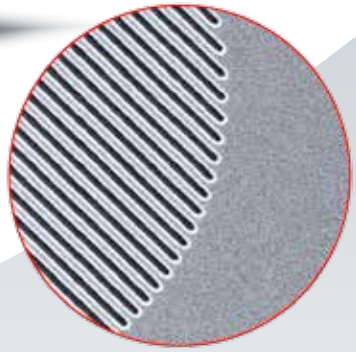
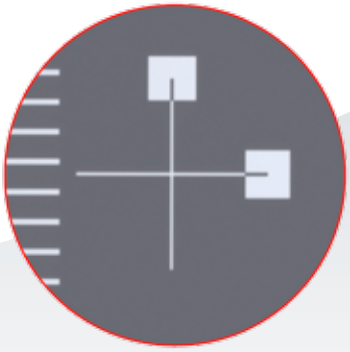
HEIDELBERG INSTRUMENTS

ULTRA

The Semiconductor Laser Mask Writer





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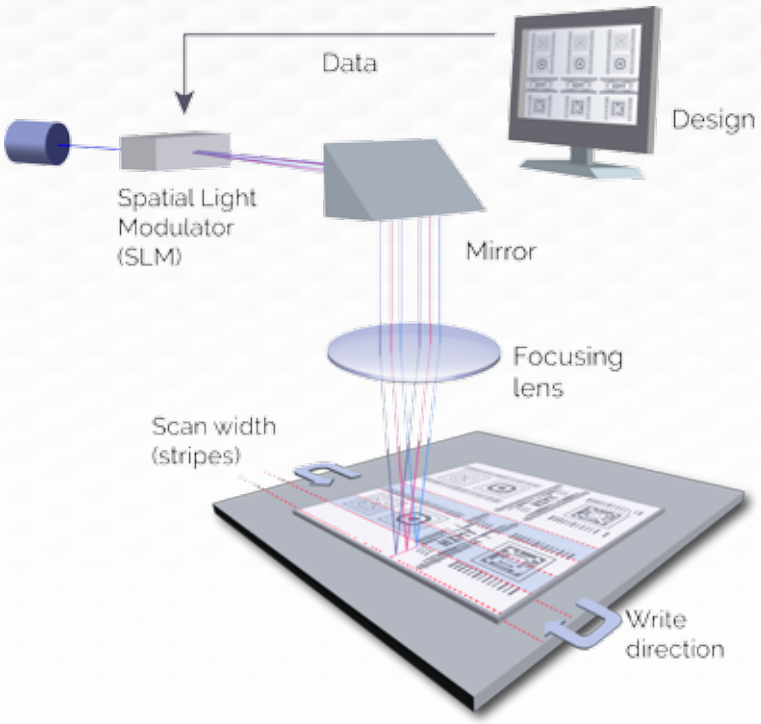
ULTRA
THE SEMICONDUCTOR MASK WRITER

The ULTRA technology has evolved from our well-established line of Volume Pattern Generators and is designed and optimized specifically for the production of semiconductor photomasks in the 180 nm design node.

Key characteristics of the ULTRA are its speed, the advanced data path, high precision, and structure uniformity, as well as the sophisticated, extremely accurate alignment features.

The ULTRA represents an economical solution with low cost of ownership. With its modern, compact build, it is easily incorporated into an existing mask shop infrastructure.



HIGH THROUGHPUT

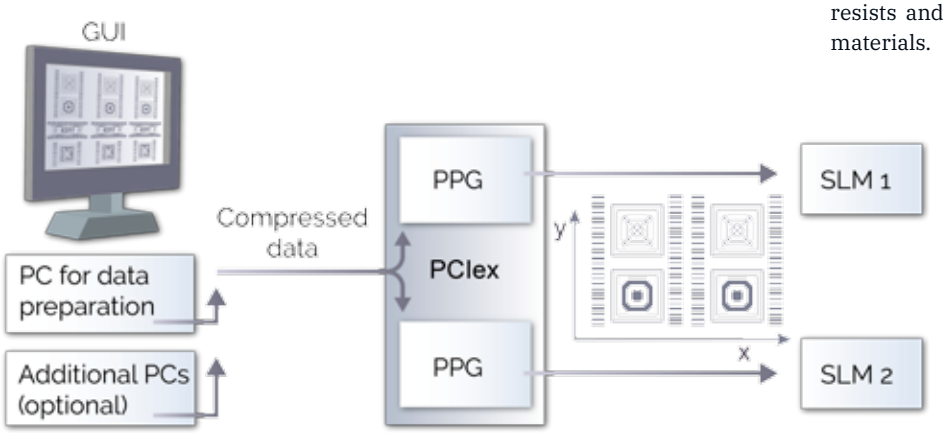
For maximum throughput and image quality, the system features two powerful high-speed Spatial Light Modulators (SLM) set up in a finely tuned physical arrangement.

The ULTRA's high-speed data path is designed to handle even complex geometries and dense patterns while upholding high exposure speeds. The stage is equipped with linear motors and air bearings, ensuring smooth travel even at top speed and large accelerations.

The ULTRA provides two speed modes: The quality mode QX reaches a write speed of 325 mm² per minute while at the same time achieving exposure results with maximum accuracy. If requirements on resolution and quality are not quite as high and the focus is on speed, the fast FX-mode allows a write speed of up to 580 mm² per minute. Typical write times for a 6″ x 6″ mask are 45 minutes in FX-mode and 75 minutes in QX-mode.

CD UNIFORMITY

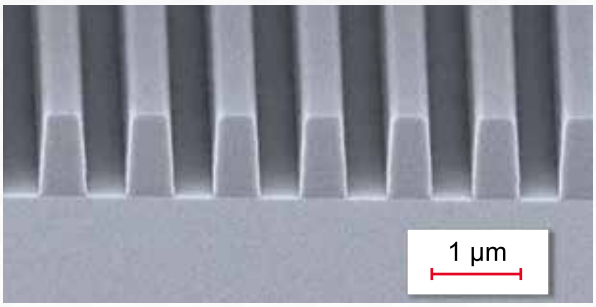
The ULTRA provides a CD uniformity of 30 nm. The intensity distribution of each SLM is automatically calibrated with a 2% precision. Focus control is achieved by an optical autofocus which operates through the main write lens, providing instant correction of focus at the location of writing and high sensitivity. A custom-designed objective with an NA of 0.9 and an address grid of 5 nm further contribute to structure uniformity and precision of edges. The entire optical path is optimized for 355 nm, allowing the use of all i-line resists and associated processes and materials.



High-speed data path

MINIMUM FEATURE SIZE

A custom-designed and integrated write lens with high NA enables the ULTRA to expose structure sizes of down to 500 nm. In fact, any aberrations are smaller than the airy disc, that is, the performance of the objective is purely diffraction-limited.

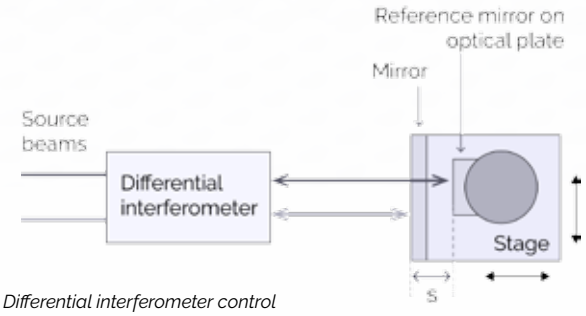


500 nm lines and spaces

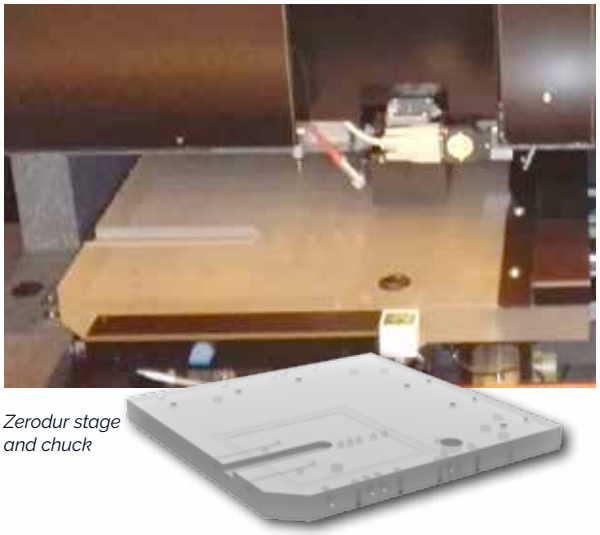
Image courtesy of IMS Chips

OVERLAY

A differential interferometer with 1.2 nm resolution controls stage motion for maximum precision and overlay accuracy. The ULTRA flowbox maintains a stable temperature to within ±0.02 K. Crucially, the stage and chuck are made of ZerodurTM which exhibits zero temperature expansion. All these factors, along with the beam stabilization, result in an overlay of 30 nm.



Differential interferometer control



Zerodur stage and chuck

2ND LAYER ALIGNMENT

The ULTRA's custom-designed write lens is optimized and corrected not only for 355 nm, but also for 640 nm, the illumination wavelength used by the camera to locate and detect alignment markers. Minimal optical aberration during image acquisition means that the camera image exhibits maximum dimensional consistency. This facilitates the 2nd layer alignment value of 100 nm.

Precise 2nd layer alignment, which is crucial in the production of phase shift masks (PSM), is achieved by a sophisticated algorithm that measures and compensates first layer distortions or irregularities: The complex matrix corrects for pattern deviations between adjoining design fields while at the same time, linear distortion correction extrapolates within the fields to compensate for x- and y-scale errors as well as rotation, translation, and orthogonality errors. All corrections and compensations are carried out at full exposure throughput which decreases write time to at least half the amount required by the conventional stepper correction process.

COST EFFECTIVENESS

The ULTRA is equipped with a 355 nm DPSS ultraviolet laser source which is qualified for typical semiconductor photoresists. With its excellent TEM_{00} mode quality, long-term performance, and low running cost it is the perfect light source for a 24/7 precision manufacturing tool. In comparison to gas lasers (such as Kr^+ and Ar^+), the DPSS laser reduces the costs by up to 80%, taking into account electricity for laser and cooler as well as the cost for refurbishment or replacement. The DPSS UV laser is very reliable with 20,000 hours of guaranteed lifetime. An exchange of the laser is typically required every 2 to 3 years and it takes no more than two days to complete the exchange. All in all this amounts to a significantly maximized equipment uptime.

ULTRA
SYSTEM SPECIFICATIONS

	QX mode	FX mode
Writing performance		
Address grid [nm]	5	10
Line edge roughness [3σ, nm]	20	40
Position accuracy [3σ, nm]	40	100
Overlay [3σ, nm]	30	60
Stitching [3σ, nm]	20	60
2nd layer alignment [3σ, nm]	100	100
CD uniformity [3σ, nm]	30	60
Minimum feature size [nm]	500	700
Write speed [mm^2 / min]	325	580
Write time for 6″ x 6″ [min]	75	45
Operation		
Protocols, standards	SECS / GEM protocols	
User interface (software)	SEMI-compliant GUI	
Maximum write area	228 x 228 mm^2	
Substrate size	4″, 5″, 6″, 7″, and 9″ masks	
System features		
Optics	• 0.9 NA objective lens • Low-distortion UV optics • Automatic calibration routines	
Laser	• 355 nm high-power solid state laser • Highly economical compared to gas laser	
Focus system	• Real-time optical autofocus	
Alignment	• Camera system • Distortion compensation • Field-by-field alignment	
Data path	• Real-time compression • Scalable hardware concept • Input formats: All standard formats, e.g. GDSII and Jobdeck	
Spatial Light Modulator	• Frequency 350 kHz • Data rate 2.4 GB/s	
Loader	• Automatic mask loader with two independent carrier stations	

Please note: Specifications depend on individual process conditions and may vary according to equipment configuration. Write speed depends on exposure area. Design and specifications are subject to change without prior notice.

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HEIDELBERG INSTRUMENTS
The power of direct writing

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