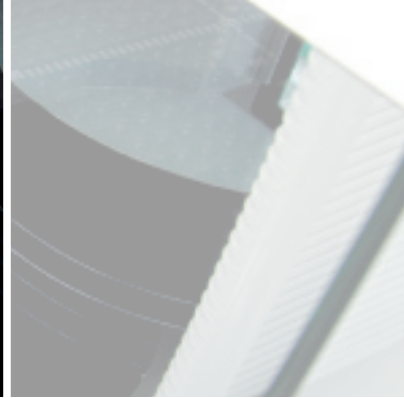


AUTOMATED MASK ALIGNER LITHOGRAPHY PLATFORM

## **SUSS MA200 Gen3**

**Enhanced 1x full-field lithography  
from lab to fab**





AUTOMATED MASK ALIGNER LITHOGRAPHY PLATFORM

## SUSS MA200 GEN3

### Full-field lithography from pilot to high-volume production

Process engineers all over the world have made Moore's promise of ever-increasing IC performance a reality. With feature sizes becoming smaller, chip integration has obviously posed new challenges. Requirements for structure uniformities and overlay accuracies are constantly getting stricter. Short product cycles make further demands on process flexibility, e.g. in the cell phone industry. At the same time these developments call for flexible equipment to foster fast-changing process environments, as well as for serious stability of production processes to support ever-stricter process tolerances.

With its decades of experience in various semiconductor markets, SUSS MicroTec understands the needs of the industry and is committed to supporting its customers in meeting these challenges with its suite of first-class lithography equipment. Special optics ensure outstanding illumination uniformity, and a dose-control mode achieves high wafer-to-wafer stability. This, together with the proven mechanical quality which results in high-class alignment capabilities, makes the MA200 Gen3 mask aligner a reliable tool for stable mass-production processes.

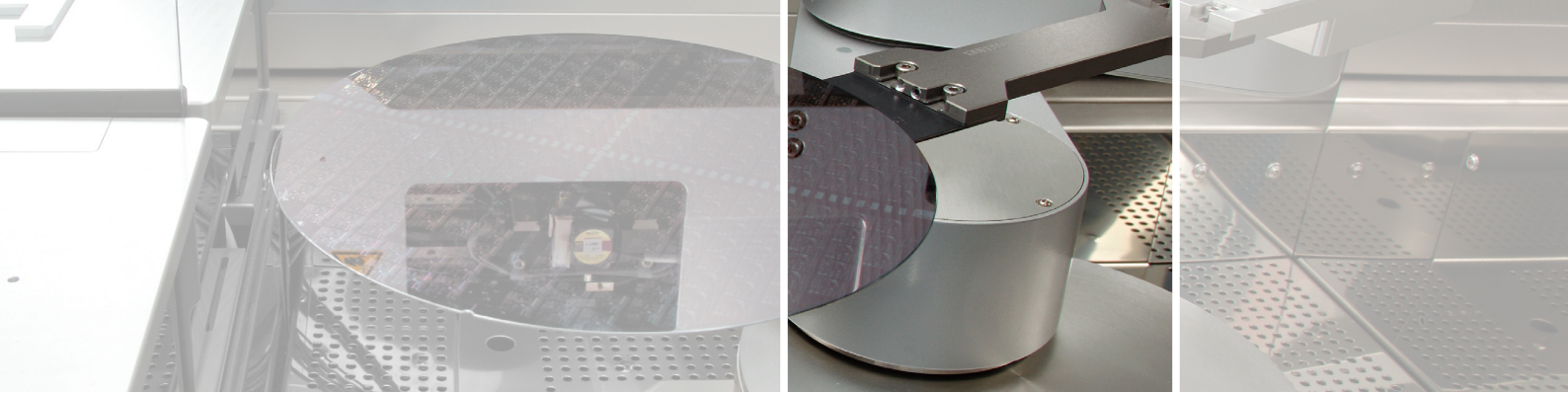
The mask aligner platform is designed for variable process requirements and allows for rapid switchover of optics and quick set-up of special toolings. The experience of our engineering teams in analyzing customer requirements and transforming these into technical solutions complements SUSS MicroTecs approach to serving its customers.



#### MA200 Gen3 HIGHLIGHTS

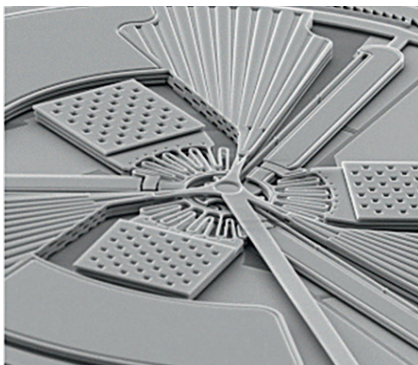
- + Leading process stability
- + Superior reliability
- + Unmatched throughput for thick materials
- + Process flexibility for a multitude of applications
- + Over seventy years of industry and process





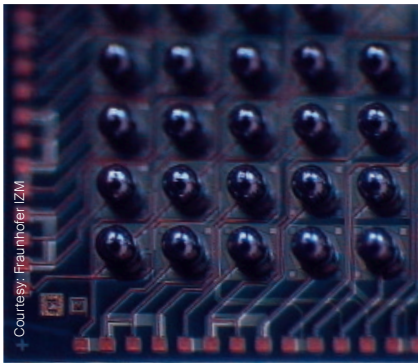
## Applications

### High yield at cost effective manufacturing



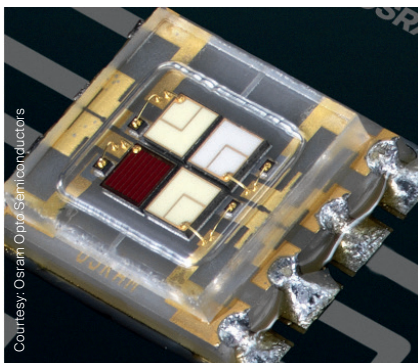
#### MEMS

With its high-intensity exposure optics the MA200 Gen3 efficiently processes the thick resists prevalent in MEMS applications. Innovative features include specific process modules such as customized edge handling tooling, special tooling designed for warped wafer processing, and systems for infrared alignment and angular exposure for steep and perpendicular sidewalls. These features make the MA200 Gen3 an enabling lithography platform for the development and high-volume production of MEMS devices.



#### WAFER-LEVEL PACKAGING

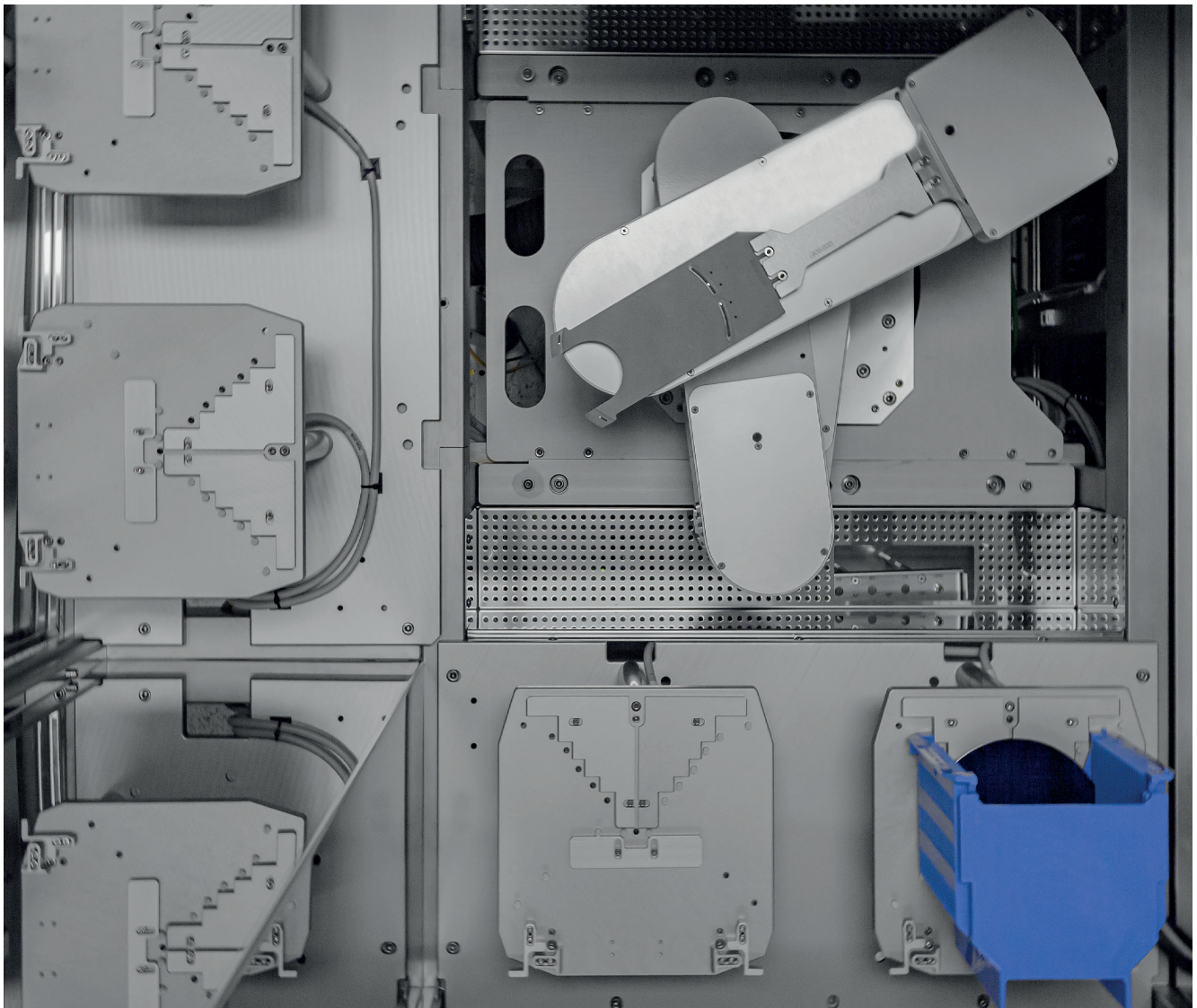
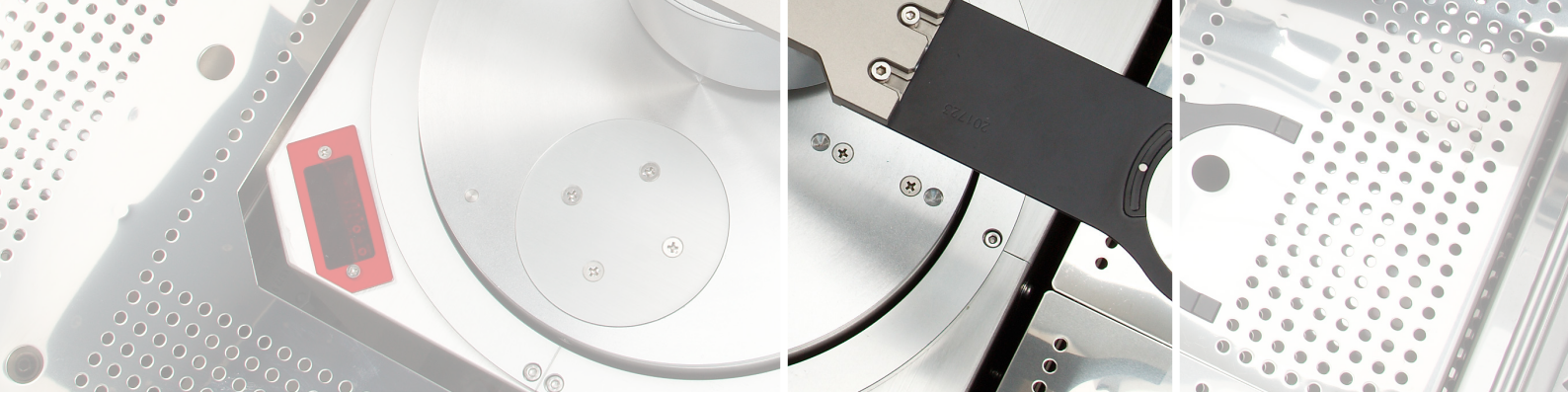
The MA200 Gen3 is geared to thick resist photolithography applications as used for advanced wafer-level packaging in general and advanced packaging processes like wafer bumping. High throughput combined with excellent overlay performance maximizes yield and ensures best possible cost of ownership. Equipped with additional features like warped wafer tooling, backside or infrared alignment, the MA200 Gen3 suits the process requirements of recently developed 3D packaging applications such as backside redistribution or TSV



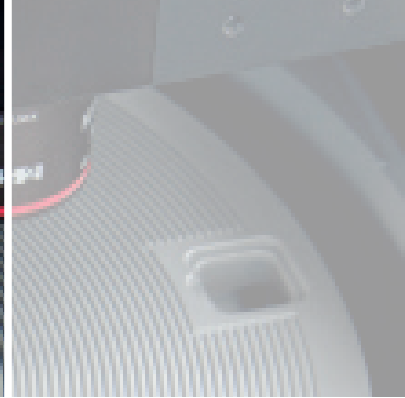
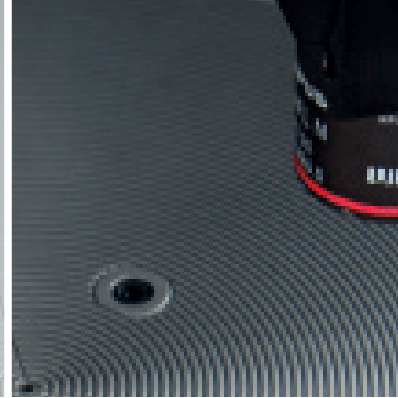
#### HB LEDs

The MA200 platform is widely used in frontend and wafer-level packaging processes in HB LED manufacturing. Advanced pattern recognition ensures highly reliable and accurate alignment of blurred or low-contrast wafer targets. Fragile and warped wafer handling toolkits enable processing of compound semiconductors such as GaN or SiC. High throughput results combined with submicron alignment accuracy and special W150 optics with very high UV-light intensity make the MA200 Gen3 a highly efficient production system for manufacturing cost-sensitive devices like HB LED.









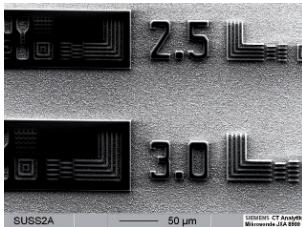
## Process know-how

### Delivering outstanding performance

The MA200 Gen3 is suited to different kinds of new technology and device manufacturing in the field of 3D integration, MEMS, LED, wafer-level packaging, compound semiconductors and photovoltaics. A great number of processes initially not used in semiconductor manufacturing have acted

as forerunners of creative new manufacturing methods. The sophisticated system design of the MA200 Gen3 integrates many of these technology trends on a fully automated equipment platform delivering outstanding performance while maintaining and optimizing costs per wafer.

#### LEADING RESOLUTION CAPABILITIES



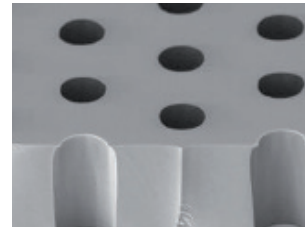
2.5 and 3 μm lines and space resolution. 20 μm proximity exposure result in DNR-L300-D1 resist on patterned 2" GaN on sapphire substrate

#### GOOD LINE EDGE ROUGHNESS



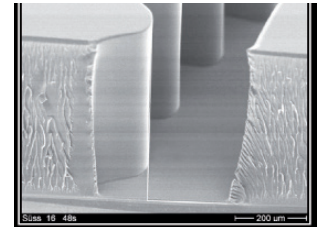
Wafer Level Packaging Structure of a RFID transponder chip as used for ID tags or electronic toll collection systems. 30 μm negative JSR THB 126N resist  
Courtesy: FhG IZM

#### VERTICAL RESIST SIDEWALLS



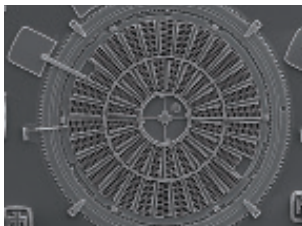
3D WLP TSV etch mask in AZ9260 (5 μm opening, 10 μm thick)  
Courtesy: ITRI

#### OUTSTANDING THICK RESIST PATTERN QUALITY



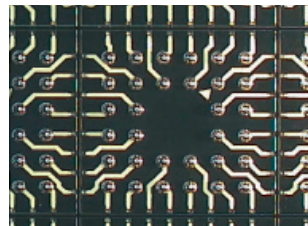
MEMS micro part: 250 μm thick SU8  
Courtesy: micro resist technology

#### HIGHLY PRECISE MICRO-MECHANICAL PATTERNING



Torsional ratcheting actuator with oscillating inner frame to ratchet its surrounding ring gear.  
Courtesy: Sandia National Lab

#### INDUSTRY PROVEN



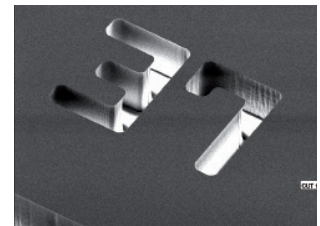
CMOS image sensor packaging with backside redistribution layer  
Courtesy: Schott

#### CAPABILITY TO EXPOSE



True-chip-size packages of HF devices

#### EXPERIENCE IN



Read / write head labeling  
Courtesy: Western Digital Corp.



# Alignment

## Accuracy meets automation

Highly reliable, accurate and quick overlay in lithographic processes is key to high yield in device manufacturing. With its great variety of alignment technologies designed to meet specific process requirements and its high degree of automation, the MA200 Gen3 delivers best-in-class alignment accuracy for optimal production results.

### PROCESS AUTOMATION WITH PATTERN RECOGNITION

The MA200 Gen3 is based on the search algorithm PatMax VisionPro™, the industry standard for pattern recognition. PatMax VisionPro improves alignment reliability in the manufacturing process by exchanging grey scale matching with true pattern recognition. It reduces the influence of variations in lighting and corrupted targets and allows for object scaling and orientation flexibility. PatMax thus minimizes costs generated by alignment errors and system halts.

The Vision Pro alignment editor provides users with direct control over training results and model quality by visual feedback. Its well designed user guidance supports setup of reliable target models.

### TOP-SIDE ALIGNMENT

With its top-side alignment system the MA200 Gen3 achieves an alignment precision down to  $0.5\text{ }\mu\text{m}$  ( $3\sigma$ ) while positioning the mask over the wafer (DirectAlign®).

### BOTTOM-SIDE ALIGNMENT

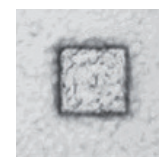
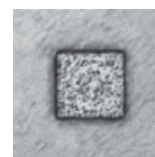
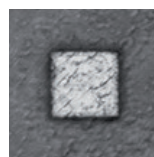
In addition to top-side alignment, many applications such as MEMS require precise bottom-side alignment. The MA200 Gen3 can optionally be equipped with bright-field bottom-side microscopes. They include an optical magnification switch and facilitate  $1\text{ }\mu\text{m}$  ( $3\sigma$ ) alignment accuracy. The BSA microscope with single- and splitfield features uses high resolution CCD cameras. The unique image storage and realtime image processing is more precise and faster than common crosshair alignment.

### INFRARED ALIGNMENT

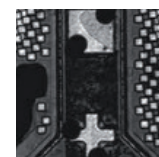
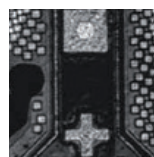
Infrared alignment allows for processing opaque, yet IR transparent materials such as GaAs, InP, silicon or adhesives, as used for thin wafer handling or encapsulation applications. The MA200 Gen3 is optionally equipped with either a transmissive or reflective IR toolset attached to the standard BSA microscopes.

### ENHANCED ALIGNMENT

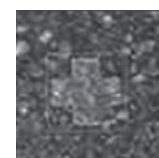
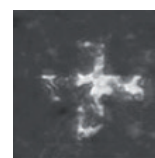
A suite of features improving the reliability of the alignment process. The suite includes improved functionality to align dark field masks with respect to active features instead of fiducials. Furthermore it allows to define redundant fiducial positions for processes where damaged fiducials are common.



Challenge: Pattern variation

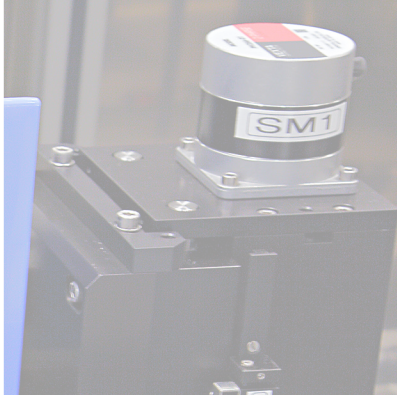
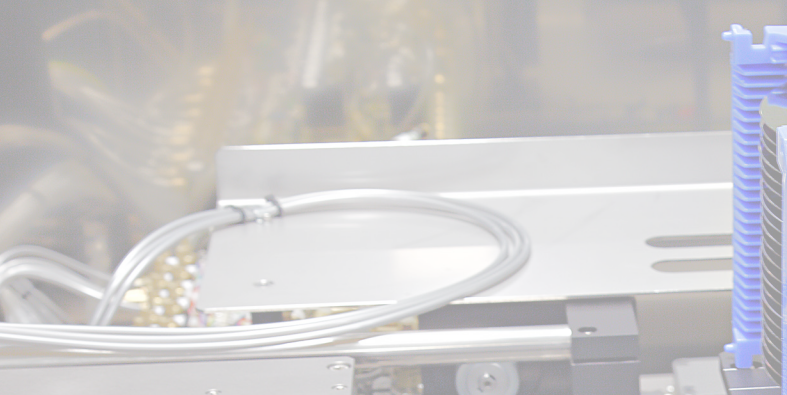


Challenge: Pattern variation and target damages



Challenge: High frequency, fragmented or low contrast targets





## Optional add-ons

### Alignment and Gap-Setting

#### DIRECTALIGN® – SUBMICRON PRECISION

As an optional feature SUSS MicroTec's DirectAlign software boosts performance of standard auto-alignment using live pattern imaging even at large process gaps and without interposition of an image storage system. Top-side alignment with DirectAlign achieves an alignment accuracy of  $0.5\ \mu\text{m}$  ( $3\sigma$ ) for the highest mask aligner precision on the market.

#### LARGE CLEAR FIELD ALIGNMENT

Designed for applications with dark field masks, the large clear field mask movement (LCMM) technology moves the mask automatically out of the field of view to accurately store wafer target position. Live mask target images are aligned to stored wafer target positions, making clear fields unnecessary in the process area of the mask.

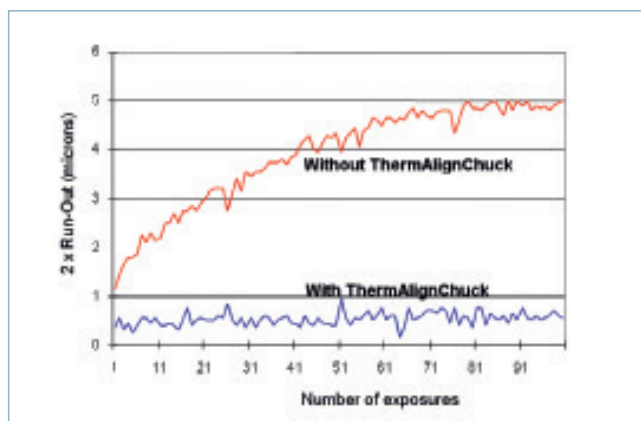
#### THERMALALIGN® – THERMAL RUNOUT COMPENSATION

Thermal runout compensation is an important factor for improving overlay accuracy of full-field exposure systems. The SUSS ThermAlign temperature control system compensates for potential thermal mismatches from photomask to wafer. It controls the temperature of the wafer chuck during the entire process and stabilizes mask temperature.

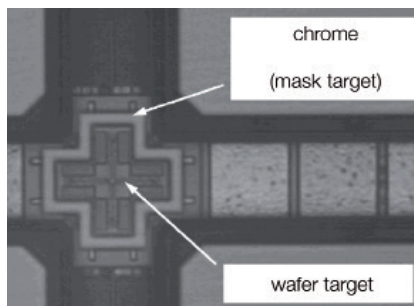
#### ACTIVE GAP SETTING

The MA200 Gen3 provides active gap setting for additional stabilization of mask-to-wafer distance. The system automatically corrects any deviation from the nominal distance between wafer and photomask. The monitoring system also helps operators detect uncorrectable errors before exposure, thus protecting wafer material.

	x left	x right	y left	y right
Mean	0.01	-0.04	0.03	0.02
Range $\pm$	0.13	0.13	0.25	0.25
$3\sigma$	0.17	0.23	0.30	0.31



Runout effect with soda lime photo masks at high exposure doses (MA200 Gen3: 5000 mJ,  $50\ \mu\text{m}$  exposure gap)



MA200 Gen3: 25 samples,  $100\ \mu\text{m}$  alignment gap,  $35\ \mu\text{m}$  exposure gap



## Exposure Optics

### Superior uniformity and resolution

As a full-field exposure system the MA200 Gen3 is capable of exposing a 200 mm wafer in one single shot, whereas other lithography methods such as step and repeat typically require 50 or more exposure steps per wafer. Its higher throughput and lower investment costs directly translate into lower cost of ownership making it an interesting solution for a wide range of lithography processes.

#### DIFFRACTION REDUCING EXPOSURE OPTICS

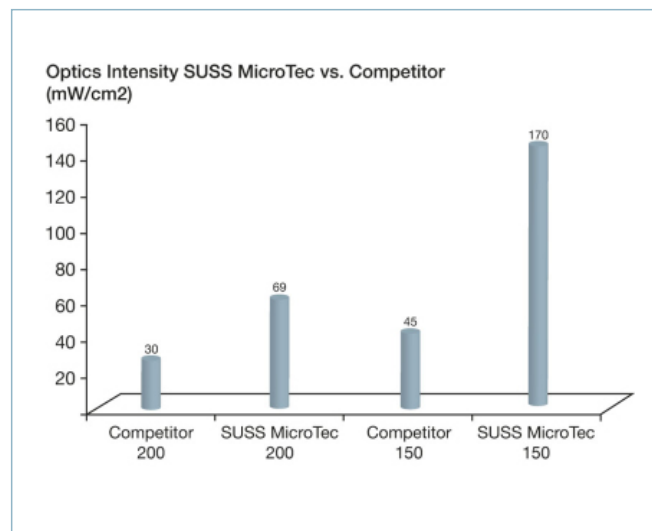
The diffraction reducing exposure optics are designed to compensate diffraction effects in both contact and proximity lithography. Instead of using a plane wave as in other proximity lithography tools it provides an angular spectrum of planar light waves to reduce diffraction effects. The selection of a proper angular spectrum improves structure resolution in the resist.

#### HR AND LGO

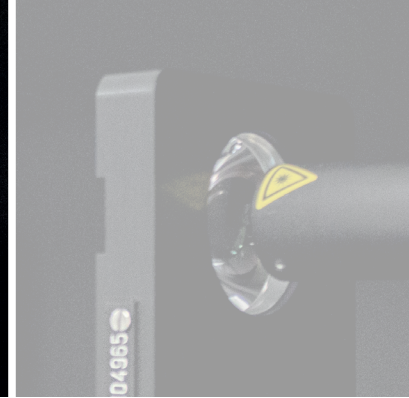
SUSS Large-Gap Optics (LGO) are tailored to achieve high resolution when exposing in large mask-to-wafer distances through a dedicated illumination angle setting. These optics are typically used for applications with high topography substrates or thick resist applications. The special SUSS HR Optics have been optimized for highest optical performance in small exposure gaps or in contact exposure mode. The high resolution optics achieve resolution down to  $3\mu\text{m}$  at  $20\mu\text{m}$  exposure gap and submicron resolution in contact. For processes with high dose requirements for 150 mm wafers the exceptionally high intensity of W150 HR optics facilitates high throughput.

#### MO EXPOSURE OPTICS®

MO Exposure Optics are based on unique high-quality microlens arrays that are combined with an exchangeable Illumination Filter Plate (IFP). They provide outstanding light uniformity and allow quick and easy changeover between both classical SUSS exposure optics, HR- and Large-Gap Optics. MO Exposure Optics additionally allow customized illumination through modification of the FP and enable the use of enhanced lithography techniques such as source-mask optimization (SMO) or Optical Proximity Correction (OPC).





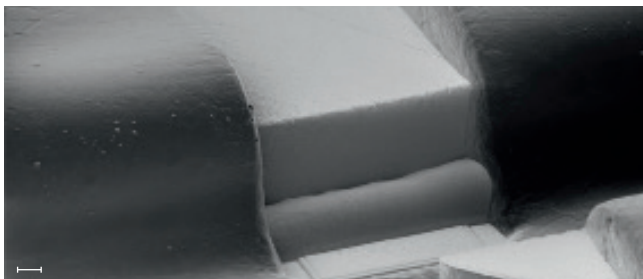
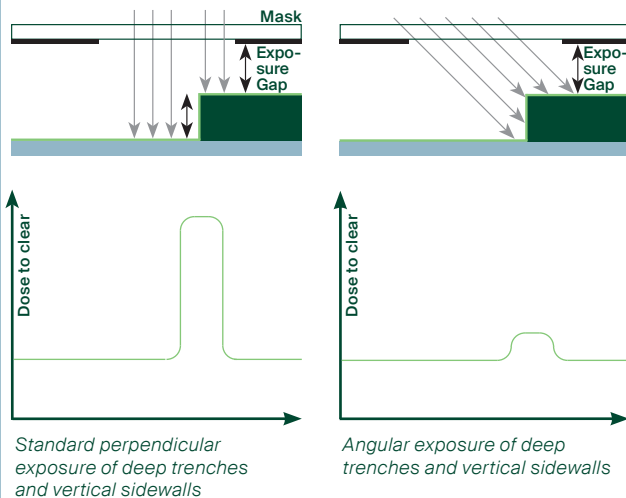


## EXPOSURE OPTICS – OPTIONS

### Angular exposure

Sidewall exposure of vertical structures is challenging for process technology, especially in positive photoresist processes. Exposure of comparatively thick vertical sidewall results in either underexposing the sidewall or over-exposing the topography. The angular exposure system of MA200 Gen3 illuminates substrates at a defined angle (45 or 60) to bring the needed doses closer to each other.

#### Comparison of Standard Perpendicular Exposure with Angular Exposure



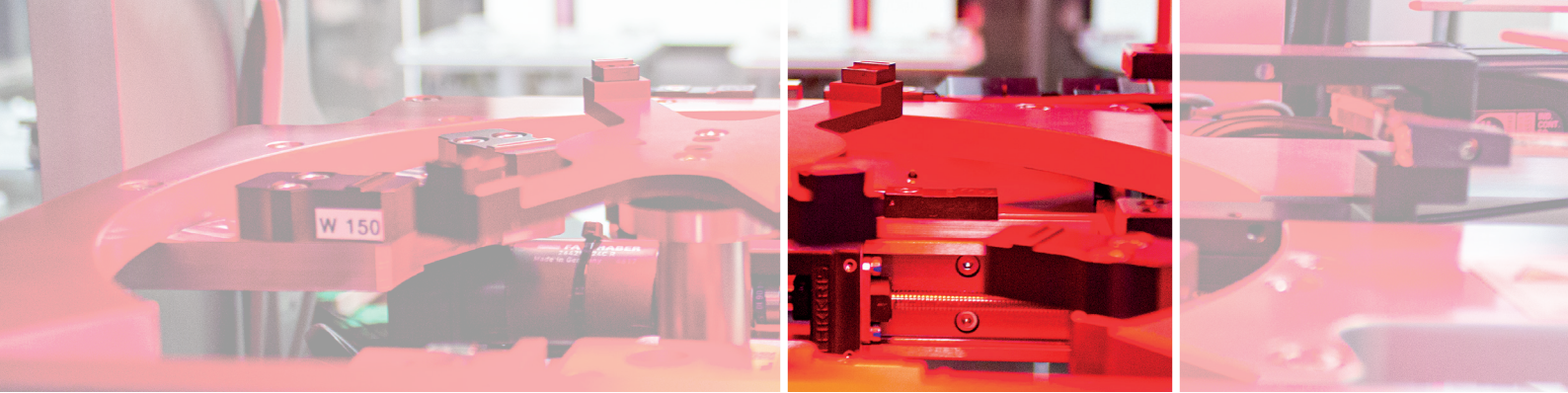
Resist mask for production of a conductive trace over a vertical sidewall

### UV-LED light source

The optional UV-LED light source concept of the MA200 Gen3 is highly efficient – UV-LED light sources reach any times the service life of conventional mercury vapor lamps. Moreover, they no longer need to warm up and cool down since the LED is only switched on during exposure. These factors significantly contribute to comparatively low energy consumption.

Compared to conventional mercury vapor lamps, LED light sources not only work more efficiently, but also are much more flexible to use. The UV-LED light source generally covers the same spectral region as mercury vapor lamps. The difference is that the UV-LED light source allows both to switch specific wavelengths on and off according to process requirements and to simply adjust their intensity if required. This eliminates the need to optically filter the light outside of the lamp house.

The service life of an LED exceeds that of conventional lamps many times over, thereby lowering costs generated by changing light bulbs. Downtimes, acquisition of new lamps, adjustments and disposal of old material belong to the past. Working with the LED lamp house is both safe and environmentally sound and is a major step up in health



## Wafer handling specials

### Intelligent solutions

Wafer handling is key to process automation. In real world production environments with changing substrate conditions, only reliable transport toolings enable high throughput. Wafer handling techniques vary with applications. The capability of MA200 Gen3's standard handling system spans from common to extraordinary materials such as wafer bows up to 300  $\mu\text{m}$  and material thicknesses down to 250  $\mu\text{m}$ . For critical applications, MA200 Gen3 offers customized handling solutions and quick tooling change-over to provide utmost flexibility for production processes.



#### THIN WAFER HANDLING

Fragile substrates such as ultra thin wafers are used in applications like 3D integration, MEMS and power semiconductors. A special vacuum chuck supports wafer thinner than 250  $\mu\text{m}$  (down to 50  $\mu\text{m}$  - membrane thickness on Taiko® wafers).

#### WARPED WAFER HANDLING

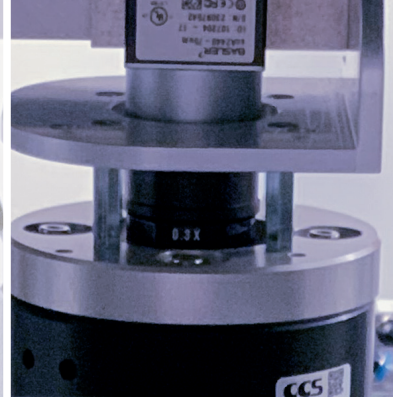
Specific handling solutions are available for warped and bowed wafers. Techniques for carefully flattening wafers before processing depend on the nature of their deformation. SUSS MicroTec's more than seven decades of engineering experience facilitates appropriate solutions.

#### EDGE HANDLING

A sensitive support system protects the integrity of wafers, and is especially necessary to protect double-sided structures such as in MEMS. MA200 Gen3 optionally comprises complete edge handling, from transport and pre-alignment to exposure stage.







## Ergonomics

### For better usability

The MA200 Gen3 provides enhanced ergonomics leading to shorter process training cycles and higher effective output.

A continuous-run load port allows for ergonomic handling of cassettes, eliminating the need to stop the machine during cassette change. This reduces the risk of wafers damaged by mishandling.

The adjustable monitor and I/O interface facilitates working at the machine even during high workload. Direct view on exposure stage simplifies machine control during process definition.

- + Continuous-run load port
- + Adjustable monitor and I/O interface



## Flow box

### controlled local

Controlling particles, temperature and humidity have positive effects on both process stability and product quality, contributing to efficiency as well as cost reduction. To provide such a controlled environment the production housing of the MA200 Gen3 can be equipped with a clean-room flow box that creates a confined process chamber.

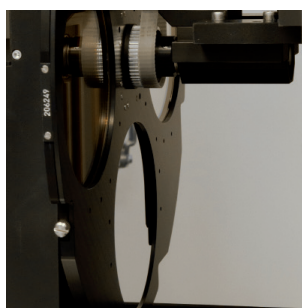


## Optional add-ons

### Flexibility to meet all lithography challenges

#### AUTOMATIC FILTER EXCHANGE UNIT

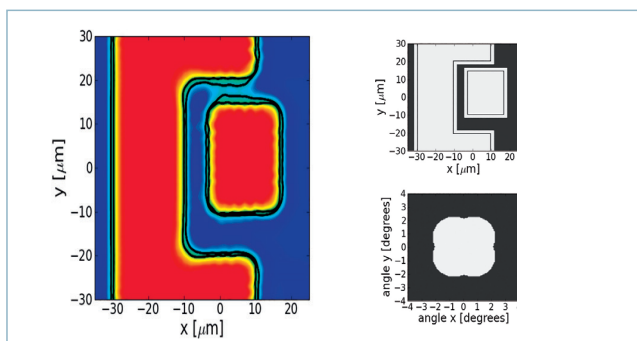
The MA200 Gen3 optionally offers an automatic filter exchange unit for up to four filters selected via process recipe. This removes the risk of operator errors, improving yield and effective throughput.



*Filter exchange unit*

#### LAB® SIMULATION SOFTWARE

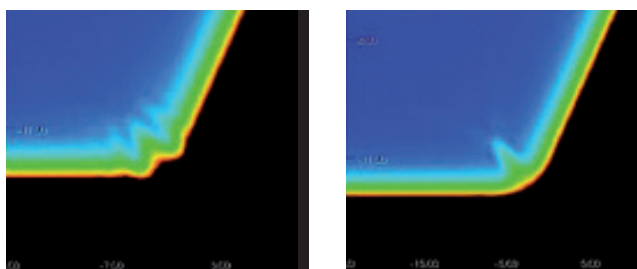
SUSS version of LAB lithography simulation software incorporates all SUSS MicroTec optics solutions, such as HR-, LGO and MO Exposure Optics, including their individual characteristics. The software reduces the need for experimental layout optimization and simplifies process development. Together with MO Exposure Optics, LAB simulation software is the enabling technology for mask aligner source-mask optimization.



*Software simulation of critical features and shortenings, optimized with customized illumination and OPC. Courtesy: FhG IISB*

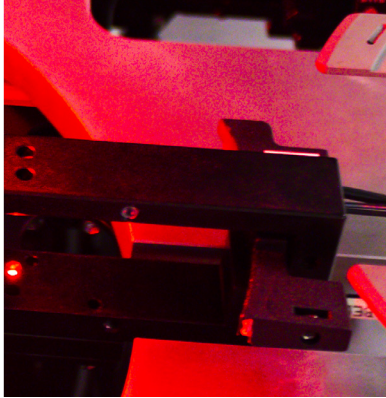
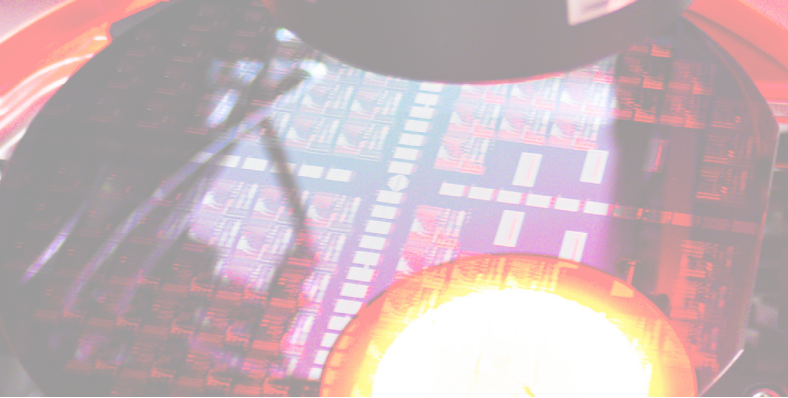
#### SOURCE-MASK OPTIMIZATION

Source-mask optimization is an illumination concept that combines best possible uniformity with flexibility to support target-adapted process solutions. It helps to reduce image errors due to diffraction or process effects. A two-pronged approach of customizing illumination filter plates and mask structure adaption helps to bring extended functionality to both, contact and proximity lithography processes.



*Structures before and after process optimization with sourcemask optimization*





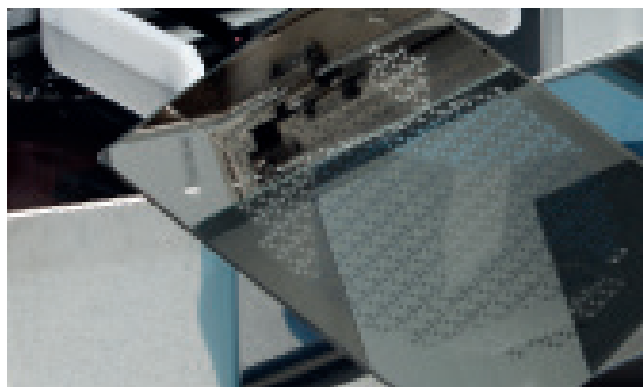
## Optional add-ons

### Flexibility to meet all lithography challenges

Requirements for process technology and equipment vary with each production process. With its modular base system and intelligent special tooling MA200 Gen3 provides solutions for a wide range of applications.

#### INTEGRATED MASK MANAGEMENT

The automated system for mask management includes identification, loading, unloading and storage of up to 20 masks. It speeds up mask exchanges and reduces risks of operator mistakes during mask change.

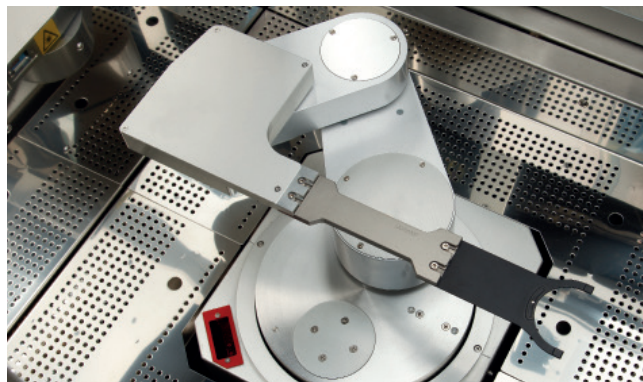


#### ULTRA-CLEAN WAFER PROCESSING

SMIF I/O and filter fan units maintain a high level of cleanliness during production. Wafer transport is performed independent of production environment.

#### CLUSTER INTEGRATION

The MA200 Gen3 can be combined with SUSS MicroTec's coat/bake/develop solutions to reduce handling steps and operator interference.

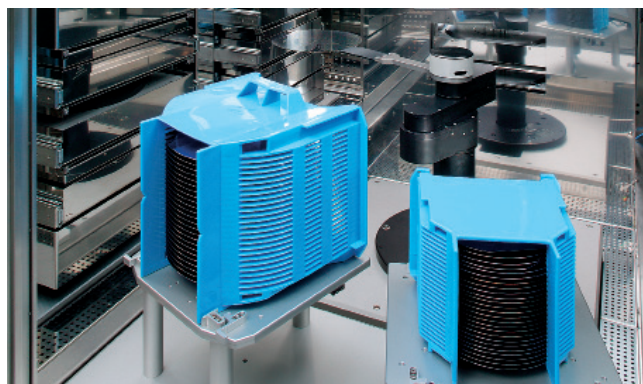


#### SECS-II/GEM

The MA200 Gen3 is designed to integrate into a fab automation system compatible with SECS-II/GEM interface standards. Level and communication details will be specified based on the SUSS MicroTec core software solution.

#### INTEGRATED POST-EXPOSURE BAKE

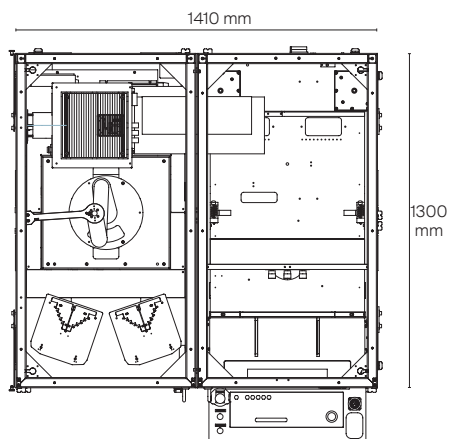
Integrated temperature plates support well-timed post-exposure bakes for optimized processing of chemically amplified photo resists as used in various packaging or bumping applications.



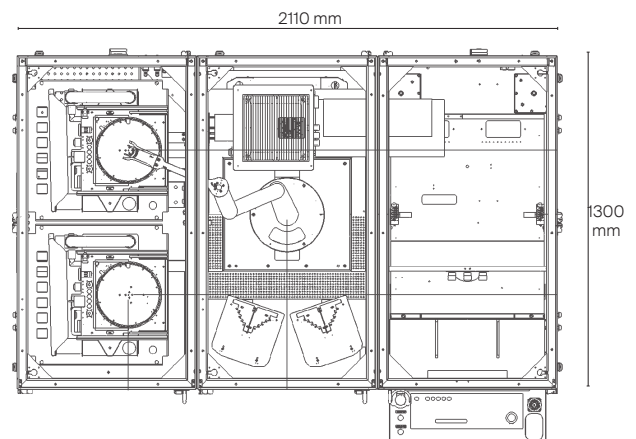


## Configurations

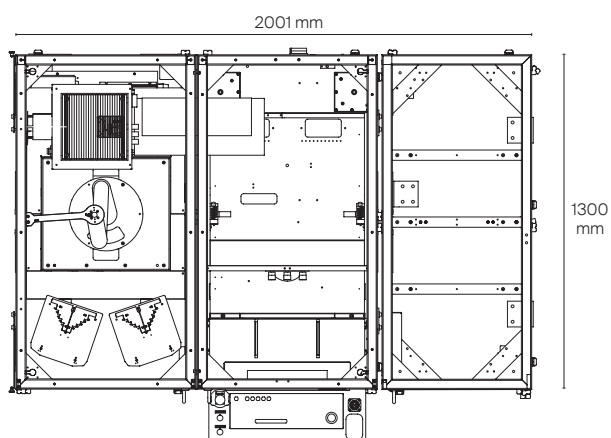
### Basic Configuration



### Integrated Post-Exposure Bake Option



### Integrated Mask Library







# SUSS MA200 Gen3

## Technical data

EXPOSURE SYSTEM			
Resolution HR LGO		3 μm (20 μm proximity) 7 μm (100 μm gap) 10 μm (150 μm gap)	
Accuracy in Constant Dose Exposure		<1%	
Exposure Modes		Vacuum contact, hard contact, soft contact, proximity, flood exposure	
INTENSITY / UNIFORMITY*			
Optics Type (1000 W)		SUSS UV-Optometer	
		Intensity	Uniformity
UV400 HR W200	365 nm	36 mW/cm <sup>2</sup>	
	Broadband	69 mW/cm <sup>2</sup>	< 3.5 %
UV400 LGO W200	365 nm	16 mW/cm <sup>2</sup>	
	Broadband	33 mW/cm <sup>2</sup>	< 3.5 %
UV400 MO HR-IFP W200	365 nm	31 mW/cm <sup>2</sup>	
	Broadband	60 mW/cm <sup>2</sup>	< 2.5 %
UV400 HR W150	365 nm	75 mW/cm <sup>2</sup>	
	Broadband	170 mW/cm <sup>2</sup>	< 3.5 %
Optics Type (UV-LED)		SUSS UV-Optometer	
		Intensity	Uniformity
UV400 MO HR-IFP W200	365 nm	25 mW/cm <sup>2</sup>	
	Broadband	60 mW/cm <sup>2</sup>	< 2.5 %
ALIGNMENT SYSTEM			
Alignment Accuracy		0.5 μm / 3 σ (TSA, AutoAL, DirectAlign) 1 μm / 3 σ (TSA, AutoAL) 1 μm / 3 σ (BSA, AutoAL)	
Pattern Recognition		Cognex (CNL, PatMax)	
Run-Out Compensation		ThermAlign chuck (optional)	
Large Clear Field Alignment		1 μm	
Prealignment Accuracy		< 50 μm	

\*Typical values for 1000 W HBO-lamp measured with SUSS UV-Optometer.  
Available values depend on lamp power, lamp type, lamp lifetime, etc.

Data, design and specification depend on individual process conditions and can vary according to equipment configurations. Not all specifications may be valid simultaneously. Illustrations, photos and specifications in this brochure are not legally binding. SUSS MicroTec reserves the right to change machine specifications without prior notice.

WAFER HANDLING	
Wafer Size	2" -200 mm, round or square
Allowable Wafer Warpage	1mm
Perforated Wafers	Yes
Carrier Mounted Wafers	Yes
Thin Wafers without Carrier (200 mm)	Thickness: down to 120 $\mu\text{m}$ Max. warpage: 5 to 6 mm
Throughput	> 160 wph FM; > 130 wph AutoAL
Wafer Size Conversion	< 5 minutes
UTILITIES	
Vacuum	< 0.2 MPa (absolute)
Nitrogen / 1500 W LH	0.2 – 0.3 MPa, 2.4 m <sup>3</sup> / h
Power / 1500 W LH	Voltage: 400 VA, 3 Phase Y Power: 2800 VA, 50 Hz
Compressed Air 1500 LH	0.2 – 0.3 MPa, 2.4 m <sup>3</sup> / h
Reliability	E-MTBF 500 h MTTR 4 h Uptime > 95 %
PHYSICAL DIMENSIONS (STANDARD CONFIGURATION)	
Height x Width x Depth	2000 mm x 1509 mm x 1405 mm

NORTH AMERICA

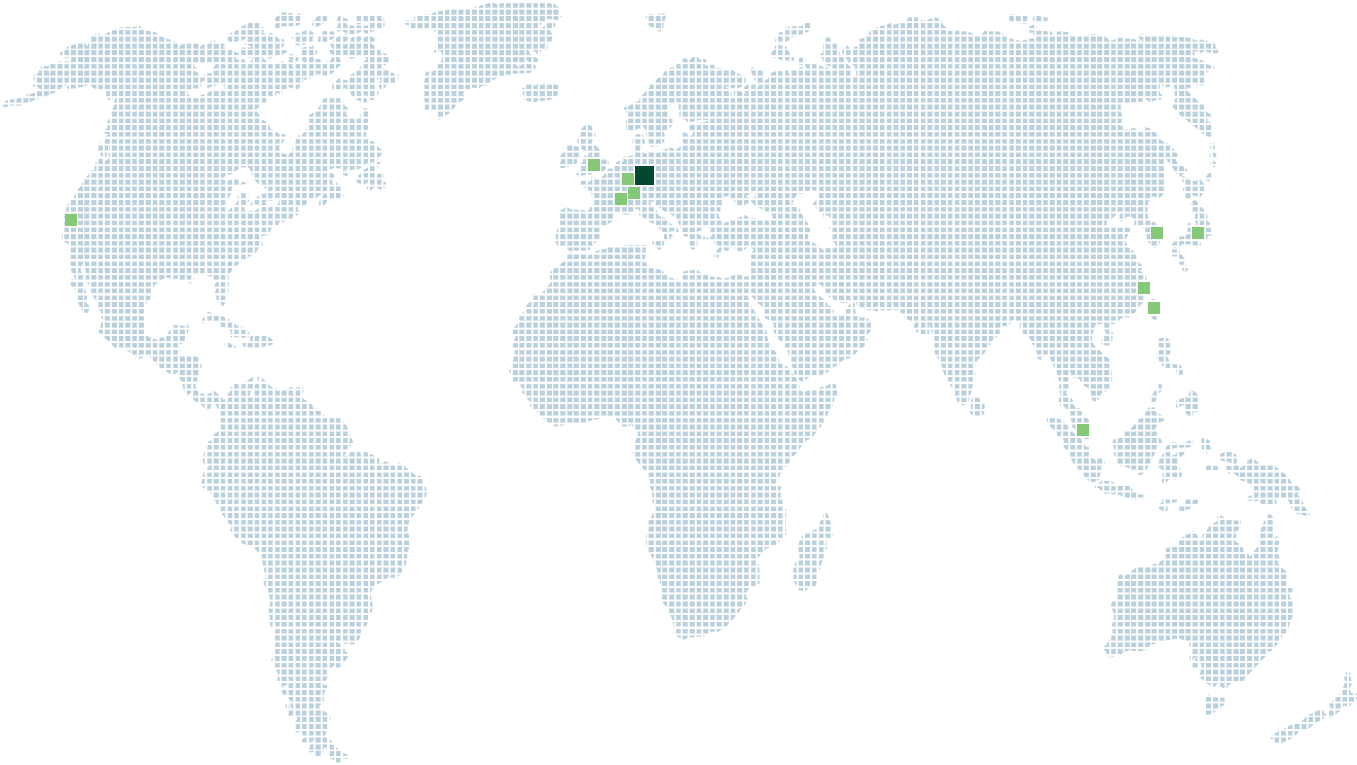
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