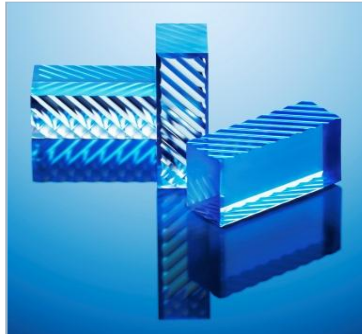
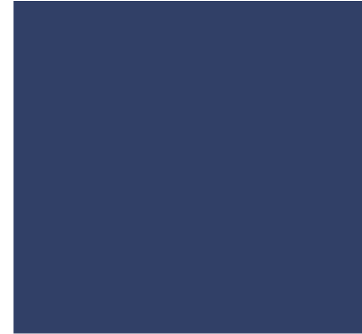
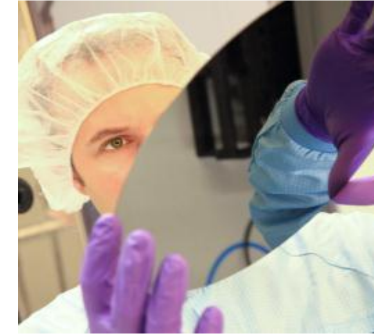






ADVANCED MASK ALIGNER LITHOGRAPHY (AMALITH)

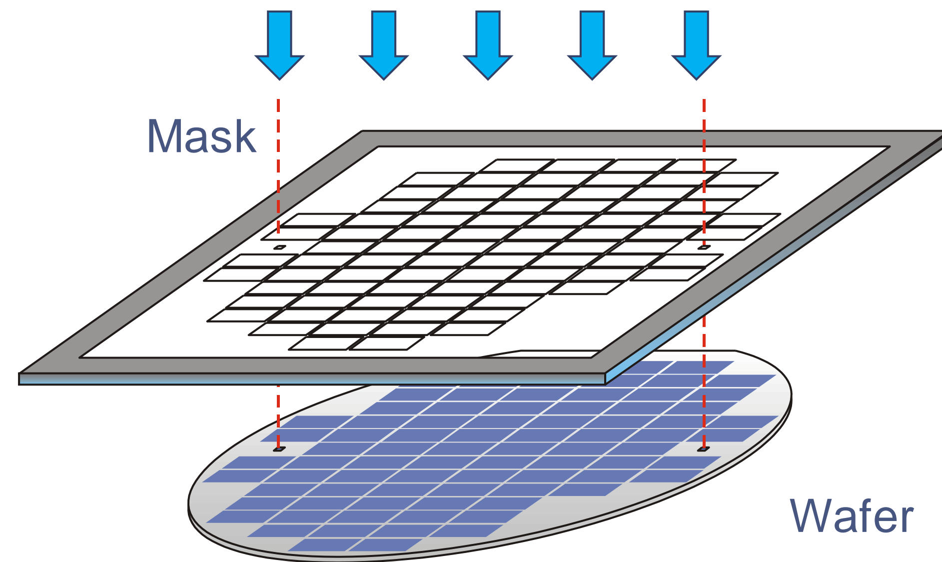
Photolithography Enhancement for SUSS Mask Aligners

SÜSS MicroTec AG, www.suss.com

SUSS MicroOptics SA, www.suss.ch, info@suss.ch

„Shadow Printing“ Lithography

- Mask illumination using collimated UV light
- Resolution ⇔ proximity gap

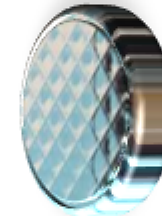


SÜSS MicroTec

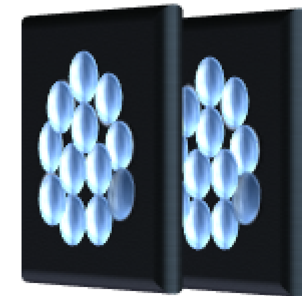
MO EXPOSURE OPTICS®

The new Illumination System for all SUSS Mask Aligners

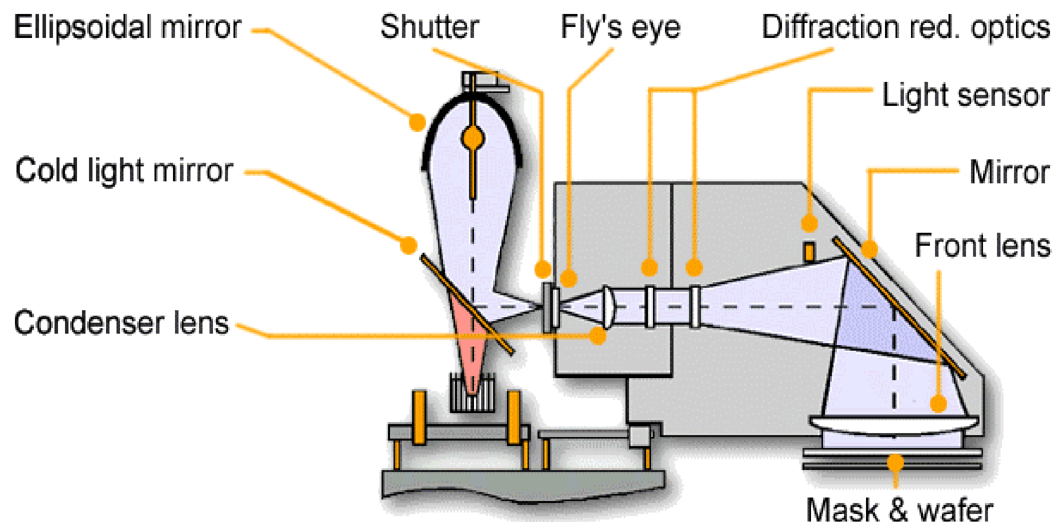
- Lamp readjustment required
- Uniformity change over lamp lifetime
- Daily uniformity test required
- Variation of illumination light over mask (angular spectrum)



"Fly's Eye"



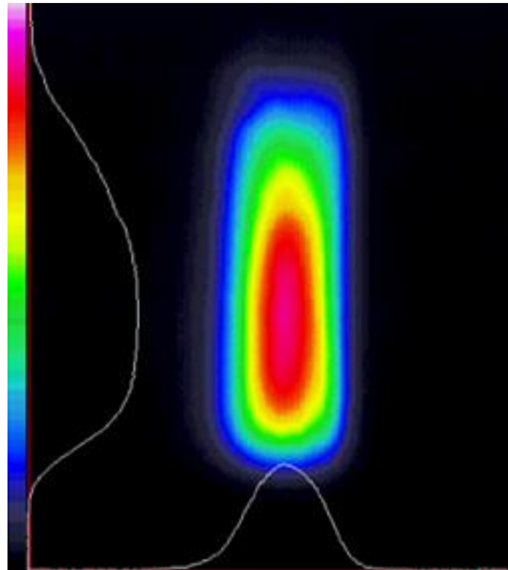
HR or LGO Lens Plates



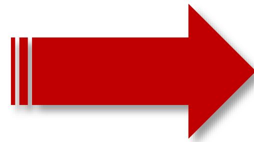
Forgot to control light uniformity this morning.

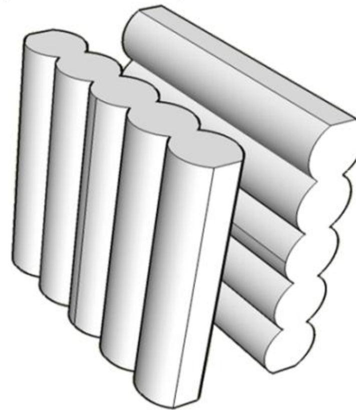
- SUSS MicroTec confidential -

KEY COMPONENTS: MICROLENS OPTICAL INTEGRATORS

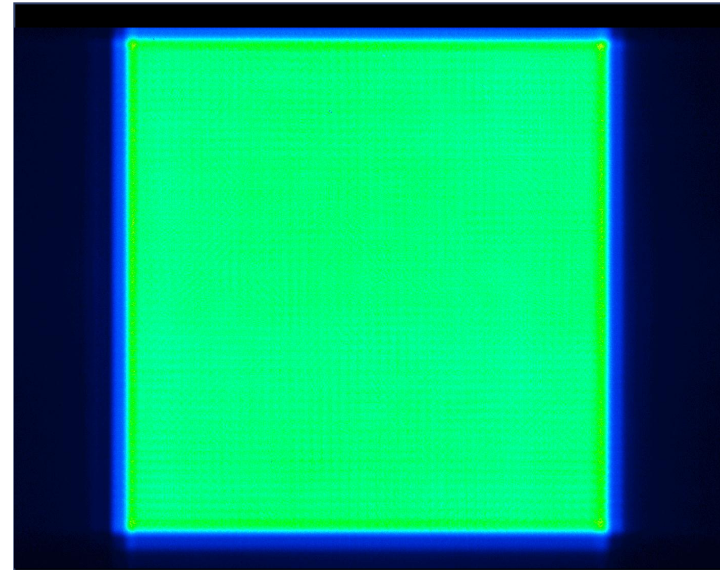


Light Source





Microlens Optical Integrator



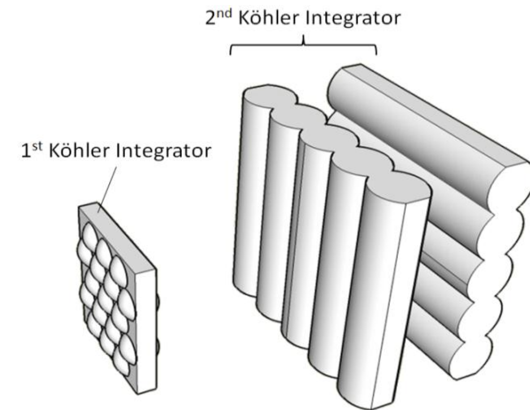
Flat-Top Illumination

SÜSS MicroOptics

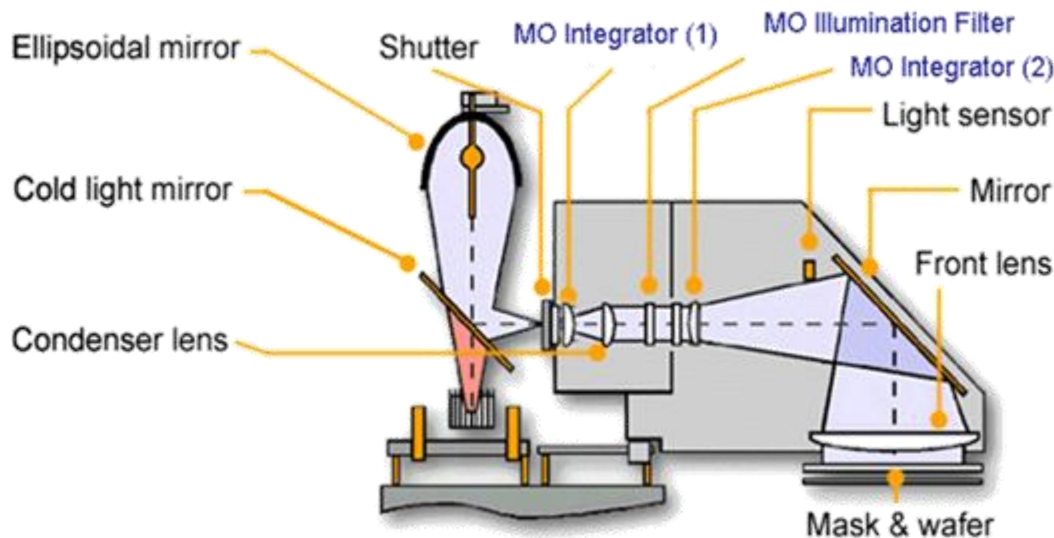
- SUSS MicroTec confidential -

SÜSS MicroTec

- **NO** Lamp readjustment required
- **NO** Uniformity change over lamp lifetime
- **NO** Daily uniformity test required
- **NO** Variation of illumination light over mask (angular spectrum)



Microlens Optical Integrators

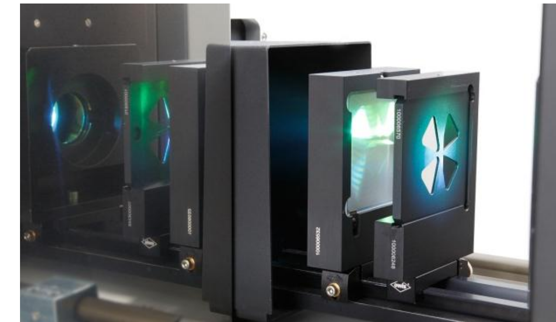


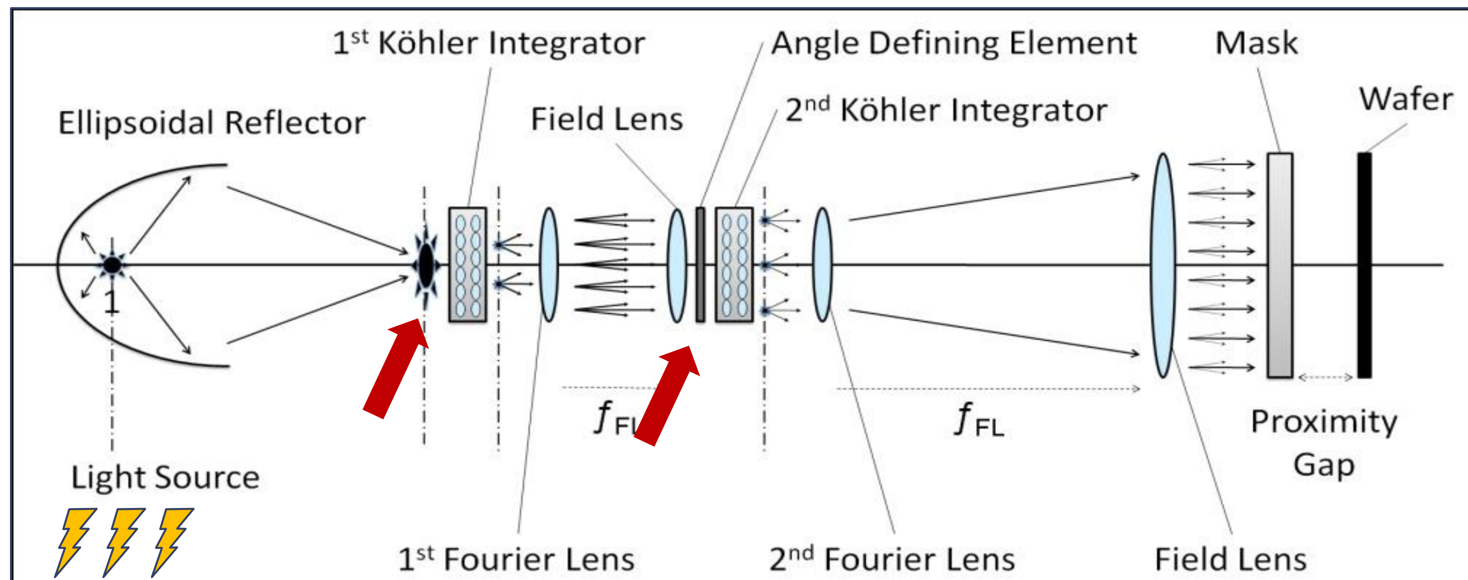
SÜSS MicroOptics

- SUSS MicroTec confidential -

MO EXPOSURE OPTICS®

- 2x Microlens Optical Integrators in the Mask Aligner illumination system
- Light homogenization in both Fourier planes
- Self calibrating light source
- Illumination filter plate (IFP)

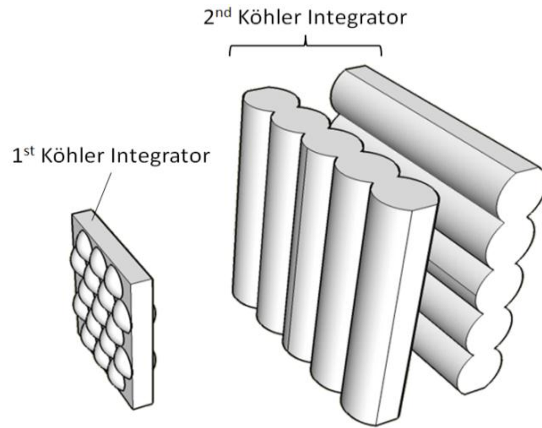




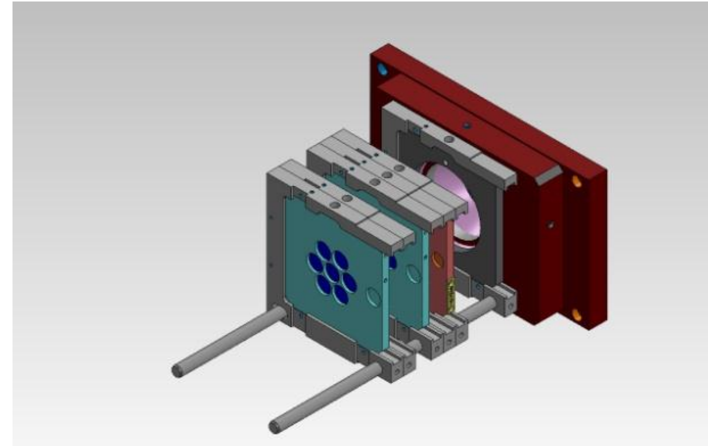
- SUSS MicroTec confidential -

MO EXPOSURE OPTICS® : QUICK INSTALLATION

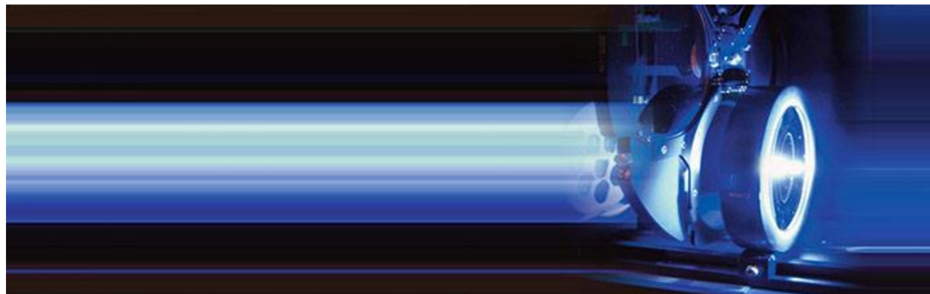
SÜSS MicroTec



Microlens Optical Integrators



Quick Installation in Mask Aligner



SÜSS MicroOptics

- SUSS MicroTec confidential -

SELF CALIBRATING LIGHT SOURCE – SAFES TIME & MONEY

SUSS MicroTec

- **Conventional Mask Aligner in Production**
  - Daily light measurement (9 or 12 points uniformity)
    - ⇨ 5 min x 365 day ~ 30 hours per year
  - 12x lamp exchange per year
    - ⇨ 30 min x 10 ~ 6 hours per year
    - ⇨ 36 hours less productive time & labor costs per year

- **MO Exposure Optics®**
  - No uniformity measurements, no lamp alignment!
  - Improved uniformity, telecentric illumination
  - CD uniformity improvement = Yield!
  - Process stability assurance = Yield!
  - Convenience!

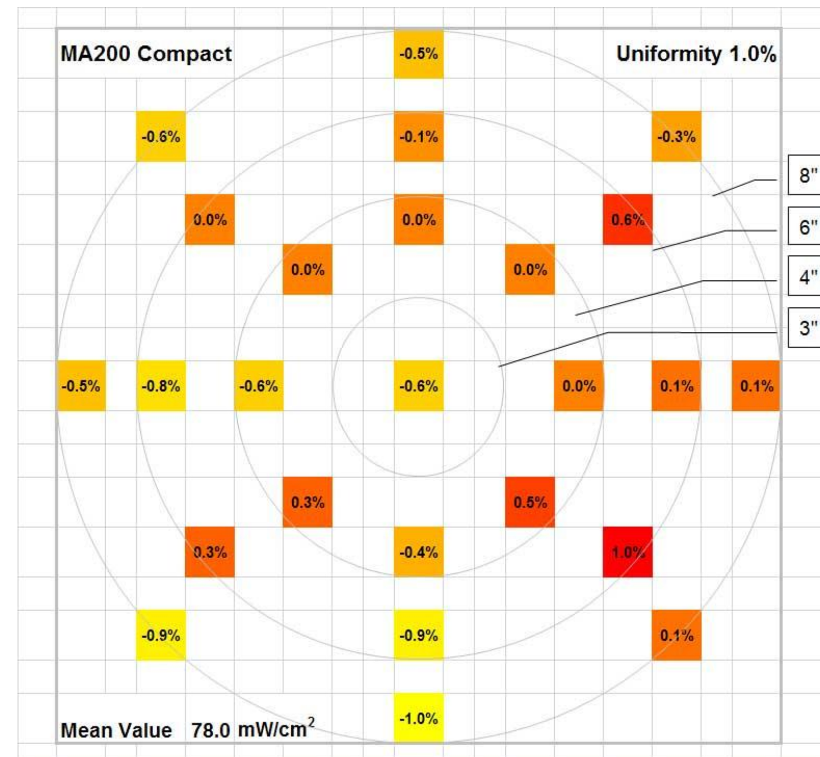
Forgot to control light uniformity this morning.

- SUSS MicroTec confidential -

BETTER UNIFORMITY – INDEPENDENT OF LAMP POSITION

SÜSS MicroTec

- Excellent light uniformity
- No lamp misalignment
- No uniformity change due to degradation of lamp electrode during lifetime cycle



Deviation from mean value in [%] for Ø200mm in MA200 Compact

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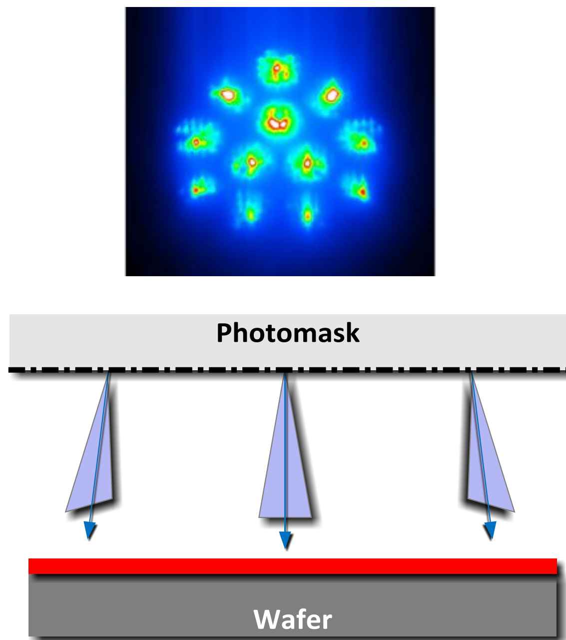
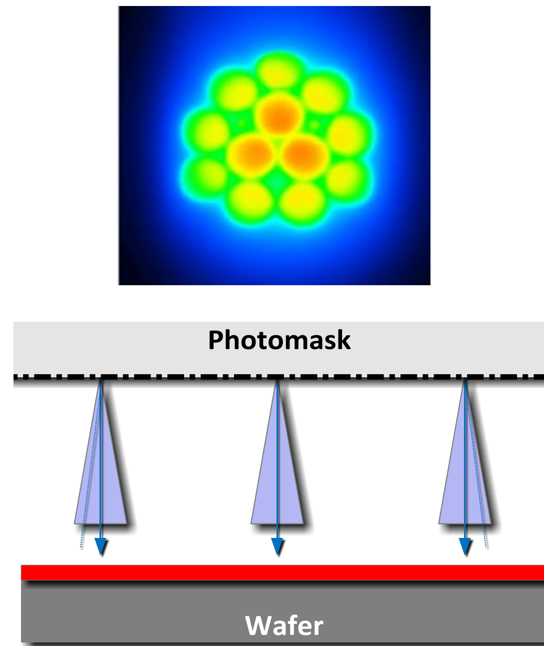
SÜSS MicroTec

Conventional



MO Exposure Optics®



Angular spectrum illumination light

Near-field light distribution behind photomask

Uniform angular distribution over the entire mask plane

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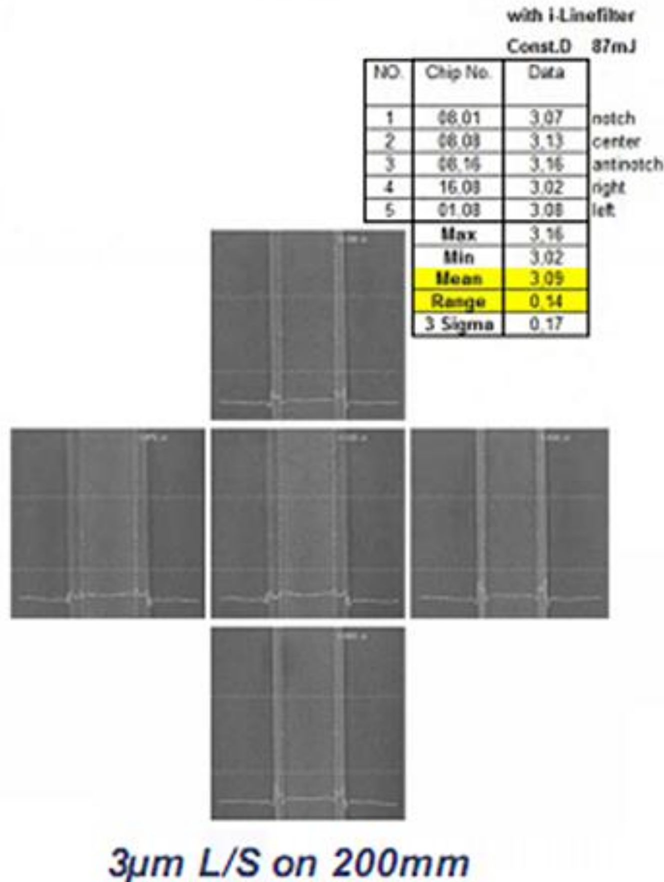


with i-Linefilter

Const.D 87mJ

NO.	Chip No.	Data	
1	08.01	3.07	notch
2	08.08	3.13	center
3	08.16	3.16	antinotch
4	16.08	3.02	right
5	01.08	3.08	left
	Max	3.16	
	Min	3.02	
	Mean	3.09	
	Range	0.14	
	3 Sigma	0.17	

3µm L/S on 200mm

850W

CD

	Front	Center	Back	Right	Left	Range	3sig	MW	min	max	%+	%-	Dosis
1	3,07	3,13	3,16	3,02	3,08	0,00	0,17	3,09	3,0	3,2	2,5	-2,2	87mJ
2	3,06	3,15	3,19	3,08	3,09	0,14	0,17	3,12	3,1	3,2	1,8	-2,5	87mJ
3	3,09	3,06	3,14	3,14	3,07	0,13	0,12	3,10	3,1	3,1	1,3	-1,4	87mJ
4	3,12	3,10	3,17	3,10	3,12	0,08	0,09	3,12	3,1	3,2	0,8	-1,6	87mJ
5	3,19	3,20	3,27	3,17	3,14	0,08	0,14	3,20	3,1	3,3	1,8	-2,3	87mJ
6	3,08	3,06	3,14	3,13	3,02	0,13	0,15	3,09	3,0	3,1	2,2	-1,7	87mJ
7	3,20	3,15	3,21	3,20	3,18	0,12	0,08	3,19	3,2	3,2	1,3	-0,7	87mJ
8	3,22	3,11	3,23	3,19	3,13	0,11	0,15	3,18	3,1	3,2	2,0	-1,5	87mJ
MW	3,13	3,12	3,19	3,13	3,10	0,14	0,10	3,13					
3sigm	0,20	0,14	0,13	0,19	0,15	0,14	0,11	0,14					
							3,1	1,5	%+				
							3,2	-1,9	%-				

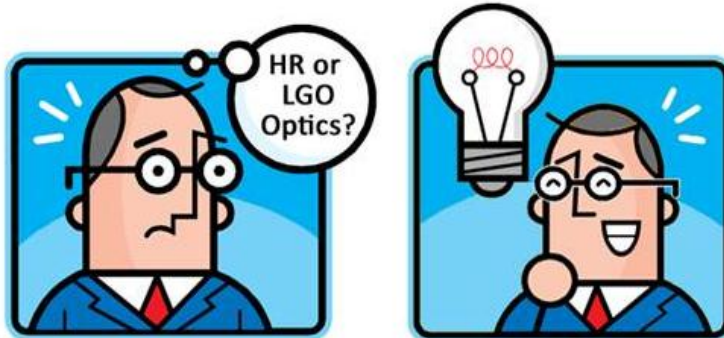
MA200 Compact

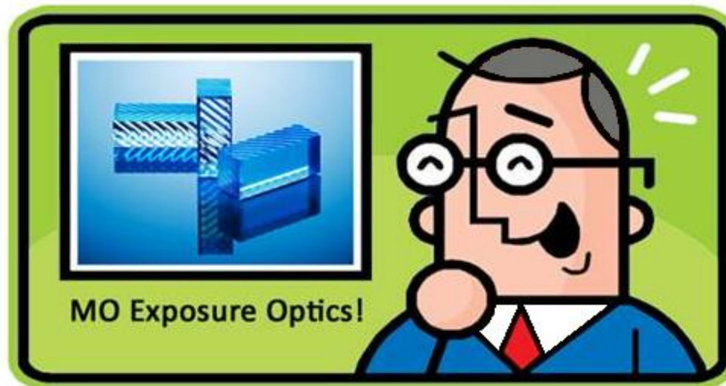
MOE (200mm production line in semiconductor fab)

- 3µm lines
- 30µm proximity gap
- i-line illumination (MO Exposure Optics®)
- Resist IX335, 1.5µm thick
- 0.17µm variation (3 Sigma)

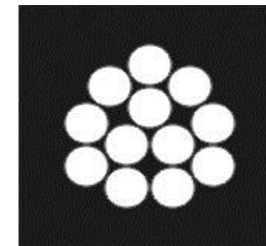
- SUSS MicroTec confidential -

SÜSS MicroTec

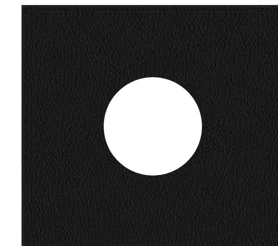




Changeover from HR-Optics to LGO-Optics in less than 5 minutes!



IFP-HR
„High Resolution“



IFP-LGO
„Large Gap“

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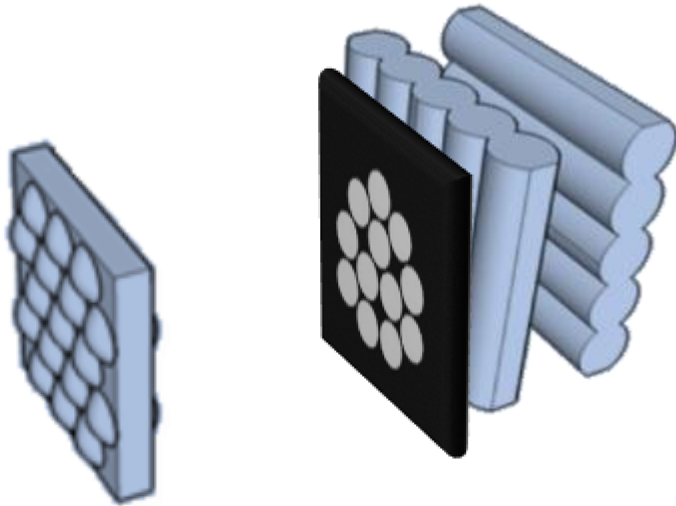
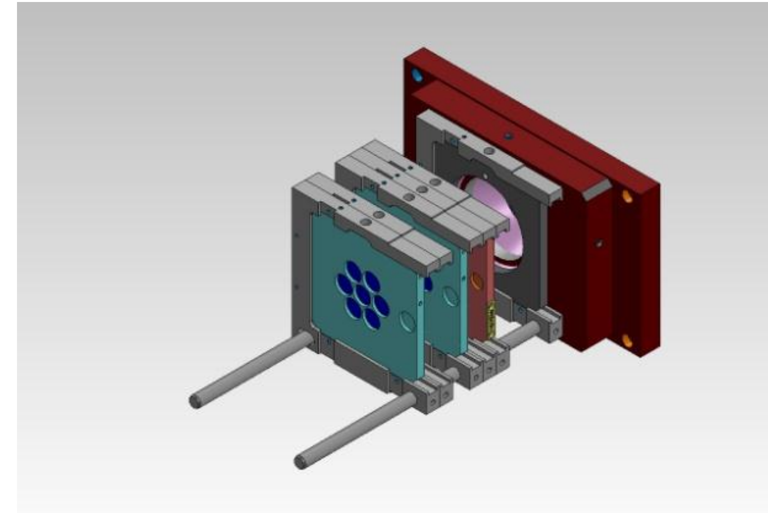
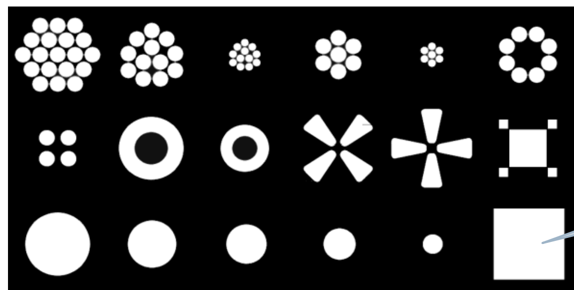
ILLUMINATION FILTER PLATES (IFP)





IFP HR



Pupil Fill Ratio (PFR) 130%

IFP " More Light"

SÜSS MicroOptics

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MO EXPOSURE OPTICS®

SÜSS MicroTec

- Self calibrating light source - no periodic uniformity measurement
- Easy lamp change without lamp adjustment
- Improved uniformity, telecentric illumination
- Very convenient – higher yield!

- One optics set for both Contact and Proximity Lithography
- Advanced Mask Aligner Lithography (AMALITH)

- SUSS MicroTec confidential -

ARE YOU STILL USING THE **CONVENTIONAL** MASK ALIGNER ILLUMINATION SYSTEM?

WE WOULD LIKE TO VISIT YOU TO SHOW YOU OUR NEW **SELF CALIBRATING** MO EXPOSURE OPTICS®!

"We love our MO Exposure Optics. It's so convenient!"

- SUSS MicroTec confidential -

ADVANCED MASK ALIGNER LITHOGRAPHY (AMALITH)

Pushing the limits!

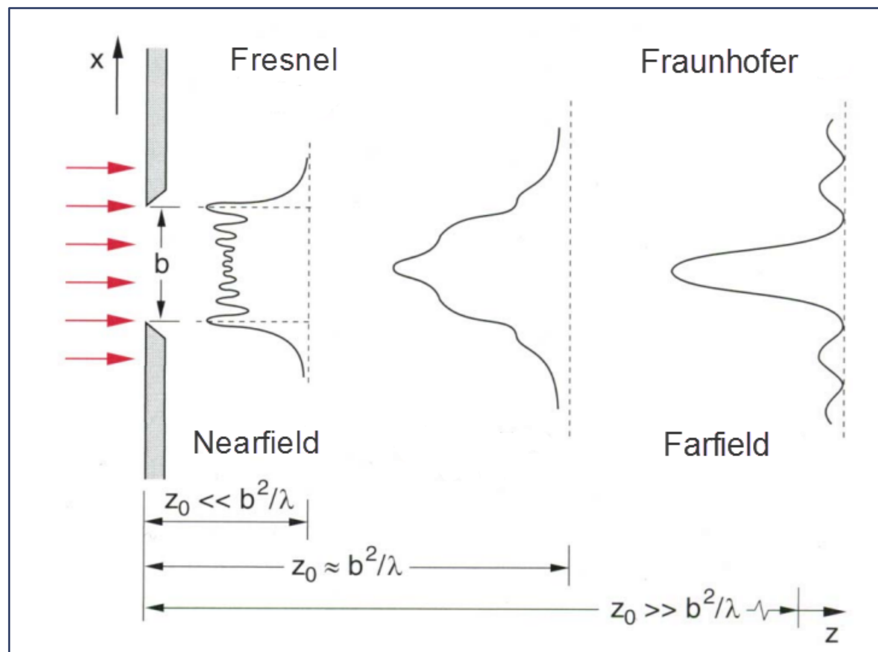
PHOTOLITHOGRAPHY ENHANCEMENT IN FRONT-END-OF-LINE WAFER STEPPERS

- Customized Illumination
  - Reduce diffraction effects (apodization)
- Optical Proximity Correction (OPC)
  - Improve critical resist structures
- Source Mask Optimization (SMO)
  - Customized Illumination and OPC
- Alternating Aperture Phase Shift Mask (AAPSM)
- ...

www.asml.com

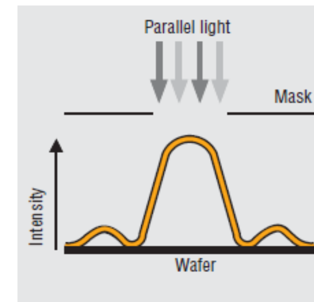
SHADOW PRINTING LITHOGRAPHY

- Diffraction effects
- Proximity artifacts
- Sidelobes

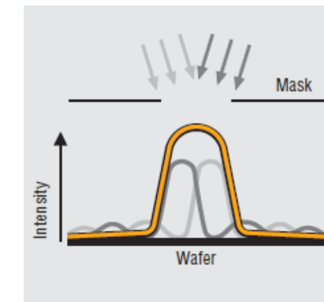


Parallel Light

Diffuse Light



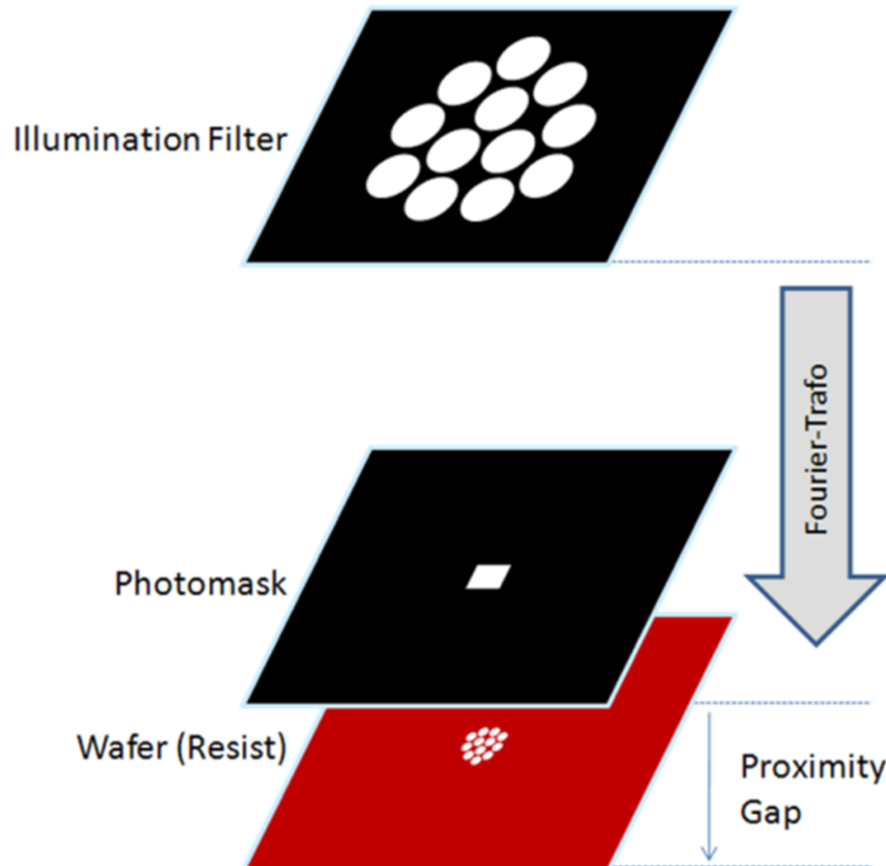
Parallel Light (sidelobes)

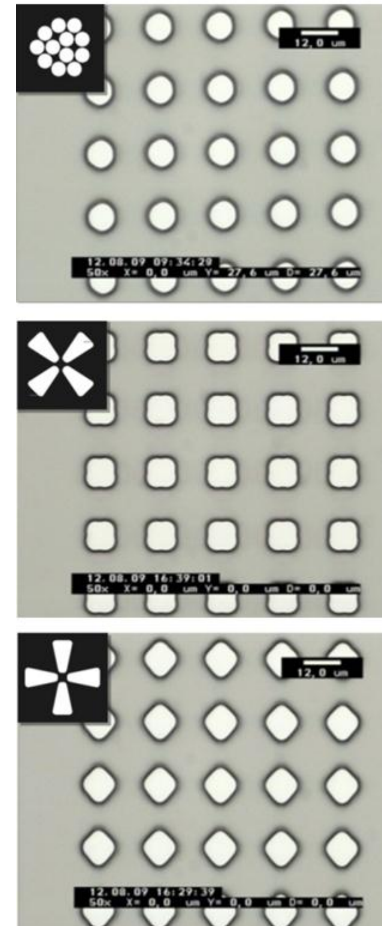


Apodization

SHADOW PRINTING – CAMERA OBSCURA

SÜSS MicroTec





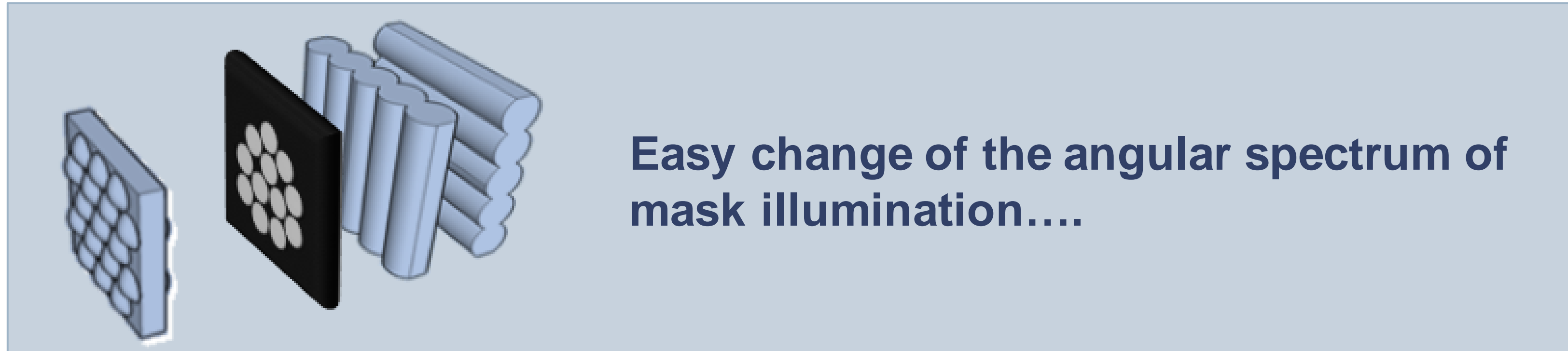
Fraunhofer IOF
SÜSS MicroOptics

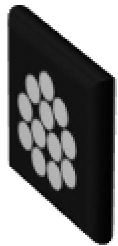
Graph: Lorenz Stürzebecher, FhG-IOF

SUSS MicroTec confidential

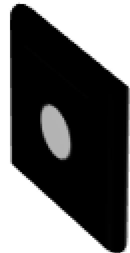
CUSTOMIZED ILLUMINATION IN THE MASK ALIGNER

SÜSS MicroTec

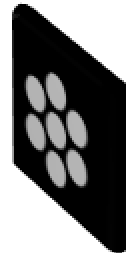




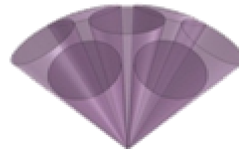
SUSS HR Optics

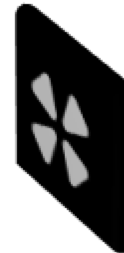


Large Gap

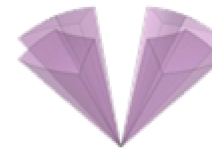


SUSS D Optics

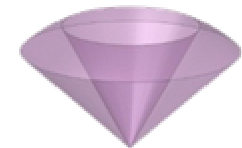




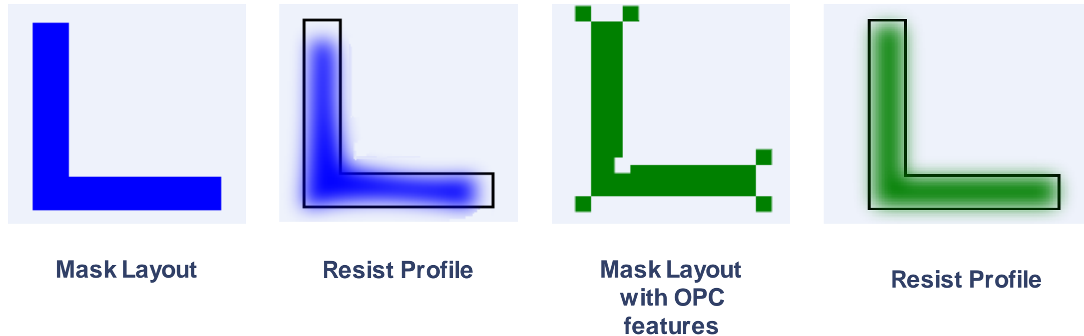
Quadrupole

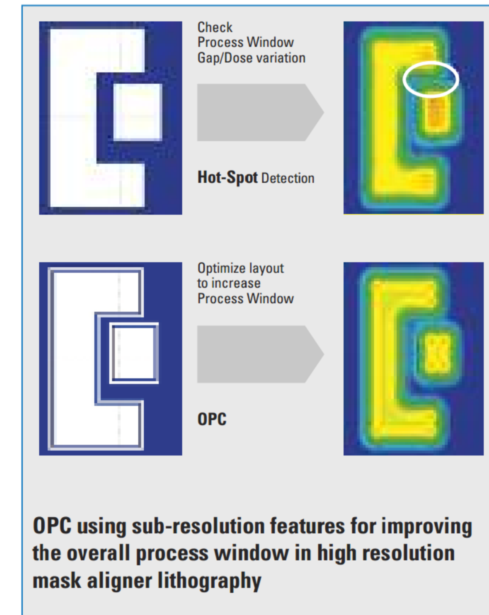


Ring



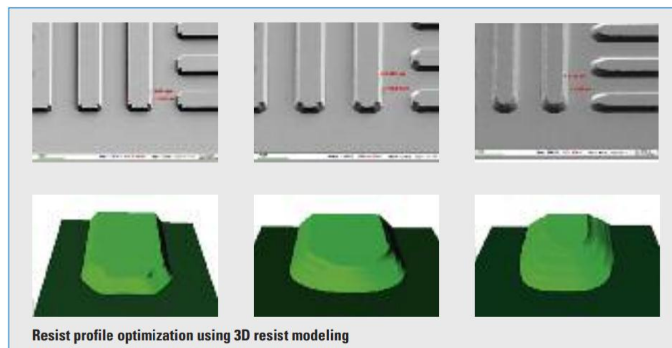
+ Optimization of the mask pattern (Optical Proximity Correction, OPC)





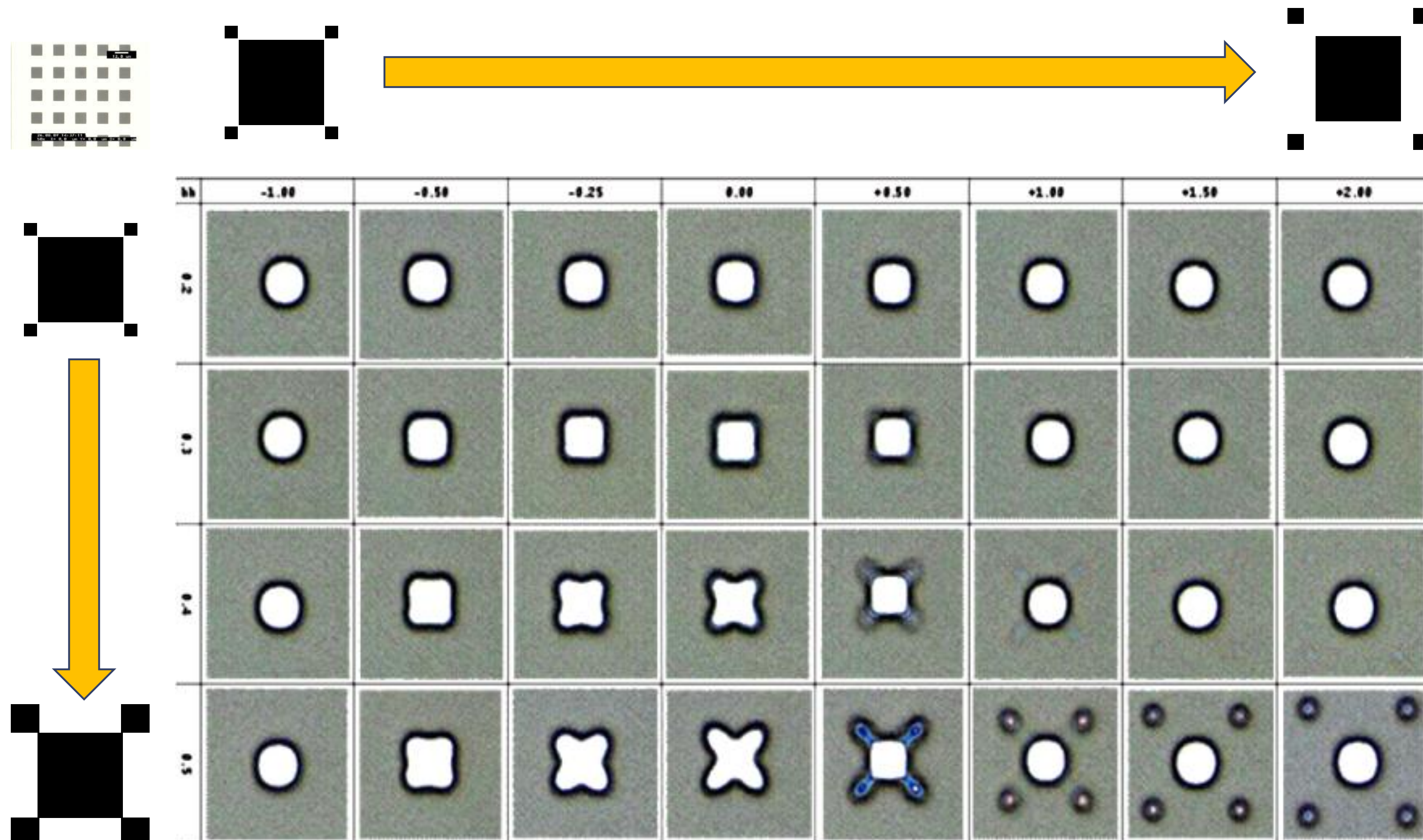
OPC using sub-resolution features for improving the overall process window in high resolution mask aligner lithography

+ Full simulation of litho process by using LayoutLAB™ software from GenISys



Resist profile optimization using 3D resist modeling

Fraunhofer IISB GenISys SÜSS MicroOptics



Square 10µm x 10µm, Proximity Gap 50µm, Photoresist AZ4110, 1.2um thick

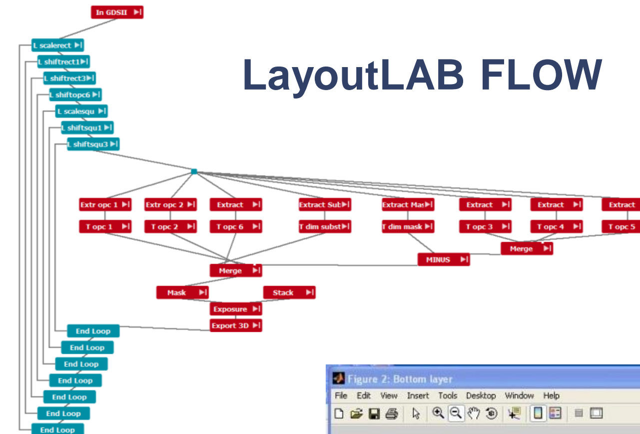
SÜSS MicroOptics

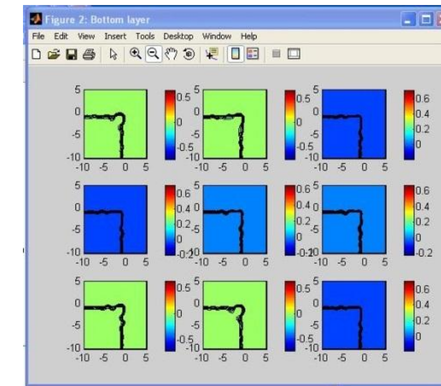
OPC FOR CORNERS OPTIMIZATION

PROCEDURE

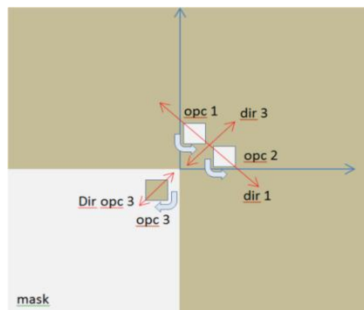
- Iterative simulations of different OPC mask layers
- Export of the aerial image for the different simulated settings (optimized for 30, 50 and 100 µm exposure gaps)
- Matlab data elaboration
- LayoutLAB resist (calibrated) simulation for the resulting best profiles

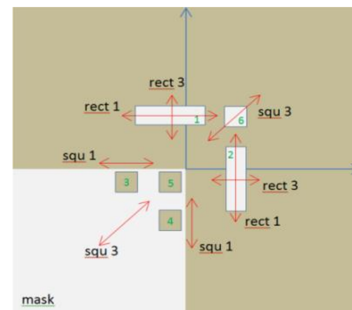
LayoutLAB FLOW

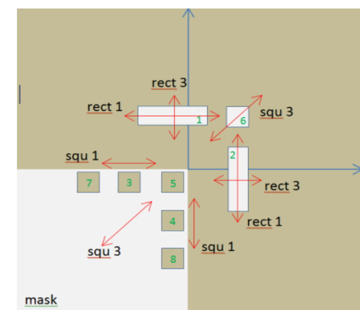




MASK LAYOUTS







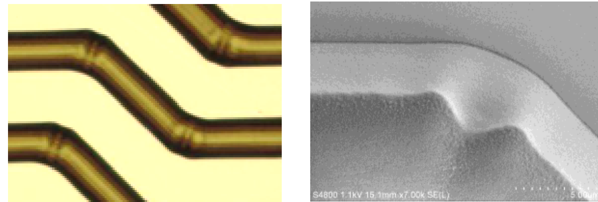
GenISys GmbH

SÜSS MicroOptics

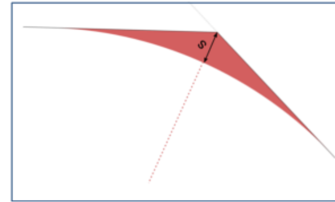
- SUSS MicroTec confidential -

INDUSTRY EXAMPLE: REDUCTION OF PROXIMITY ARTIFACTS BY SMO

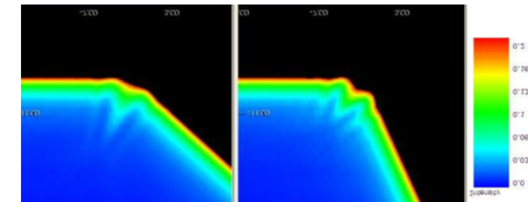
SUSS MicroTec



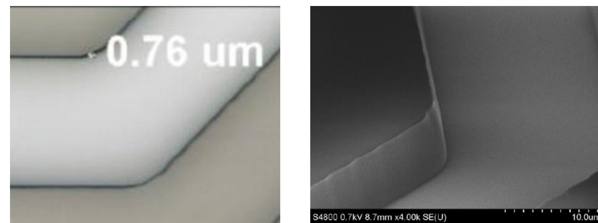
Proximity artifacts in redistribution lanes: Deformations in lane edges.



Fillet reduces erosion

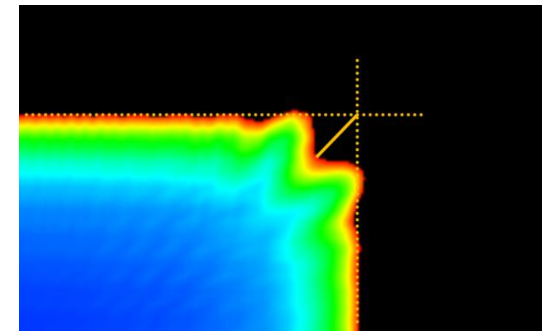


Simulation LayoutLAB software



Corrected: 30µm Exp Gap, SB 90°C, 300sec, 650mJ in MA200 Compact with MO Exposure Optics

Source Mask Optimization (SMO)

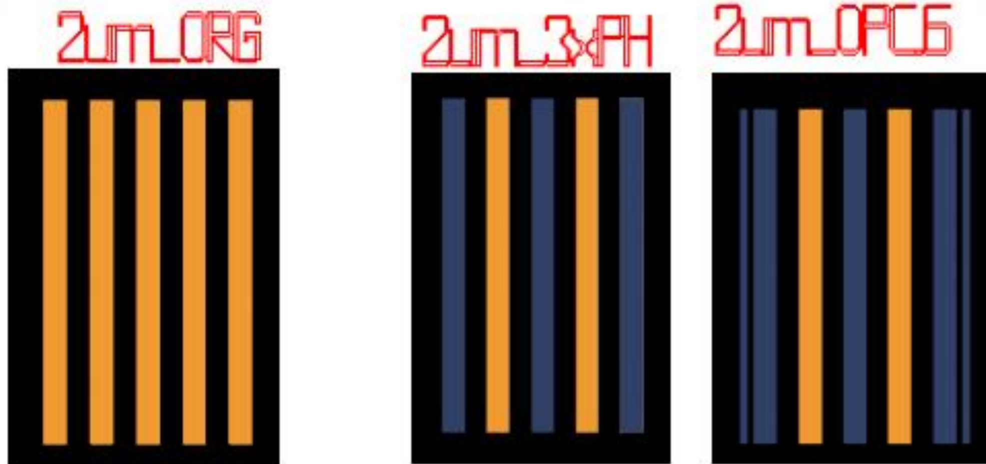


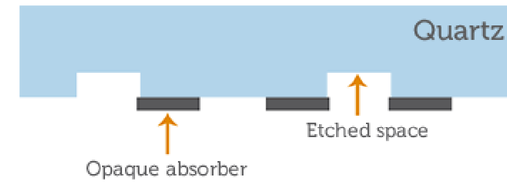
Proximity artifact: Deformation (protrusion) due to diffraction effects (simulation in LayoutLAB)

- Simulation enables significant process improvements
- Customer purchased five MA200 Compact Mask Aligners equipped with MO Exposure Optics®

GenISys

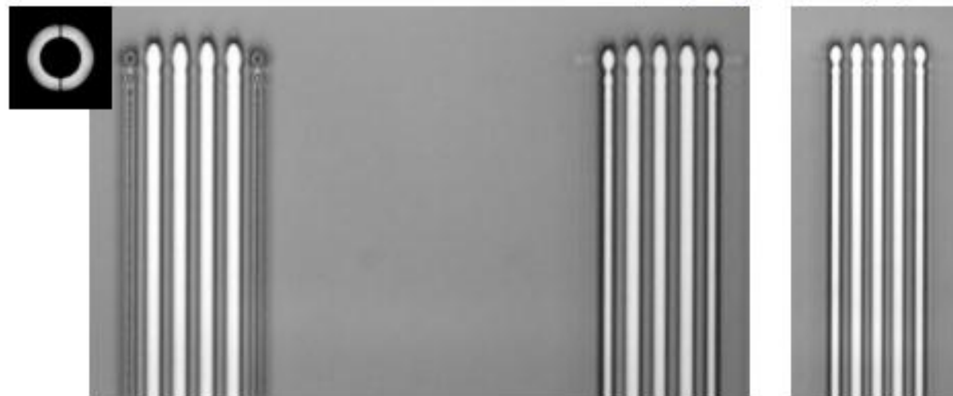
L&S 2 µm IN MASK ALIGNER AT 30 µm PROXIMITY GAP





Alternating Aperture Phase Shift Mask (AAPSM)

Broadband, Big ring IFP, 12s [57]



TOPPAN
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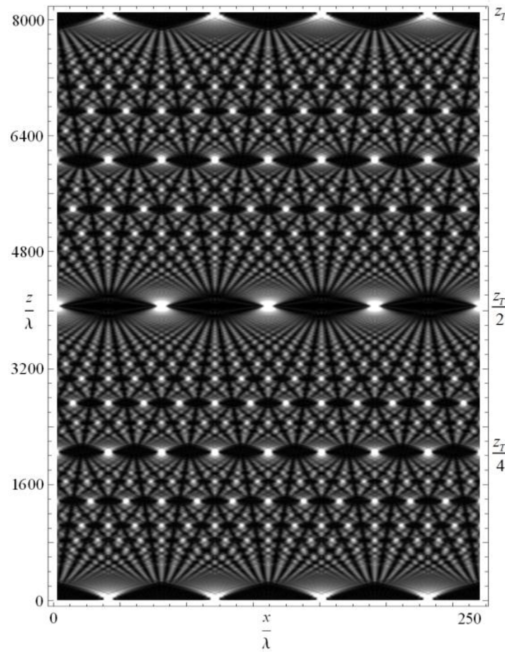
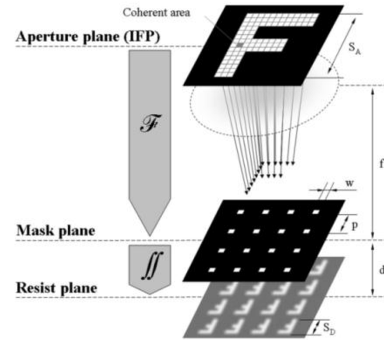
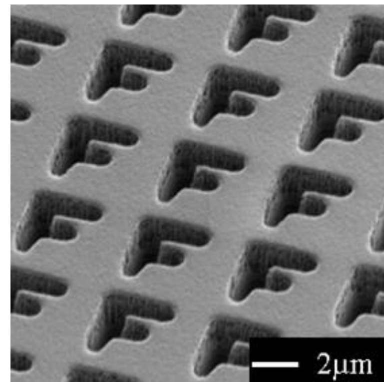
AMALITH: PINHOLE TALBOT LITHOGRAPHY

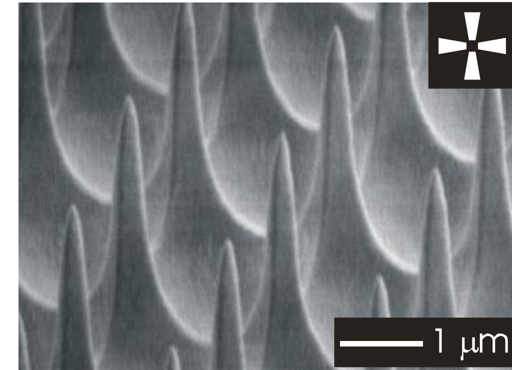


Talbot Lithography

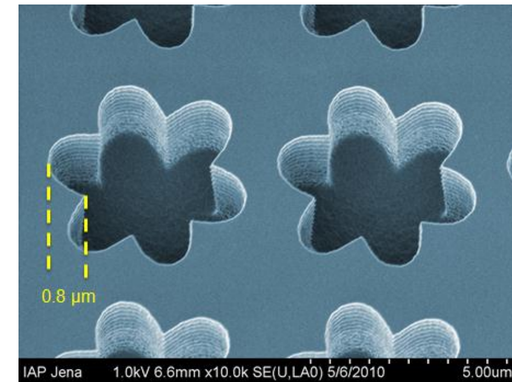




MO Pinhole-Talbot Lithography



MO Half-tone Proximity Lithography



MO Pinhole-Talbot Lithography

Fraunhofer IOF

SÜSS MicroOptics

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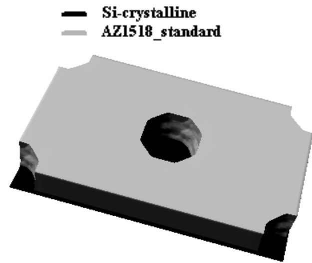
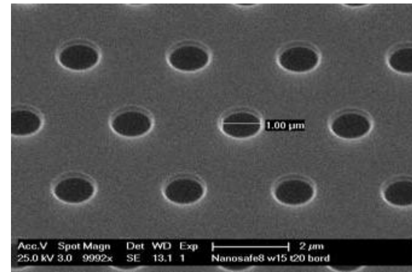
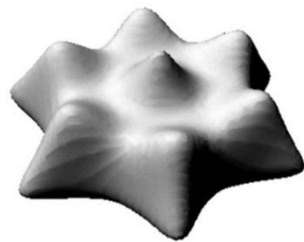
+ Contact printing of 1µm structures



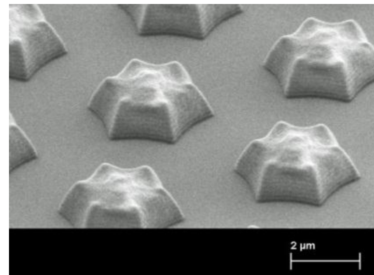
Simulation result



Printing result

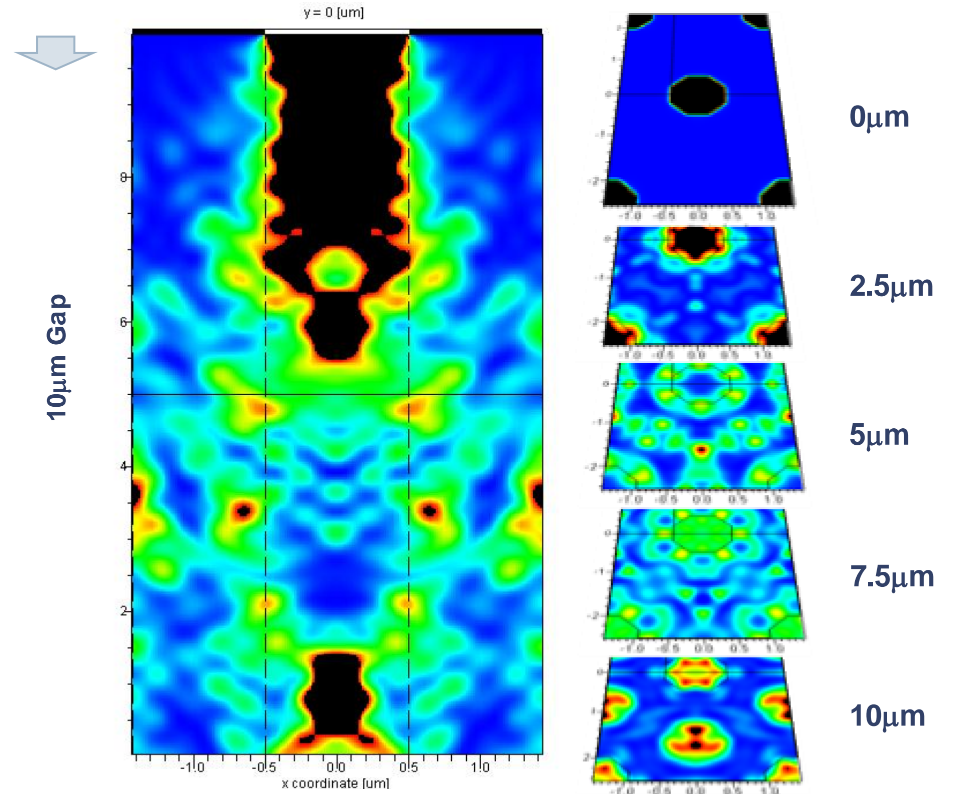


Simulation



Print result

+ Simulations using LayoutLAB™



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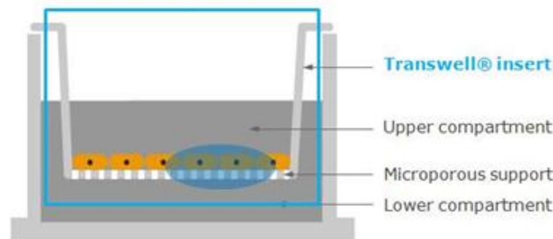
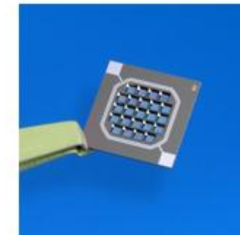
AMALITH for porous supports for cell cultures

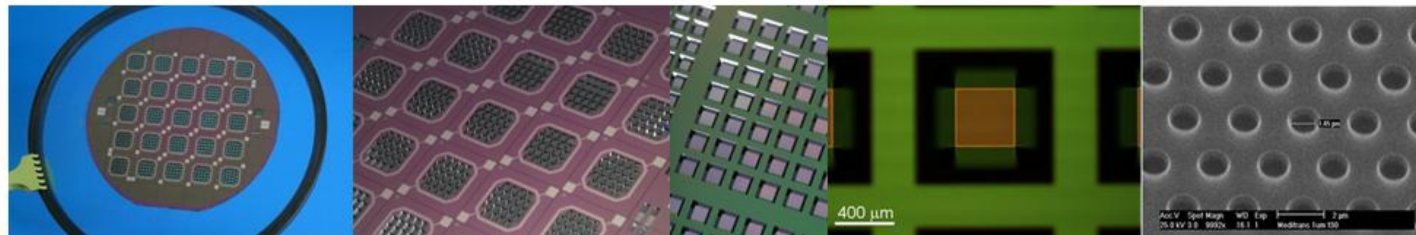
- Microfabricated cell supports have unique features not found in commercially available versions
- ***Need for low cost process for submicron pore dimensions***
- Strong interest from end-users in toxicology and pharmacology



Adapted from Corning technical information

thickness: 500 nm





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