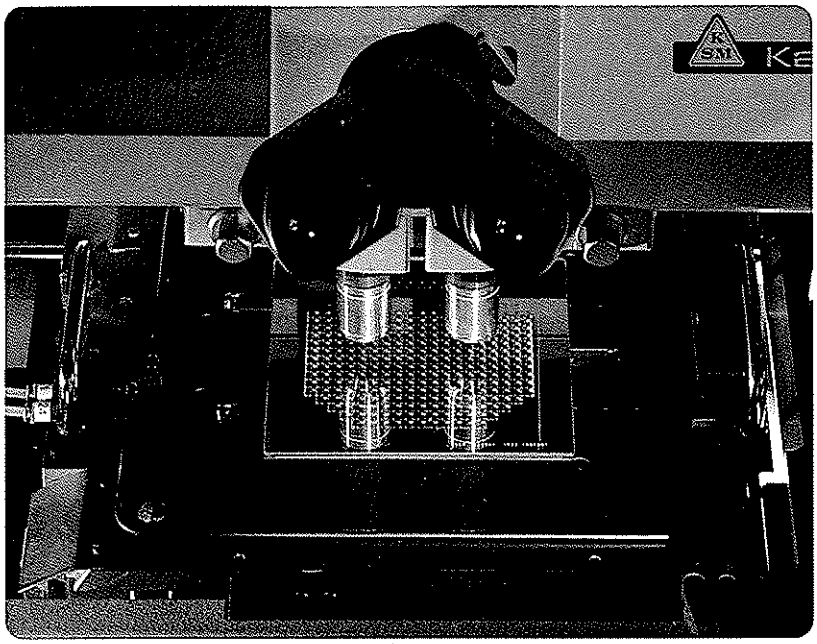


A New Level of Contact
and Proximity Lithography

8-31-94

SUSS MA 150
SUSS MA 150 M

SUSS MA 150 and SUSS MA 150 M have opened up new performance levels for contact and proximity lithography of wafers and substrates.
The result:
in many processes these lithography techniques may now be used more economically, reliably and rapidly than projection or E-beam lithography.

SUSS MA 150

6" high-performance production mask aligner with high throughput and high yield. PC control with plasma touch screen operation.

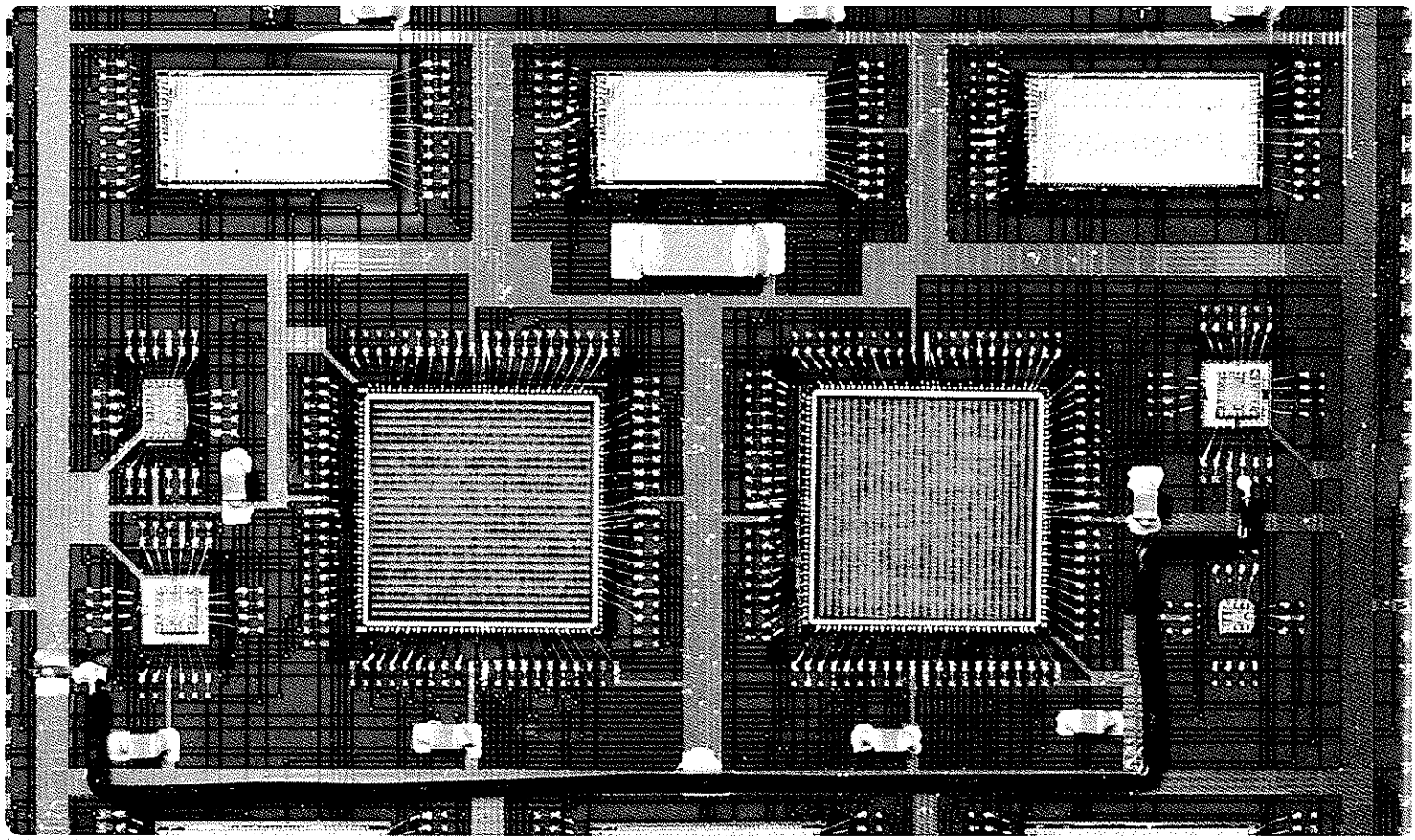
SUSS MA 150 M

6" mask aligner with manual substrate handling, PC control with plasma touch screen operation, for laboratory, research and development use, for small scale or pilot production.

SUSS MA 100 und SUSS MA 100 M

4" mask aligners.

Karl Suss



SUSS MA 150
SUSS MA 150 M

Illustration above: HDMI module (Courtesy of Honeywell).

Titel page: Feature produced by the SUSS XRS 200 X-Ray Stepper, utilizing the SUSS LSX 10 Plasma Focus X-Ray Source.

SUSS MA 150 and SUSS MA 150 M are a new generation of state of the art contact and proximity mask aligners that offer a new, sophisticated level of performance. They combine time-proven features with the latest technology for wafer, substrate and partial wafer lithography, and incorporate important defect minimization techniques such as backside handling.

The result:
At relatively low investment, contact and proximity exposures for a wide variety of special processes may now be performed faster and more reliably than with projection or E-beam lithography. Mask wear and machine-related defects are reduced to a minimum. The printed feature edges are steeper, even in thick resist layers. Higher exposure intensity results in higher throughput, even for large substrates.

Outstanding features of the machines are:
High level of performance, high throughput and high yield. Proximity applications and extremely high-resolution contact lithography far down into the submicron range on large wafers, substrates and special materials up to 6" x 6". X and Y shifts are below 0.1 μm and cannot be detected with optical means.

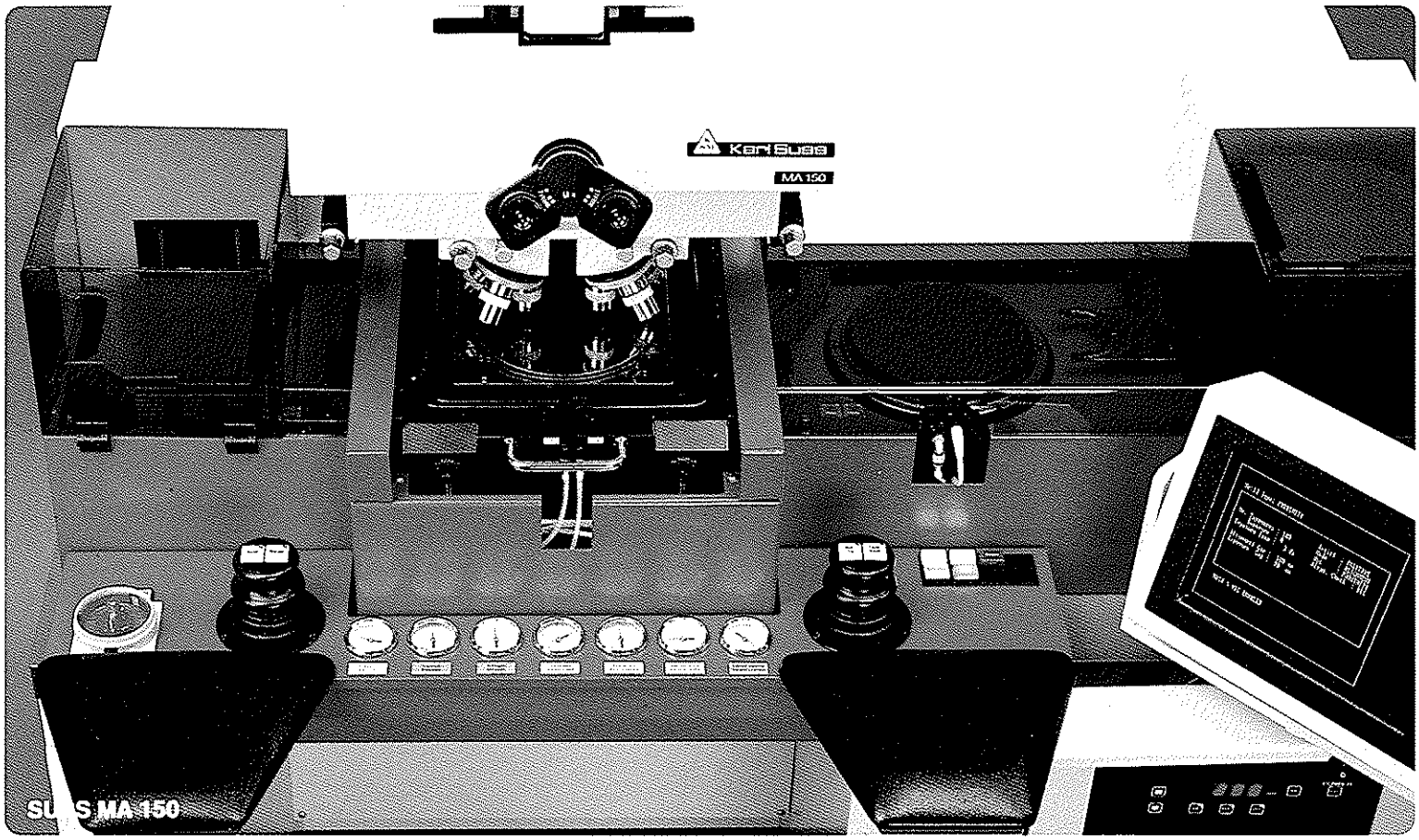
Spectral ranges for exposure:
UV 400/300/250 with high pressure lamps up to 1000 Watts, UV 249/193 with excimer laser. Even the 400 nm versions of both machines deliver 0.6 μm resolution in vacuum contact. Using the UV 300 and UV 250 spectral ranges or an excimer laser increases resolution to 0.2 μm.

SUSS MA 150
6" production mask aligner for fully or semi-automatic processing of wafers or substrates. PC control with plasma touch screen operation. Programming and storage of up to 100 different processes. Automatic alignment on request.

SUSS MA 150 M (without cassette loader)
6" mask aligner with manual substrate feed for wafer, partial wafer, substrate and special material processing. For laboratory, research and development use, as well as for small scale or pilot production.

SUSS MA 150 and SUSS MA 150 M
are delivered for lithography of either
a) wafers,
b) substrates or special materials

SUSS MA 100 and SUSS MA 100 M
Versions of the above mask aligners for up to 4".



Range of Applications

Wafer and substrate lithography processes: silicon, ceramics, glass, up to 6" x 6" highly fragile materials (GaAs, InP, InSb).
With their contact and proximity processes, the SUSS MA 150 and SUSS MA 150 M in various base configurations cover the entire application range from semiconductor to non-semiconductor lithography.

Special accessories tailored to different requirements lead to mask aligners for special applications:

High Density Interconnect Technology
Special chucks with increased vacuum suction and sophisticated exposure optics with high-intensity lamps provide an ideal tool for HDMI processes on warped substrates in combination with thick resist films. Substrates are handled only from the backside. The SUSS MA 150 with appropriate accessory equipment is being applied more and more often in this field and has become the market leader.

Mix and Match Operation
with other lithographic processes. The SUSS MA 150 may be adapted to coating and developing systems; it is equipped with a host computer interface. In a typical wafer fabrication line, for example a SUSS MA 150 can serve three wafer steppers or vice versa.

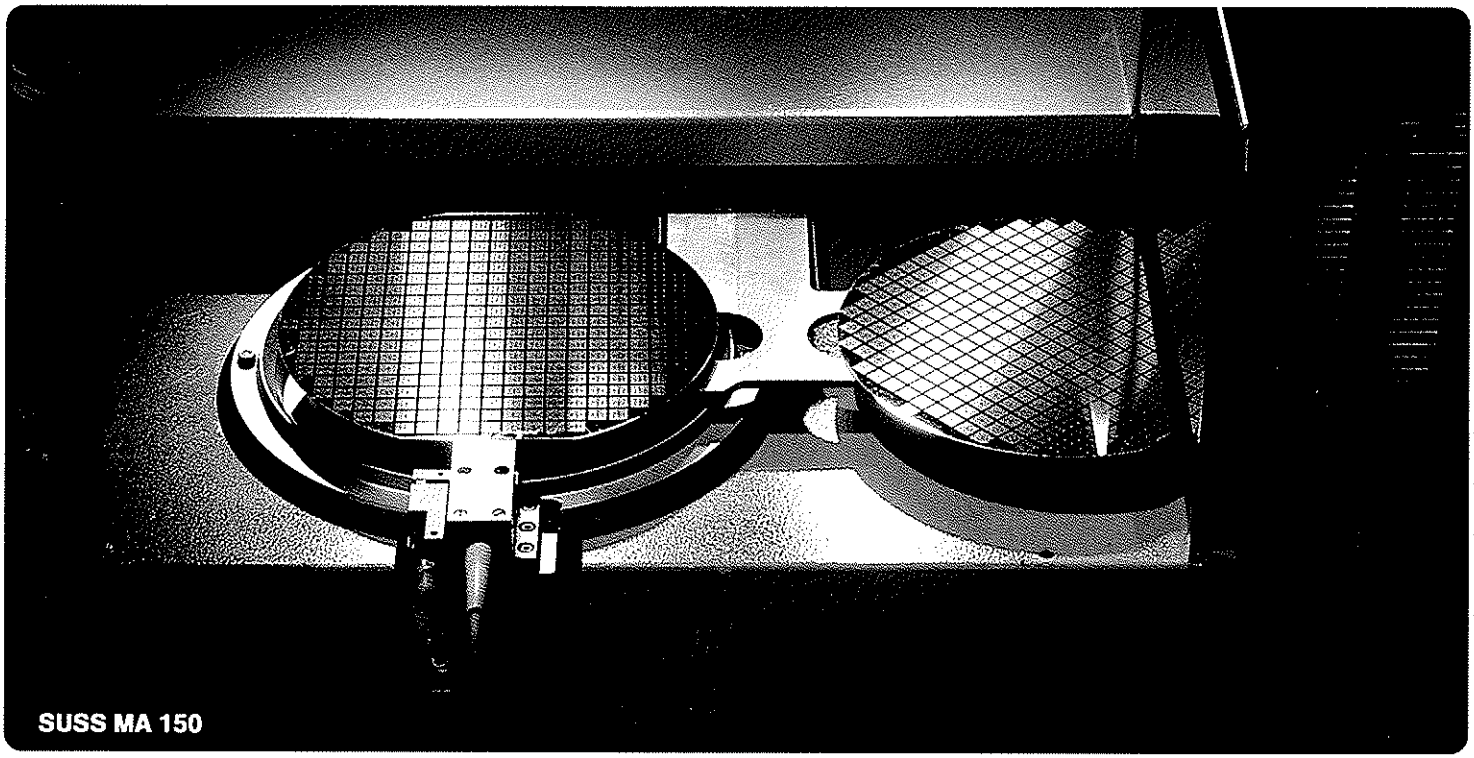
Thin Film Technology
The extraordinarily reliable SUSS mechanics can process thick and heavy substrates easily.

Power Devices and High Frequency Hybrids
Lithography for these components benefits from automatic cassette-to-cassette handling (both of wafers and round or square substrates), fast change-over times, high reliability and high throughput. The SUSS MA 150 is the mask aligner of first choice for this application.

Powerful Software
The diverse parameters necessary for a process may be programmed and saved. Numerous monitoring functions ensure smooth and reliable production operation. Of course, comprehensive service programs are also part of the package.

Throughput
Depending on process conditions, the SUSS MA 150 mask aligner features throughput of up to 80 wafers or substrates per hour; the SUSS MA 150 M processes up to 60 wafers or substrates per hour.

SUSS know-how in mask aligner construction is unique and unsurpassed in the semiconductor industry.



SUSS MA 150

SUSS MA 150 and SUSS MA 150 M: Advanced Mask Aligner Technology at a Glance

SUSS MA 150 prealignment station, accuracy ± 15 µm.

Back Side Handling
A pick-and-place system handles wafers and substrates only from the back side. This minimizes machine generated defects.

Fast Alignment
The SUSS M 206 and SUSS M 236 split-field microscopes have been specifically designed with an enlarged objective separation distance to align 6" substrates. The high prealignment station accuracy (SUSS MA 150: ± 15 µm) or the high prealignment accuracy on the exposure chuck (SUSS MA 150 M: ± 25 µm) result in only a minimal relative alignment movement between mask and substrate. This contributes decisively to fast and mask-saving alignment.

Shorter Exposure Times due to High Exposure Intensity
The SUSS LH 1000 lamp house is designed for operation with a 1000 Watt lamp and 6" exposure field. 350 W and 500 W lamps may be used as well; an excimer laser can also be adapted.

Free Selection of Lithography Processes through Choice of All Spectral Ranges with Focus on Exceptionally High Resolution or Process Latitude
Spectral ranges UV 400/300/250/249/193. Individually optimized diffraction reducing exposure systems for each spectral range. This results in high resolution.

Renowned SUSS Precision in Durable Mechanics and Pneumatics
The mask alignment stage is motorized in its X, Y, Θ and Z movements; a single-step mode is integrated for fine alignment. Top loading mask holders ease loading of large masks. They also contain the proximity elements. Exposure chucks may be exchanged simply and without tools. Wedge-error compensation is performed using the proven SUSS principle; its pressure may be adjusted between 5 and 12 N.
The machine works with practically no shift. The result: high production output at low per chip cost and negligible defect density, i.e. high productivity and efficiency.

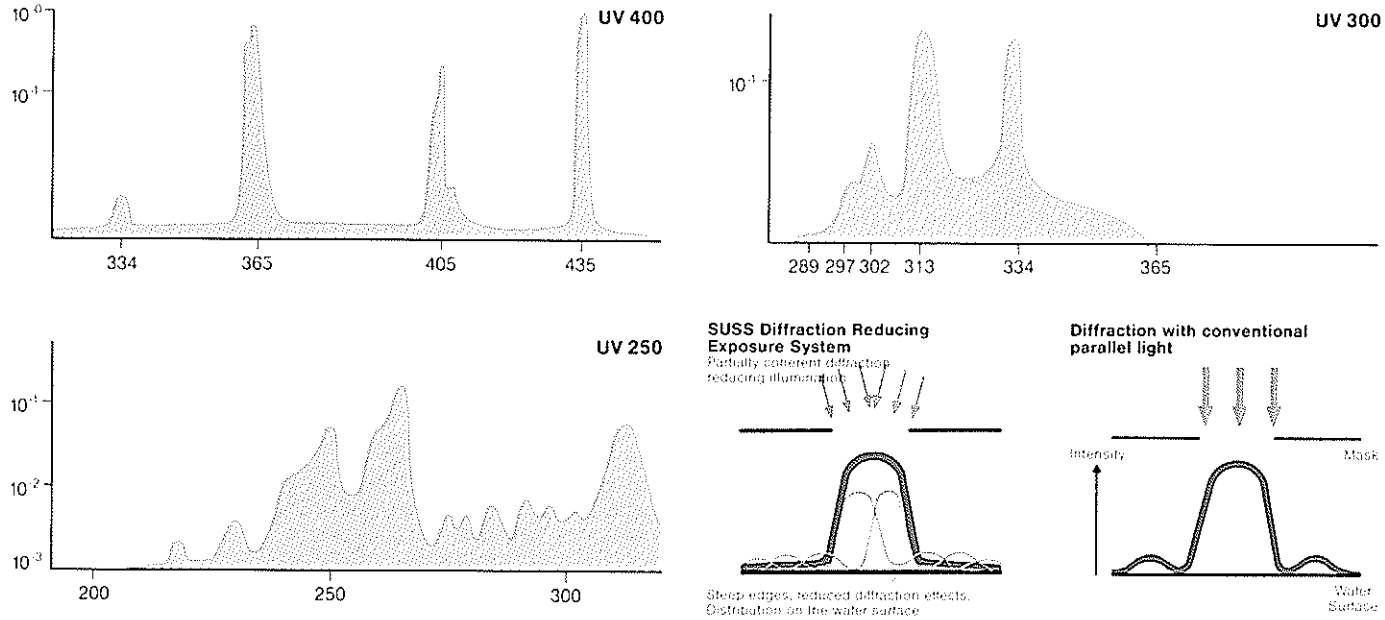
Simple Operator Instruction
Operation is quick to learn, the working sequence is automated. Operating elements are placed ergonomically. The plasma touch screen for control and programming safely guides the operator through the process. The SUSS MA 150 version can run fully automatically if the high prealignment accuracy is sufficient for the process.

Easy Change Over
All machines can rapidly be converted to different wafer or substrate sizes and processes.

Absolute Reliability
The system features high up-time as the basis for extraordinary production performance.

Easy Access to All Machine Elements
This results in a high level of servicing ease, backed by comprehensive application support.

Intensity distribution in the various spectral ranges



Wavelength scales are identical in all graphs;
intensity scaling varies, however. Therefore, the different spectral range intensities may not be directly compared.

Achievable resolution with the various spectral ranges and the effects of diffraction-reducing exposure systems

Resolution

The achievable resolution of exposed structures with a suitable photo resist in contact/proximity lithography is influenced primarily by:

- the exposure wavelength.
- The gap between mask and wafer during exposure, this gap being a function of wafer topography, cleanliness, exposure mode, and chuck design.

The SUSS MA 150 and SUSS MA 150 M are suitable for all contact and proximity exposure modes:

- Proximity. A preselected gap exists between mask and wafer.
- Soft Contact. A slight mechanical pressure is used to produce contact.
- Hard Contact. Mechanical and pneumatic pressure is applied to produce contact.
- Vacuum Contact. The contact between mask and wafer is optimized by evacuating the gap.

Proximity Mode. The resolution obtained depends on the distance between mask and substrate. While greater exposure distances provide longer mask life and lower defect rates, resolution is compromised. Reduced gaps yield shorter mask life, resolution is however improved.

Soft and Hard Contact provide resolutions of 1 - 2 μm under good wafer topography conditions.

Vacuum Contact allows considerably higher resolution than soft or hard contact, see table on p. 7.

If desired, the vacuum between mask and wafer can be regulated. However, process parameters such as photoresist thickness and uniformity are also decisive for highest resolution. Even under ideal conditions, line widths may only be achieved of the same order of magnitude as the wavelength of exposure illumination. It is therefore useful to employ the shorter wavelength regions of corresponding high-pressure lamps. The monochromatic illumination of an excimer laser is an ideal exposure source.

Further Considerations for Spectral Range Selection

Shorter exposure wavelengths are often desirable, not necessarily to achieve higher resolution, but instead to obtain greater process latitude. UV 300 is particularly attractive in this respect since it is compatible with conventional resists and glass or quartz masks. For example, a process developed using near UV (UV 400) may easily be refined by UV 300. For optimum flexibility, a SUSS MA 150 or SUSS MA 150 M with an excimer laser source may also be used with conventional lamps and corresponding exposure optics.

Diffraction-Reducing Exposure Systems

Diffraction effects at the edges of mask structures are proportional to the square root of wavelength and limit the achievable exposure resolution. Shorter wavelengths thus enhance the resolution.

However, diffraction effects may also be limited by diffraction-reducing exposure systems. KARL SUSS has developed such systems for the various spectral ranges and exposure processes. They are significant factor in the improvement of resolution. Therefore, every SUSS MA 150 and SUSS MA 150 M mask aligner contains a SUSS diffraction-reducing exposure system individually optimized for the particular spectral range and exposure process.

All components used in both the UV 400 and UV 300 exposure systems are made of herasil. Filter elements provide different spectral ranges with the same lamp.

UV 250 exposure systems, on the other hand, are made of suprasil, which is transparent to the deep UV radiation produced by suitable lamps. This exposure system may also be used with a lamp and associated filter elements for processes in the UV 400 or UV 300 regions.

Processing techniques in the UV 250 spectral region require a suitable photoresist: it is impossible to filter out all the intensity at longer wavelengths and simultaneously preserve sufficient intensity in the deep UV, (exposure times of a few minutes). Here, PMMA resist is frequently used, as it is sensitive only below 260 nm.

If a monochromatic light source such as an excimer laser is used, then the photoresist may be chosen on the basis of etch resistance or process latitude factors. Even in the deep UV, the laser's high intensity permits shorter exposure times. Equipment using an excimer laser incorporates a special suprasil diffraction-reducing exposure system. Either 193 nm (ArF) or 249 nm (Krf) can be selected as exposure wavelength.

Technical Data	SUSS MA 150	SUSS MA 150 M
Wafer Size	3" – 150 mm	Partial Wafers – 150 mm
Substrate Size	3" x 3" – 6" x 6"	Partial Substrates – 6" x 6"
Exposure Optics		
UV 400 350 – 450 nm	Hg-Lamp 350 W/1000 W	Hg-Lamp 350 W/1000 W
UV 300 280 – 350 nm	Hg-Lamp 350 W/1000 W	Hg-Lamp 350 W/1000 W
UV 250 240 – 260 nm	CdXe-Lamp 350 W	CdXe-Lamp 350 W
UV 249 249 nm	Excimer Laser	Excimer Laser
UV 193 193 nm	Excimer Laser	Excimer Laser
	10 W average Power at 193 nm	10 W average Power at 193 nm
	7.5 W average Power at 193 nm	7.5 W average Power at 193 nm
	Stabilized	stabilized
Uniformity (150 mm dia.)	± 5 %	± 5 %
Exposure Modes:		
Proximity:		
Alignment/Exposure Distance (selectable in 1 µm steps)	0 - 999 µm	0 - 999 µm
Soft Contact:		
Adjustable Contact Pressure	0.03 - 0.07 N/cm²	0.03 - 0.07 N/cm²
Hard Contact:		
Adjustable Contact Pressure between Chuck and Wafer via Nitrogen	0.04 - 0.16 N/cm²	0.04 - 0.16 N/cm²
Vacuum Contact:		
max. diameter	150 mm	150 mm
X-Y-Θ Stage:		
Alignment Range in X and Y	± 3 mm	± 5 mm
Alignment Range in Θ	± 3 degrees	± 5 degrees
Smallest Alignment Step in X and Y	0.1 µm	0.1 µm
Smallest Alignment Step in Θ	4.7×10^{-6} degrees	4.7×10^{-6} degrees
Max. Alignment Speed	0.4 mm/sec.	0.4 mm/sec.
Max. Mask Size	7" x 7"	7" x 7"
Microscope Manipulator:		
Movement Range in X	± 20 mm	± 20 mm
Movement Range in Y		
towards operator	15 mm (Option: 65 mm)	65 mm
away from operator	10 mm	10 mm
Rotation Range	± 4 degrees	± 4 degrees
Max. Microscope Speed	2.4 mm/sec	2.4 mm/sec
Microscope	M 206/M 236	M 206/M 236, M 204/M 234, M 400
Cassette System with Prealignment Station		
Maximum Wafer Size	150 mm	
Maximum Substrate Size	6" x 6"	
Cassettes	metal or plastic, adjustable	
Prealignment Accuracy (measured at the edge of a 150 mm wafer on the prealignment station)		
On the exposure chuck	± 15 µm	± 25 µm
Machine Time		
Machine Time without Alignment and Exposure	26 sec/Wafer	
Throughput incl. Alignment and 5 s Exposure Time	80 Wafers/Hour	60 Wafers/Hour
Utilities		
Vacuum	< – 0.8 bar (200 mbar)	< – 0.8 bar (200 mbar)
Compressed Air	5 - 7 bar, 1 m³/h	5 - 7 bar, 1 m³/h
Nitrogen	2 - 3 bar, 0.5 m³/h	2 - 3 bar, 0.5m³/h
Power Requirements	1200 VA with 350 W Lamp	1200 VA with 350 W Lamp
	2000 VA with 1000 W Lamp	2000 VA with 1000 W Lamp
Dimensions		
Height x Width x Depth	1680 x 1210 x 1180 mm	1680 x 1210 x 1180 mm
Weight	approx. 500 kg	approx. 500 kg

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