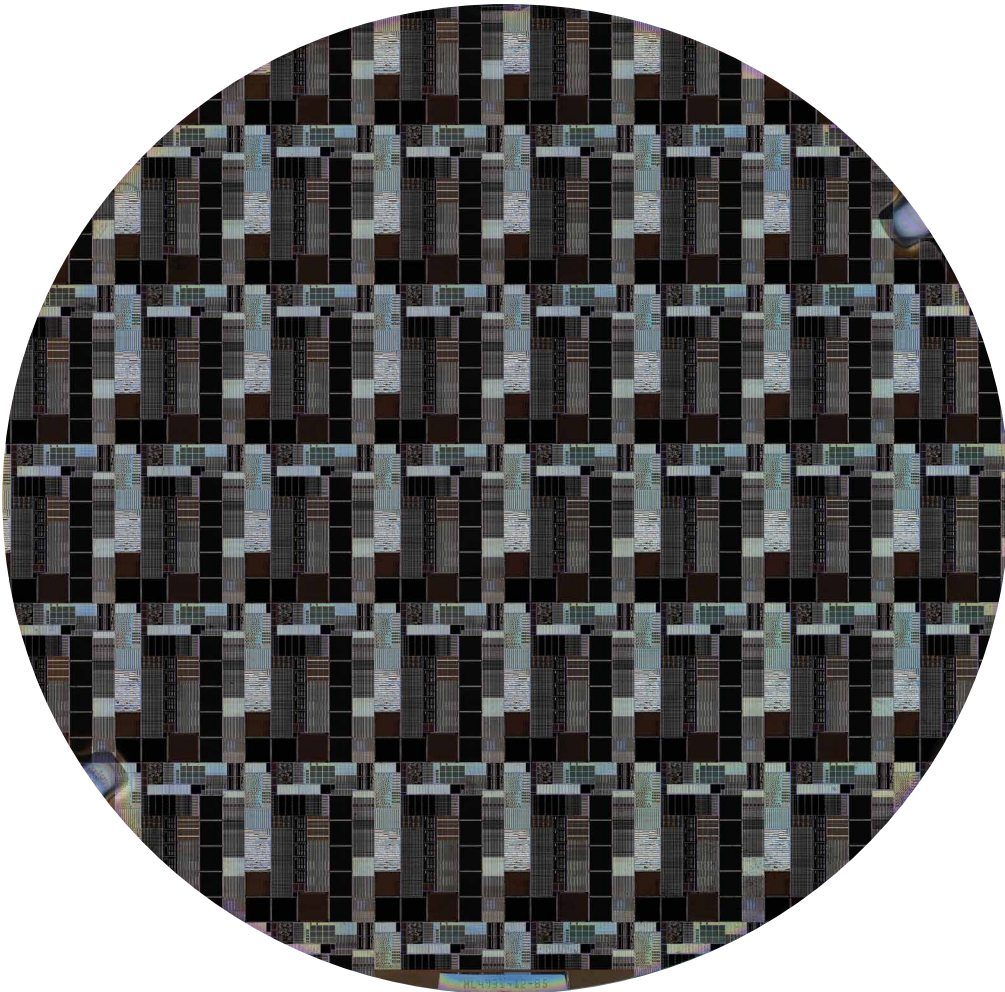# chromasens
IMAGING FOR PROFESSIONALS

WAFER MACRO DEFECT INSPECTION

CASE STUDY

Why macro defects are crucial to wafer manufacturing

In semiconductor manufacturing yield and manufacturing throughput are the critical factors driving the costs of the chips / ICs. To improve the yield, manufacturers depend on in-line quality inspection systems, which can be deployed after most processing steps. Manufacturers inspect the intermediate products at many points starting from raw wafers and ending with packaged ICs. The goal of the numerous inspection systems is to capture the defects at an early stage to allow for process optimization and yield enhancement, finally reducing the production costs. Even in a stable process defects cannot be fully avoided, die inking is used to digitally mark defective dies. Defective dies are sorted out after the dicing process. The shrinking geometries of the semiconductor devices challenge the inspection system capabilities to resolve the defects on micron and sub-micron scale. Whereas macro defect inspection has a crucial role in the modern manufacturing processes which are driven by decreasing structure sizes. Any defect or contamination, also on the wafer backside, can have severe impact on the production quality and finally the yield.

In-line inspection systems are designed to detect yield-limiting defects on 100% of the wafers. Therefore, the cycle time of the inspection system is crucial for the overall production volume of the Fab and therefore key factor for the design of high-end inspection systems. Within wafer manufacturing defects are roughly classified into two major groups:

1) Micro defects < 1μm
2) Macro defects > 1μm

For micro defect inspection in the nanometer range highly sophisticated deep UV (DUV) laser scanning systems or electron scanning microscopes (ESM) are used. Whereas in the micrometer domain (μm) conventional optical microscopes and camera systems are state of the art.

Beside macroscopic contamination and defects many micro defects can be identified indirectly by macro defects. For example, shifted patterns or changed coating thickness can lead to altered color appearance due to changed optical refraction.

Using high resolution and high-speed machine vision cameras, inspection systems suitable to detect macro defects can be designed to enable 100% inspection of the wafer production. The high throughput can be realized by covering the full width of the wafer by a single acquisition. Deploying such macro defect inspection systems have various advantages:

– 100% in-line quality control at high throughput

– Cost effective process control

– Direct feedback to process engineers for yield optimization

– Traceability of every single wafer in different stages of the production

– Fast return of investment

Types of defects captured with this scanners are **cracks, scratches, stains, foreign particles, unpolished areas, residues, water marks, pinholes, peeling, defects after dicing.**

Line scan technology plays a crucial role in building such macro defect scanners for wafer inspection. **Chromasens** line scan camera families **allPIXA evo** and **allPIXA wave** with **TDI (Time delay Integration)** options and with high resolution up to **16,384 pixels** are perfectly suitable to build such high performance inspection systems.

allPIXA line scan camera families – exclusive features

There are two outstanding features of **Chromasens allPIXA cameras**, which are dedicated for wafer inspection systems:

1) Master Slave camera synchronization
2) Multi-channel LED-flash control / LED strobing

Covering the complete FOV of a wafer of **300mm** at a resolution of **5-15 μm/pixel** requires multiple line scan cameras. Those cameras need to be perfectly synchronized to allow for stable image acquisition and subsequent image analysis. The **Chromasens** Master Slave camera synchronization feature allows to perfectly synchronize N=1,2,3,4,5,6 number of cameras. A highly stabilized image data acquisition enables a direct image comparison to track the stability of several processing steps like coating and etching. For multi camera alignment **Chromasens GCT SW tools** comes with an integrated camera adjustment cockpit. The **Chromasens** camera alignment adapter allows for quick, precise and stable alignment of multi camera systems.

The power of different lighting geometries

The ideal lighting condition is key in machine vision to highlight specific structures, object features and defects. Typically, a single lighting geometry is not sufficient to inspect challenging surfaces like processed wafers. In many applications at least two light geometries like brighfield and darkfield are required (*figure 1*).

Dark-field illumination is helpful, for example, to detect cracks, scratches or foreign objects, while bright-field illumination makes water stains visible, among other things.
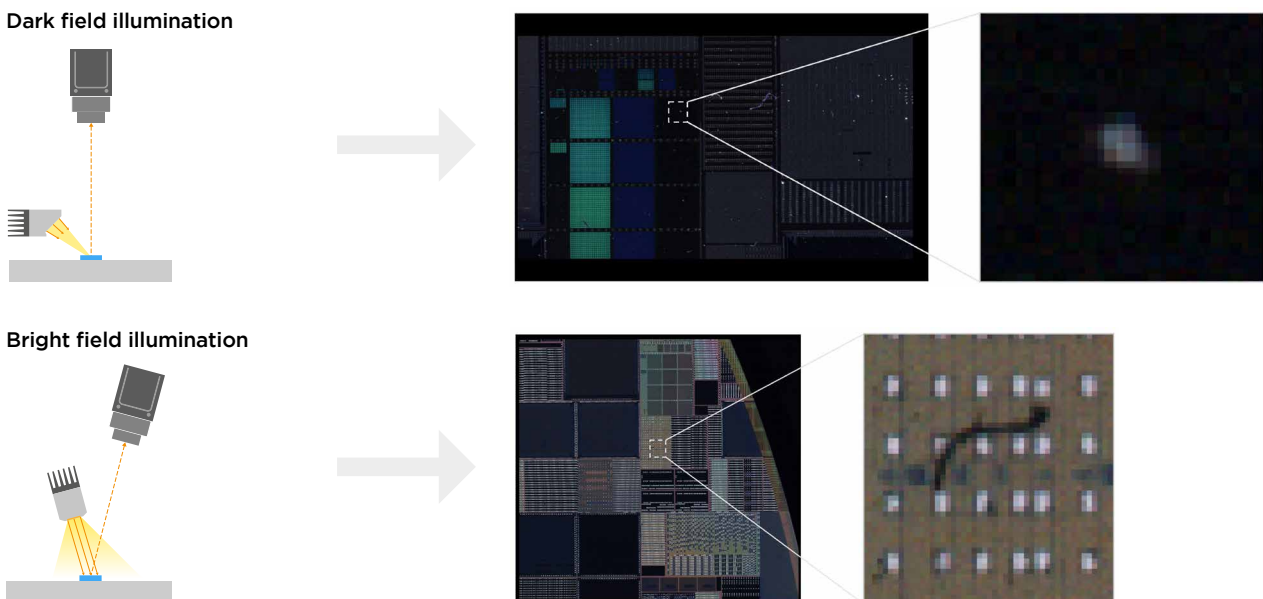
Dark field illumination

Bright field illumination

Figure 1: *Typical Dark- and Bright Field Condition for Surface Inspection*

Completing multiple acquisitions in a single scan will save time and money. The multi-channel flash feature of **allPIXA** cameras (figure 2) can acquire multiple images in a single scan, whereas every image is recorded under different illumination conditions. In addition, high color fidelity helps to achieve excellent results in defect detection.

Furthermore, the large full well capacity of the sensor enables a high dynamic range which can be ideally leveraged in combination with the camera internal gamma correction which effectively helps to expand the usable dynamic range of the image data. The blooming resistance of the **CMOS** sensor based **allPIXA wave** and **allPIXA evo** cameras is outstanding, which is very import to avoid signal crosstalk in high dynamic range image content.
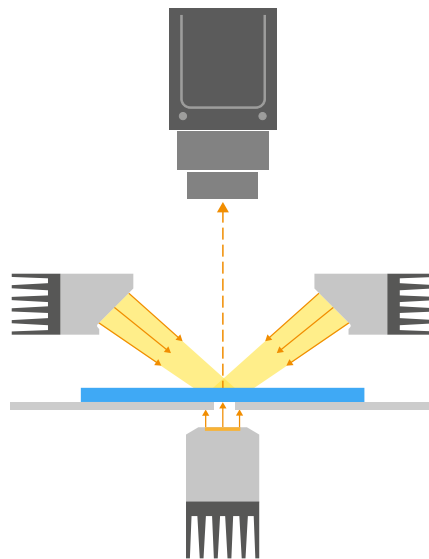

Figure 2: *Multi-channel flashing of allPIXA cameras enables to scan with up to four different illumination geometries in a single scan.*

allPIXA cameras deliver excellent image quality and versatility with its unique image processing features like:

- Advanced automatic white balancing
- gamma correction
- Integrated color correction matrix
- 8k cameras offer 2 stage color & 4 stage mono TDI
- Highly configurable IO interface

allPIXA camera families offer versatile interface options, each supporting specific use cases. For the typical wafer diameter of 300 mm a camera system with two **allPIXA 15k** cameras achieves a resolution of about **10 μm**. Depending on the interface, up to **68 kHz** in full color are possible to support very short scan times even with 2 and more light conditions in one pass.

There are three different interfaces to choose from: a cost-efficient **Camera Link** interface, which supports an extended **cable length of up to 15 meters** for the **allPIXA wave** camera. **CoaxPress** and **10 GigE** are available with the **allPIXA evo** camera: the **4 x CXP 2.0** interface for longer cable lengths and highest speeds and the **dual 10GigE** interface via fiber optics for longest cable lengths.

Figure 3: *The Chromasens Line Scan Vision Platform enables versatile configurations of multi-camera and multi-light geometry systems.*

Chromasens offers complete solutions for inline-inspection systems based on standard building blocks (figure 3). We offer support through an extensive online configuration tool:

https://chromaconfig.de/

Fully-customized Vision Solutions

For cost, maintenance, functional and environmental condition optimized vision systems we offer fully custom designed inspection systems. Our team has over 20 years of experience in ruggedized use case specific vision system design – built to be up and running 24/7 for many years. Beside design, production and image processing & algorithm competence we also support through **full product lifecycle management** according to **Copy Exactly!** requirements.

Invented to solve your challenges

Chromasens line scan cameras and light sources offer versatile helpful functions and features which help to build the ideal line scan camera system for challenging surface inspection tasks in semiconductor manufacturing environments. If you cannot find the ideal solution on our homepage and product configurators – get in touch with **Chromasens** line scan experts to brainstorm about your custom vision solution to solve your vision task.

The resulting system concept fulfils your requirements regarding cost, image quality, speed and available space.

For further information or requests please contact us for more information at „**sales@chromasens.de**"

THE LINE SCAN EXPERTS

LINE SCAN CAMERAS

LED LINE SCAN LIGHTING

3D LINE SCAN CAMERAS

CUSTOMIZED OEM SOLUTIONS

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