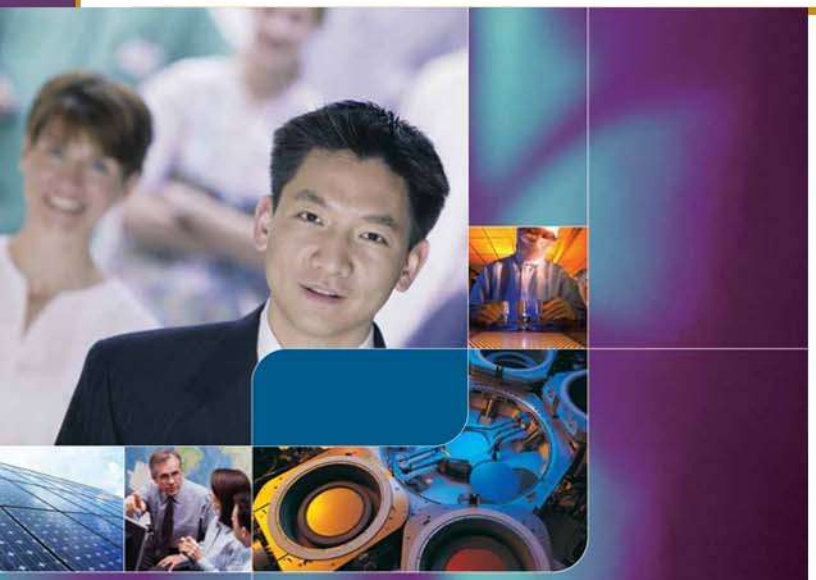
Innovative Mask Aligner Lithography for MEMS and Packaging



Dr. Reinhard Voelkel

CEO SUSS MicroOptics SA

September 9th, 2010

semi™
國際半導體設備材料產業協會

SUSS Micro-Optics

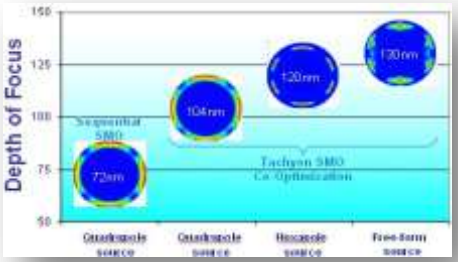
SUSS MicroOptics is a leading supplier for high-quality Micro-Optics and part of SUSS MicroTec Group

SUSS MicroOptics is “Preferred Supplier” for Carl Zeiss SMT AG providing Micro-Optics’ components for Deep UV Illumination in ASML Lithography Systems.

Micro-Optics in Front-End Lithography

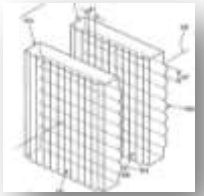
Customized Illumination
Pupil Shaping (DOE)
Now: FlexRay™
programmable illumination
technology

Excimer Laser (193nm)
Laser Beam Shaping
Laser Beam Homogenizing



Customized Illumination

Diffractive Optical Elements (DOE)
MEMS (FlexRay™)



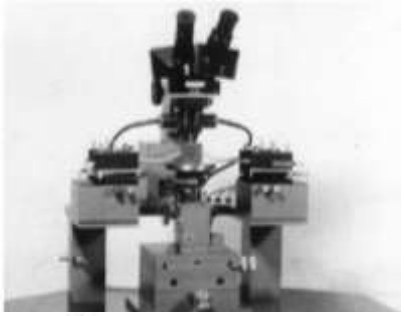
Microlens
Homogenizer

Micro-Optics is Key Enabling Technology in Front-End Lithography

SEMICON Taiwan 2010

MEMS: Photolithography

Mask Aligners are the work horse of SEMI industry since the very beginning



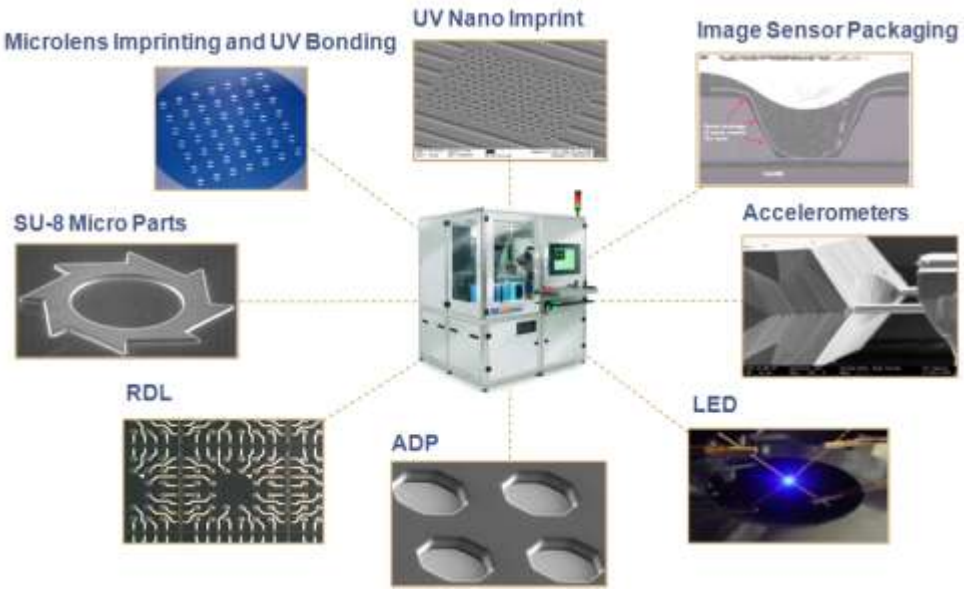
Karl Suss

SÜSS MicroTec

SUSS MicroTec MA200 Compact

Photolithography

Mask Aligners are used for MEMS, Packaging and SEMI



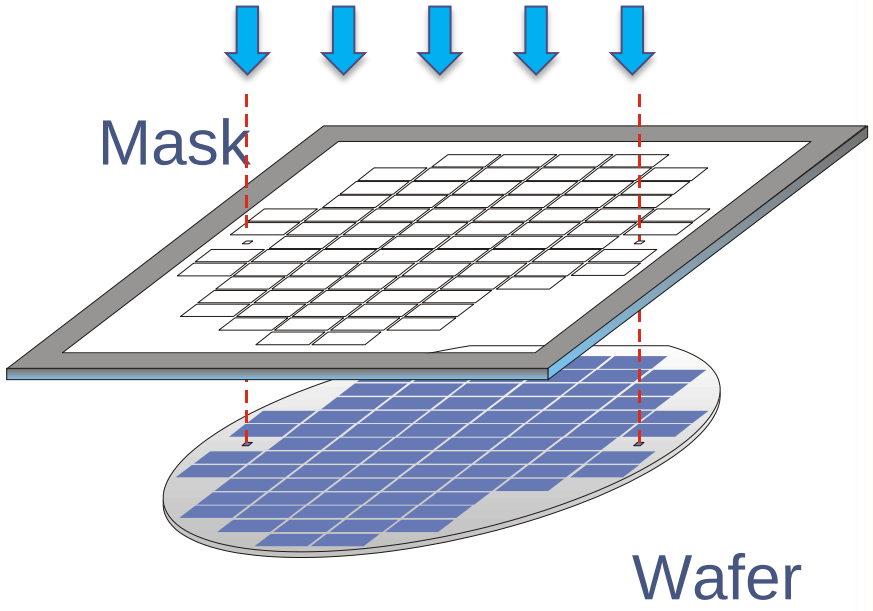
SUSS MicroTec MA200 Compact

Back End Lithography

Mask Aligners Lithography is „Shadow Printing“

Mask illumination using UV light

Resolution <=> proximity gap



Photolithography

Mask Aligners are

- Mature technology
- Cost-effective
- Fast (high throughput)
- Service friendly
- Easy to use
- Convenient

SUSS MicroTec MA200 Compact

Challenge

BUT

a Mask Aligner is
a Mask Aligner is
a Mask Aligner!

Myth or Facts?

Reaching limits: Change to Projection?

Think twice, because

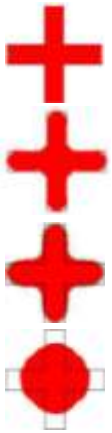
- High capital investment
- High costs per wafer
- Change established processes
- Reduced focus budget
- Can‘t print to the very edge of wafer…

Mask Aligners are so convenient!

Mask Aligner Lithography

Illumination makes the difference!

- Diffraction
- Partial Coherence



CONTACT

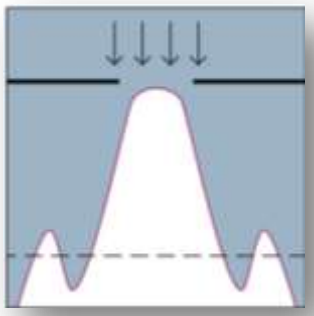
GAP: 20 µm

GAP: 50 µm

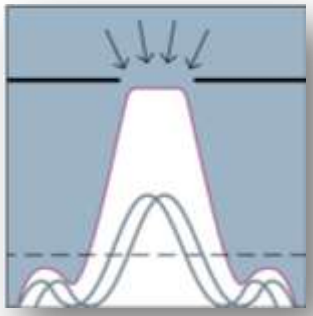
GAP: 100 µm

Parallel Light

Diffuse Light

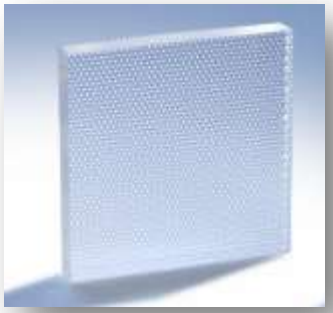


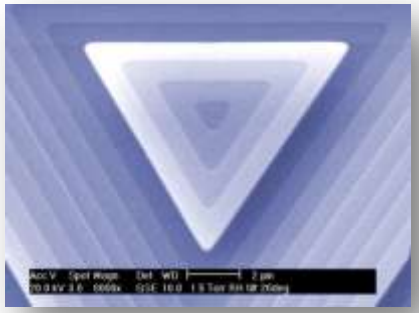
Parallel Light



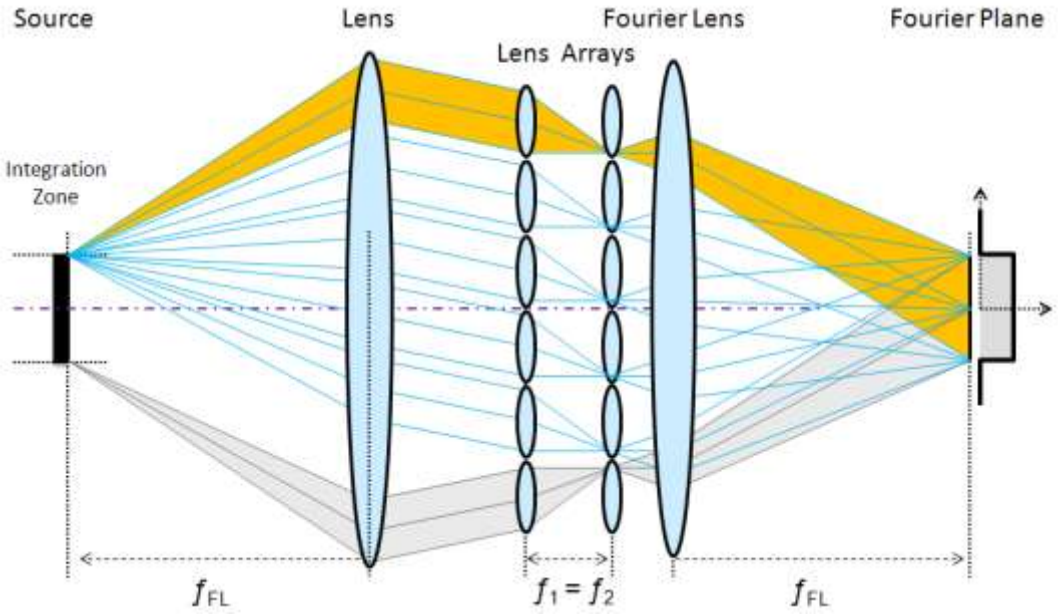
Apodization

Micro-Optics is also Key Enabling Technology for Mask Aligners!



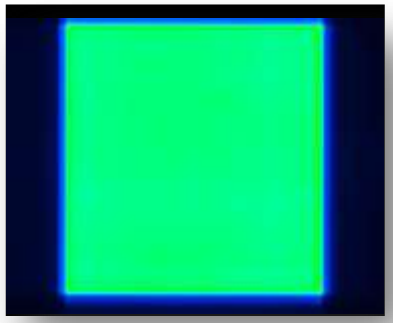


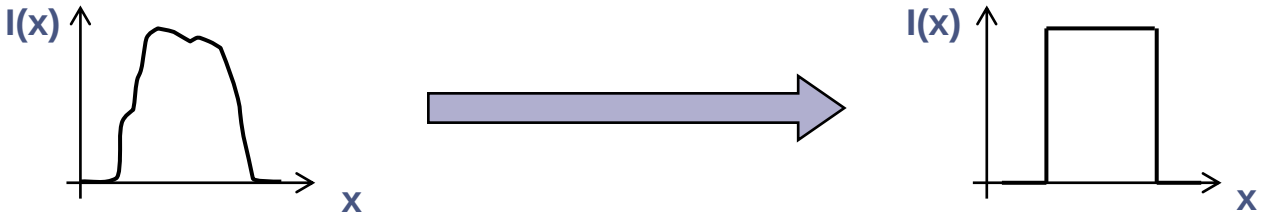
Fly's Eye Homogenizer
Microlens Optical Integrator (Köhler)



August Köhler
(1866-1948)

Flat-Top Intensity Profile

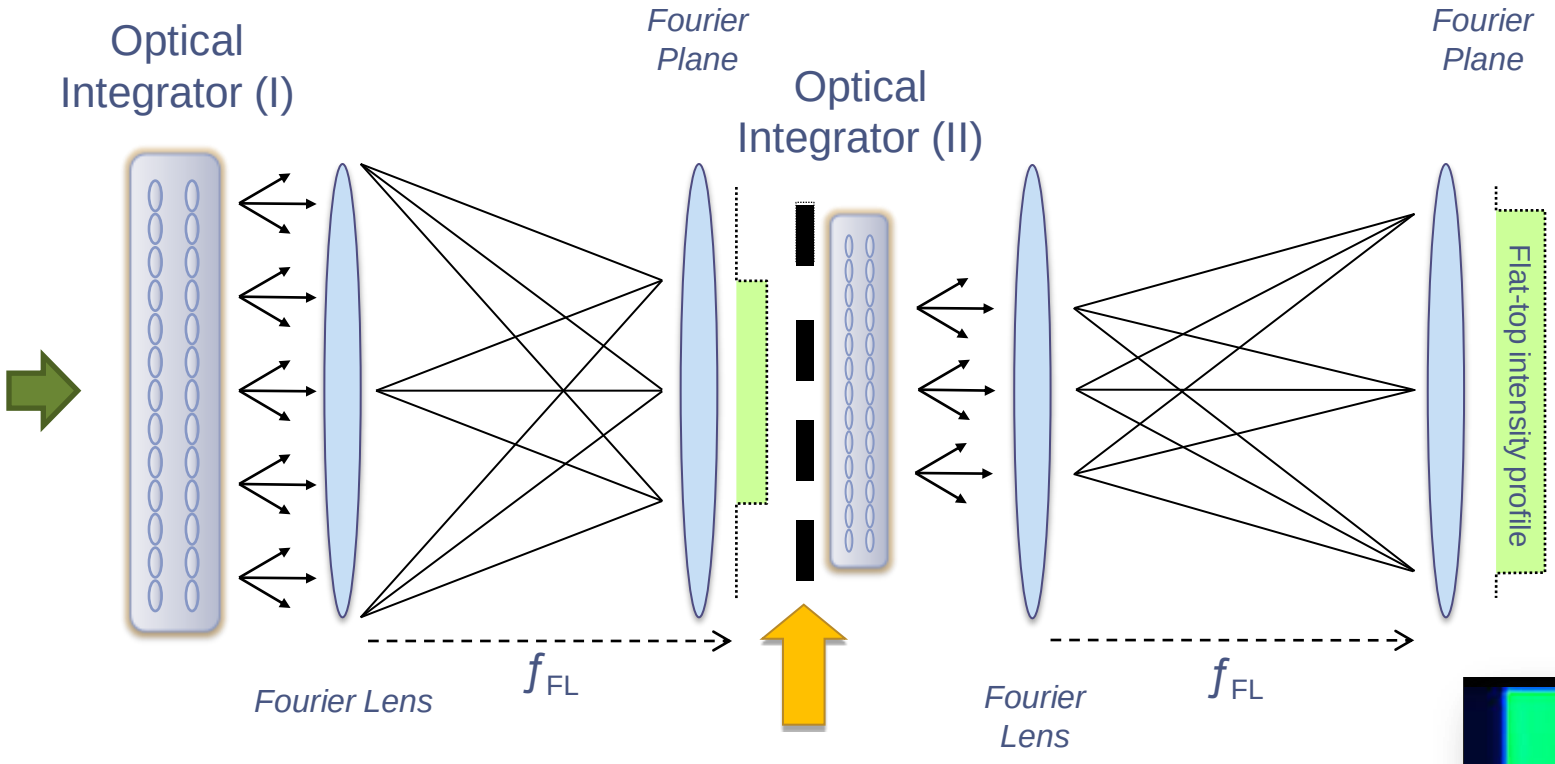




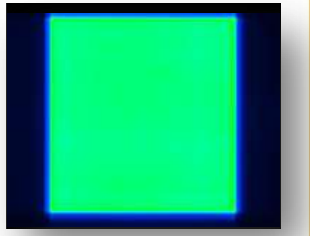
MO EXPOSURE OPTICS

Innovative Illumination System for SUSS Mask Aligners

Technology Backbone: Microlens Optical Integrators (Köhler)



Exchangable Illumination Filter Plate (IFP)



Patent pending

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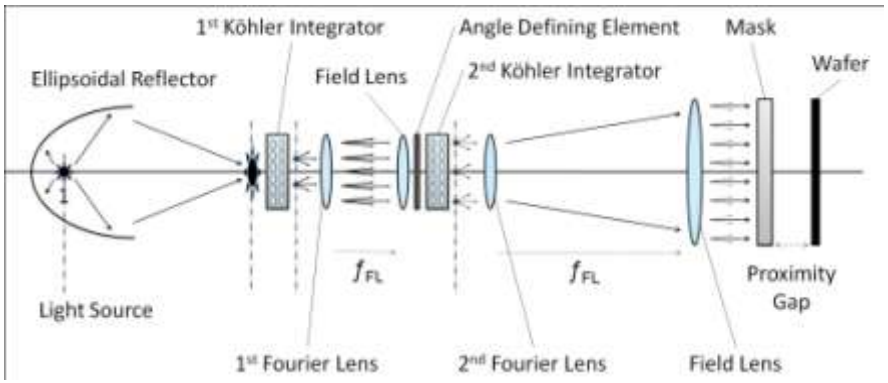
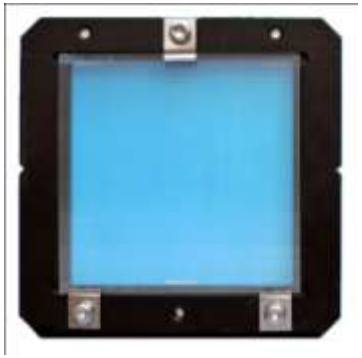
MO Exposure Optics

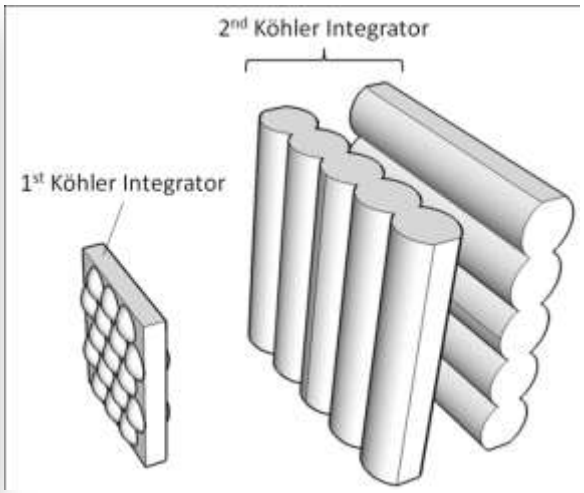
Library of Illumination Filter Plates (IFP)





Microlens Array

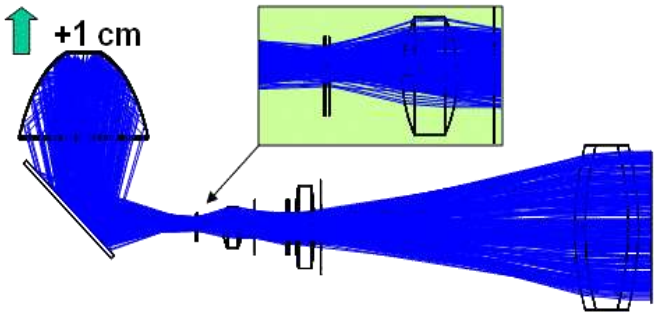
Optical System MA 200



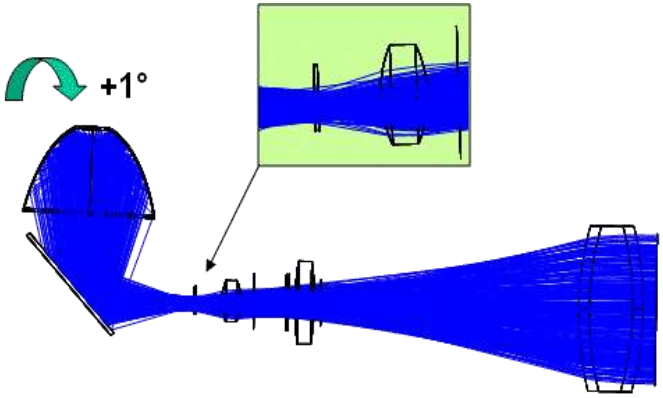
Microlens-based Optical Integrators

SEMICON Taiwan 2010

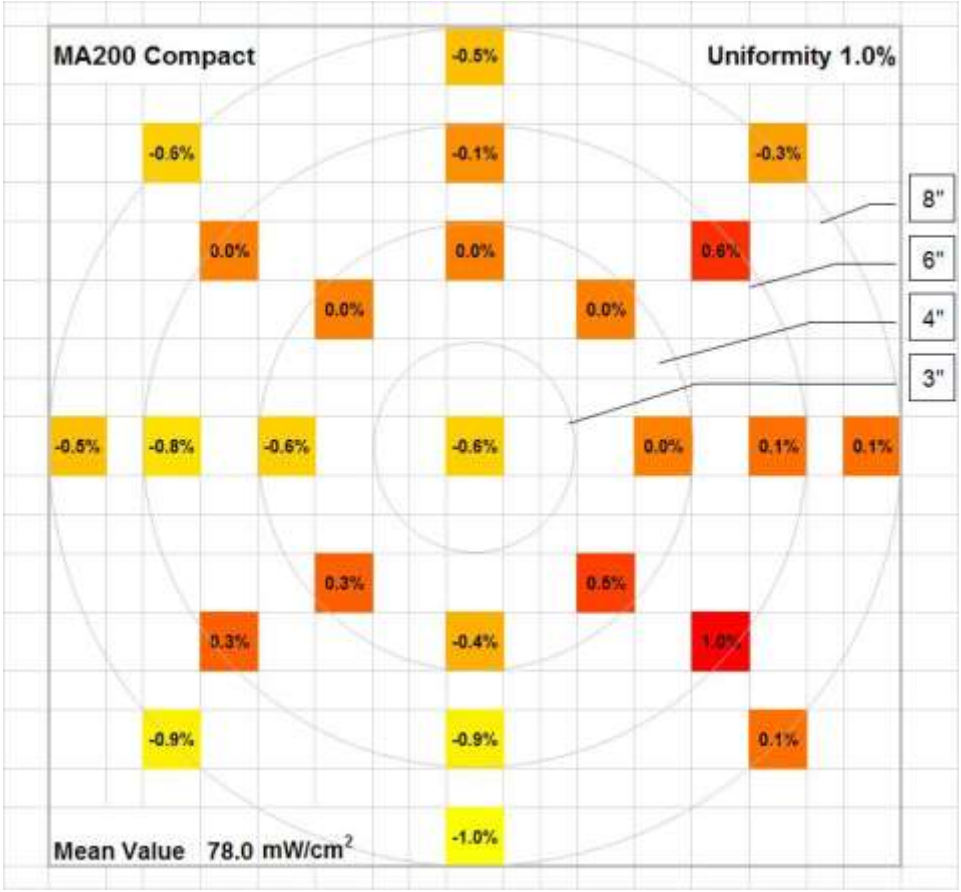
Excellent Uniformity Independent of Lamp Position



Lamp Position: Uncritical



Lamp Tilt: Uncritical

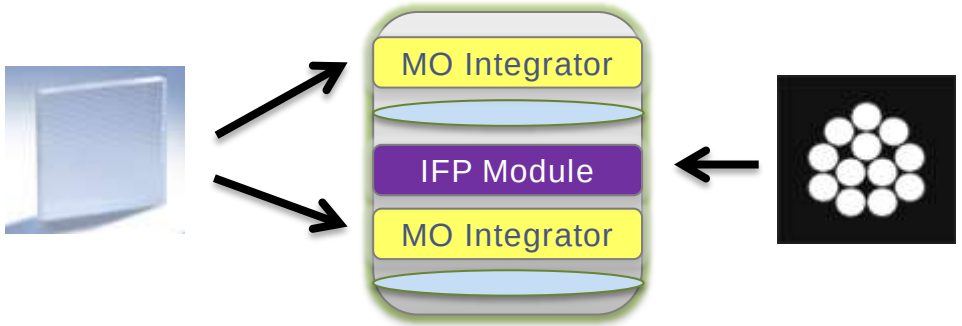


Deviation from mean value in [%] for Ø200mm in MA200 Compact

Stabilize the Mask Aligner

Features

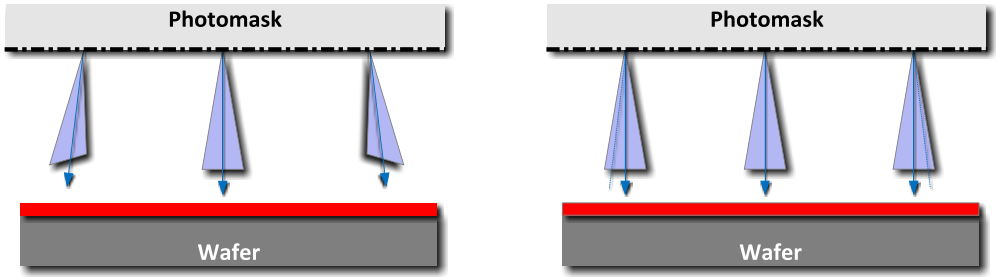
Stable Light Source
Excellent Uniformity
Telecentric Illumination



Micro-Optics | MO Exposure Optics | Illumination Filter Plate

Benefits

Reduced Downtime
Improved CD Uniformity
Larger Process Window
Higher Yield



Standard Mask Illumination | Telecentric Mask Illumination

Technology Enhancement

Microlens-based MO Exposure Optics provides

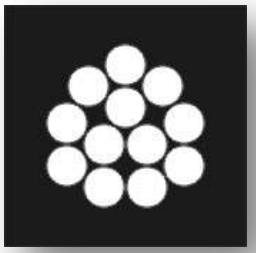
- Stabilized light source
- Excellent light uniformity
- Telecentric illumination

in Mask Aligners

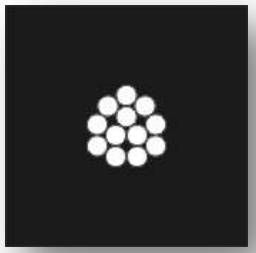
Exchangeable Illumination Filter Plates

Features

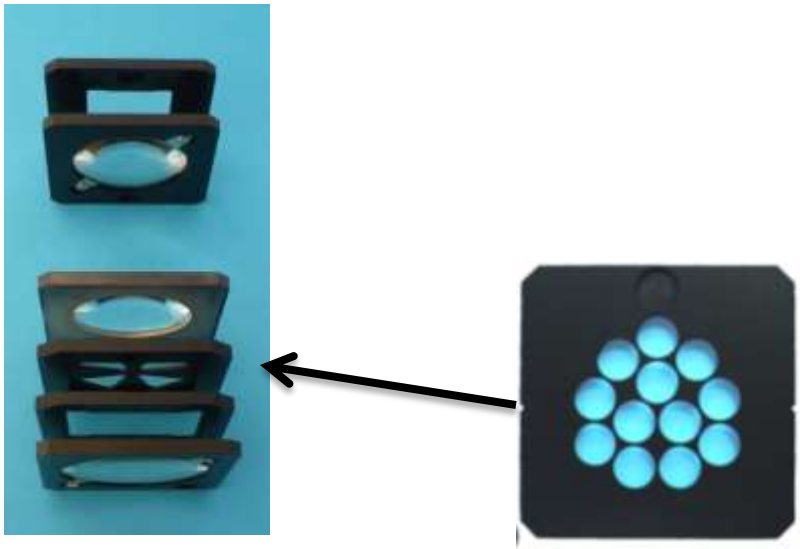
- HR to LGO change in less than 1 min
- Illumination filter plates (IFP)
- Customized illumination



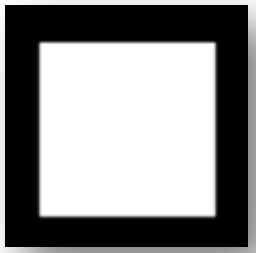
IFP-HR
„High Resolution“



IFP-LGO
„Large Gap“

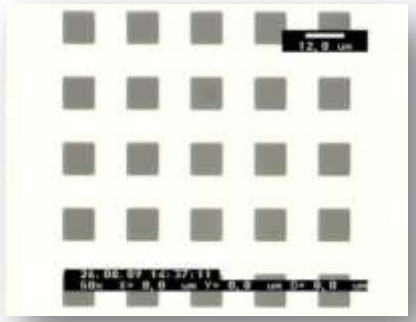


Exchangeable Illumination Filter Plate (IFP)

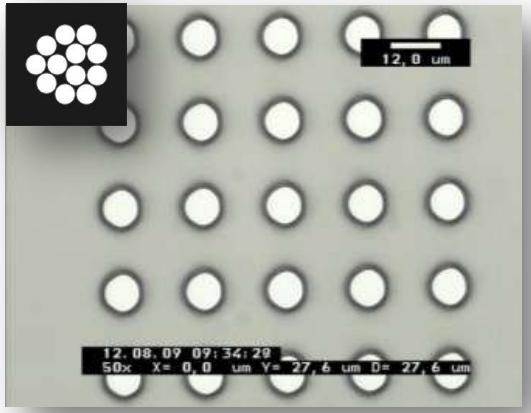


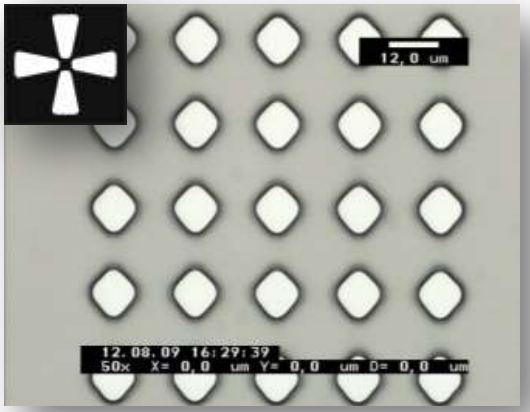
IFP-C90
„More Light“

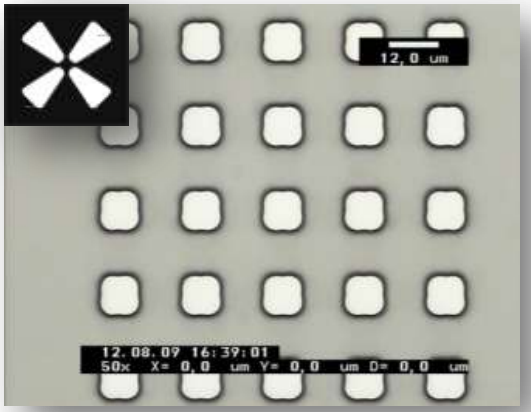
Optimize Diffraction Customized Illumination



Photomask Pattern
Square 10x10μm^2







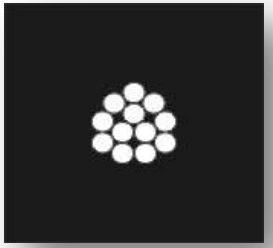
1.2μm thick resist (AZ 4110), 100μm Proximity Gap, SUSS MA8

Optimize Diffraction Customized Illumination

Features

- HR to LGO change in <1 min
- Illumination filter plates (IFP)
- Customized illumination

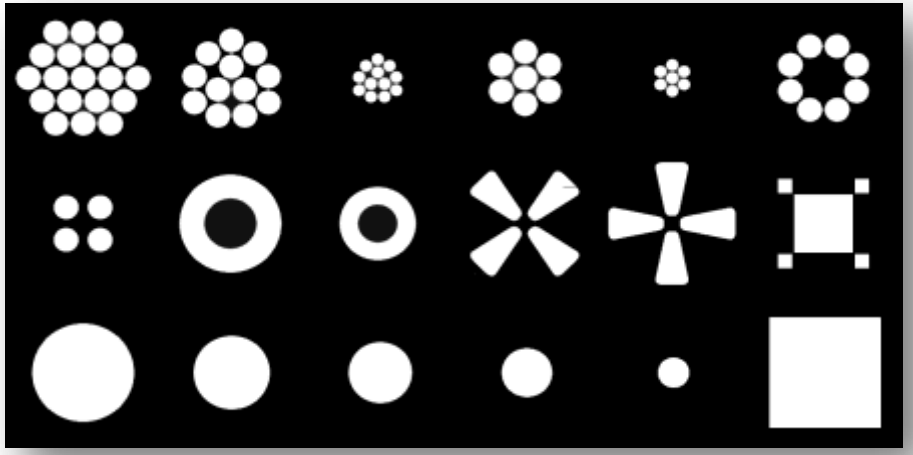
HR: High Resolution



LGO: Large Gap

Benefits

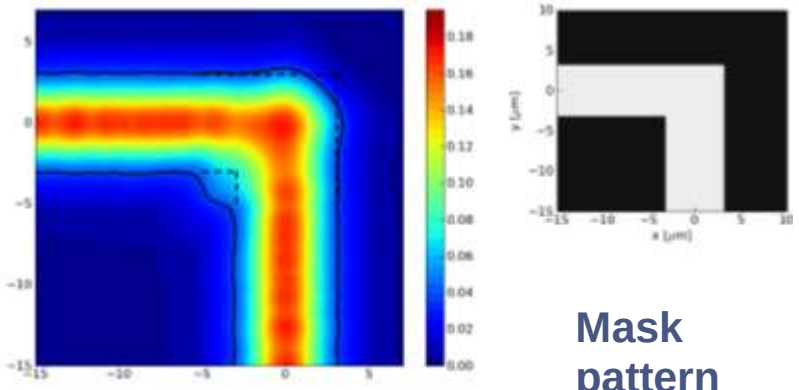
- Flexible illumination
- Diffraction reduction
- Resolution enhancement technology (RET)
- Optimized lithography process



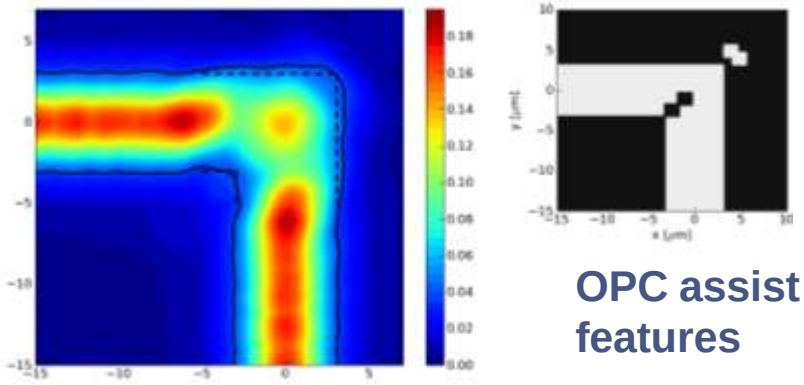
Library of Illumination Filter Plates (IFP)

Optical Proximity Correction (OPC)

Aerial image (simulation)



Mask pattern

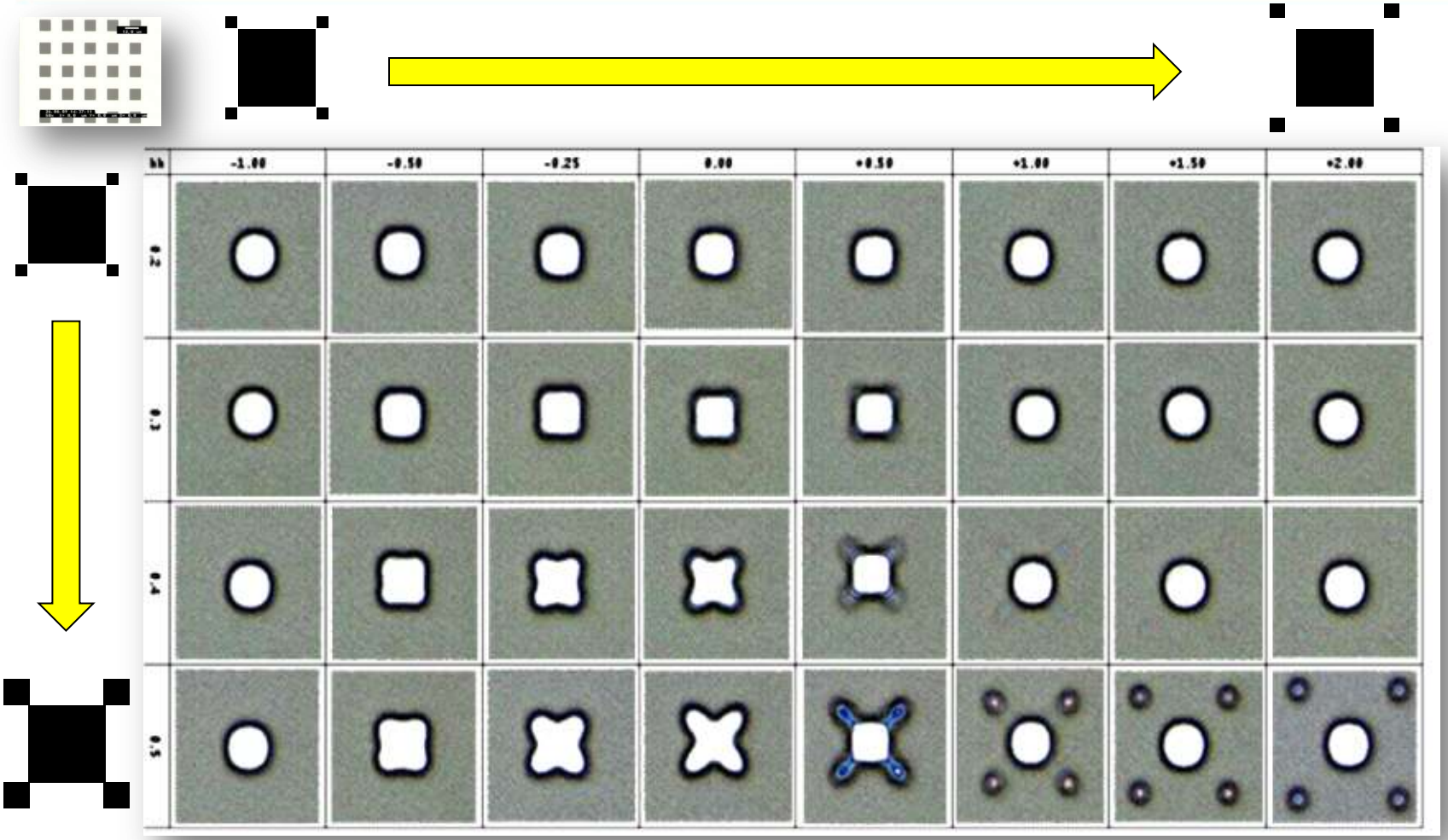


OPC assist features

- Aerial image 6µm line
- Proximity gap 40µm
- Mask layouts (right)
- OPC assist features (bottom)
- Reduction of the rounding of the inner and outer corner

Ref: Kristian Motzek, FhG-IISB, SUSS Report Sept 2010

Optical Proximity Correction (OPC)



Square10μm x 10μm, Proximity Gap 50μm, Photoresist AZ4110, 1.2um thick

Expertise in Lithography Simulation

Lithography Simulation
Source-Mask Optimization Service
Research & Technology Partners

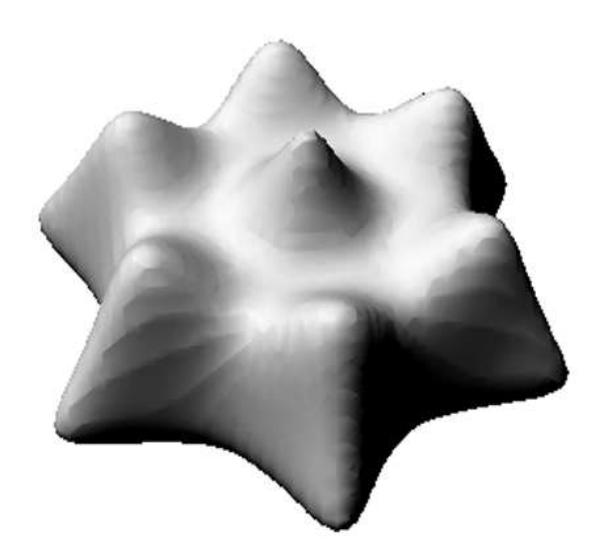
TOPPAN
TOPPAN PHOTOMASKS, INC.

Fraunhofer IISB

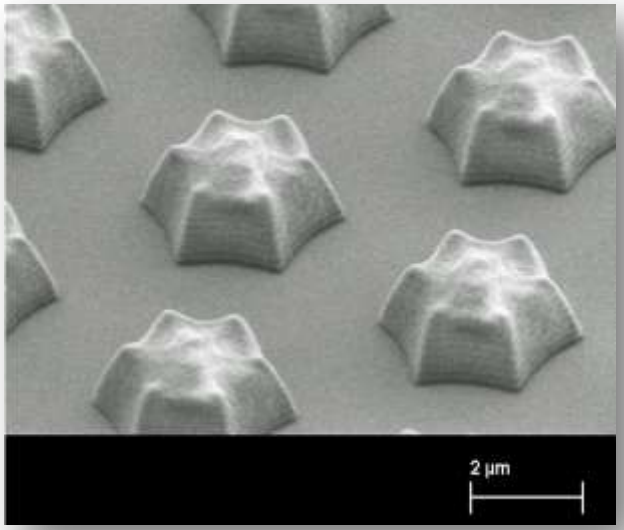
Fraunhofer IOF

FHV University of Applied Sciences

GenISys

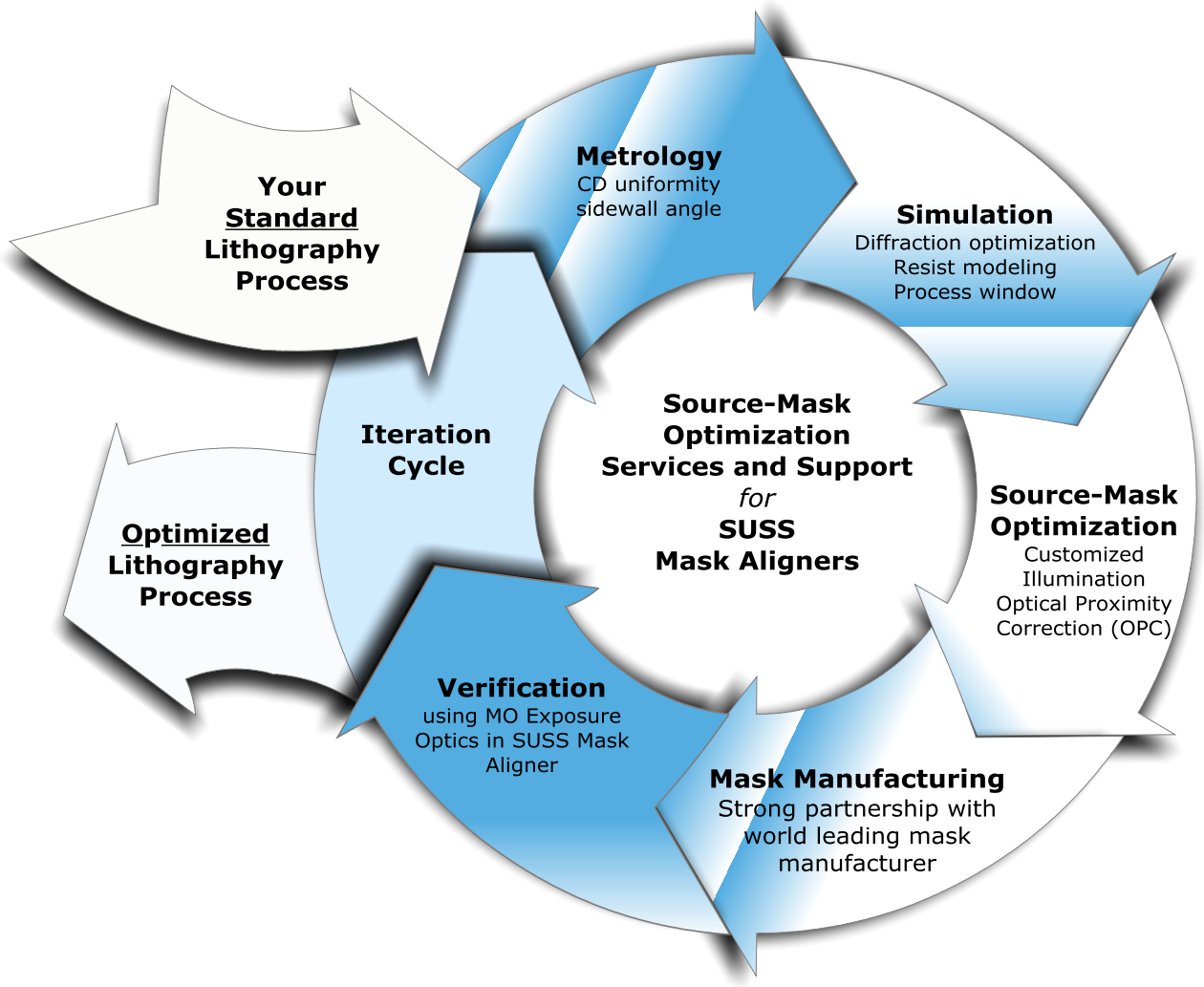


Simulation 3D Resist Structure
(Layout Lab, GenISys)



Printed Resist Structure

Source-Mask Optimization Service



SUSS MicroOptics

TOPPAN PHOTOMASKS, INC.

Fraunhofer IISB

GenISys

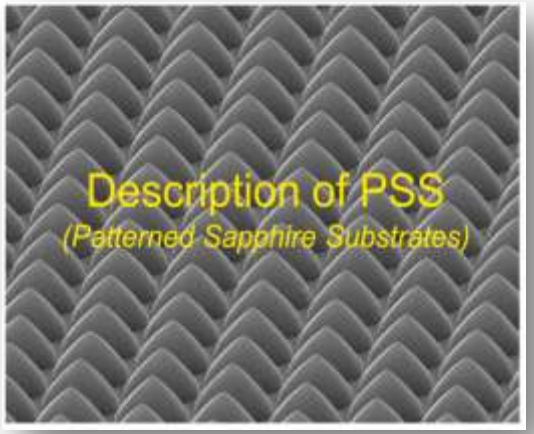
Example: LED Requirements for PSS

Patterned Sapphire Substrate

- Epitaxy
- Effiency
- Beam Confinement

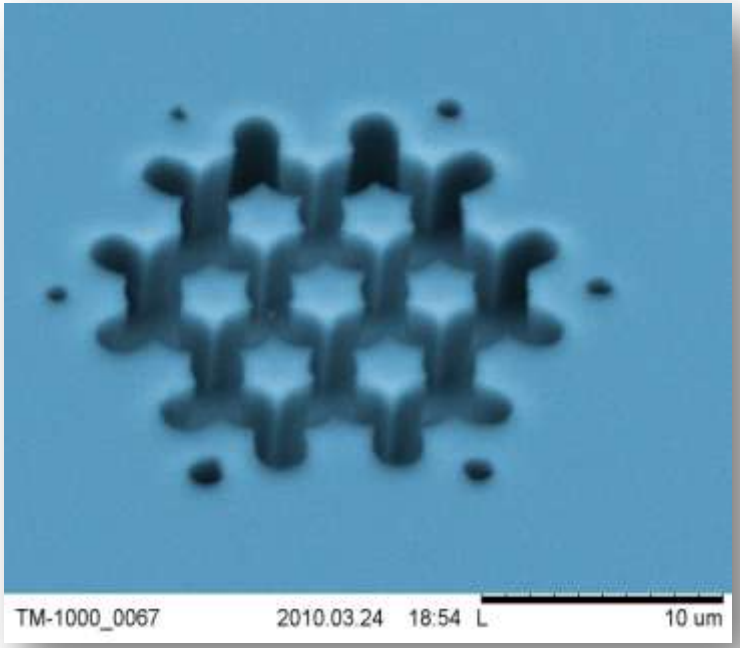
Process

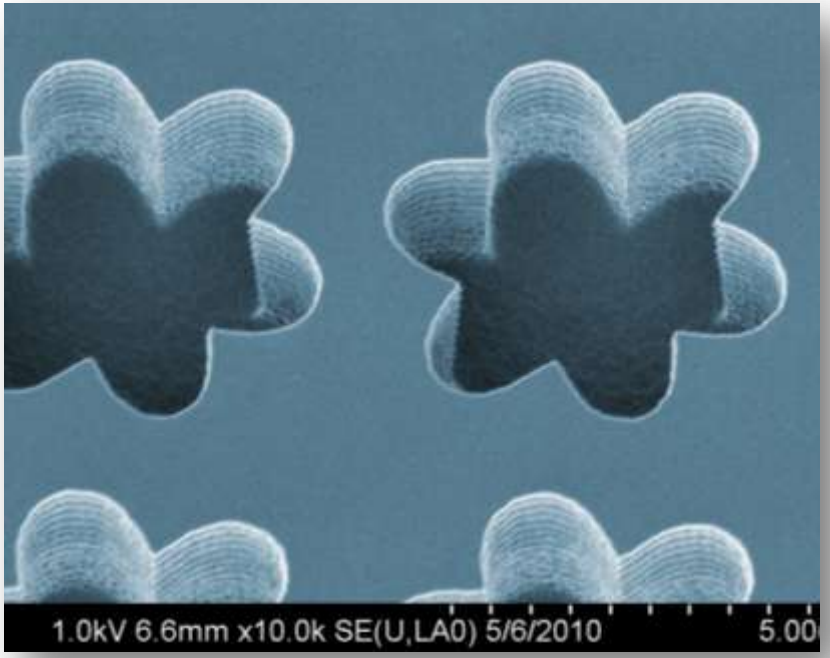
- Hexagons/Cones, ≈ 3µm
- RIE-ICP (Chlorine) Etching



www.corial.net

Example: LED
Source-Mask Optimization

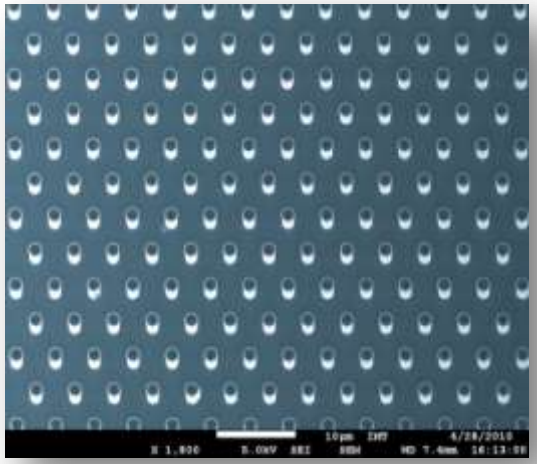


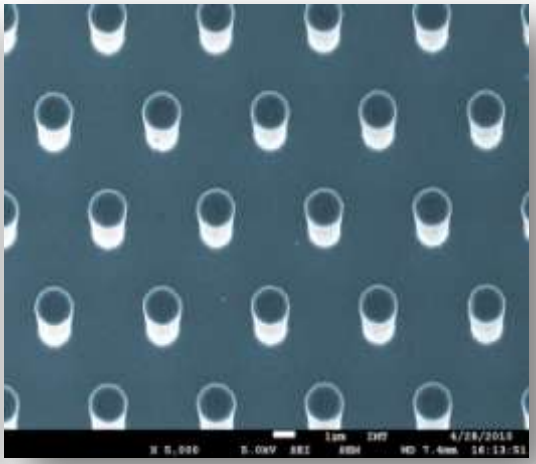


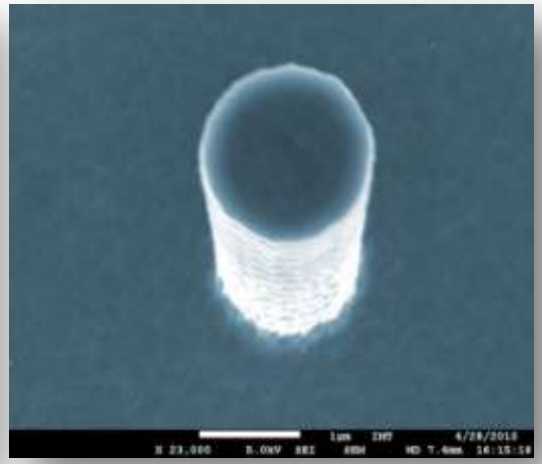
Optical Proximity Correction
(Proximity Gap 30μm)

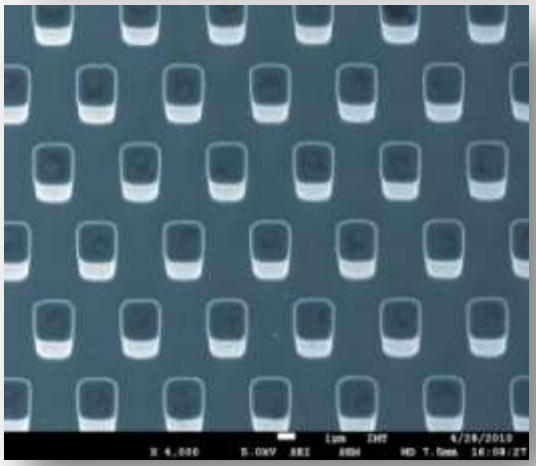
MO Talbot Lithography
(Proximity Gap 102μm)

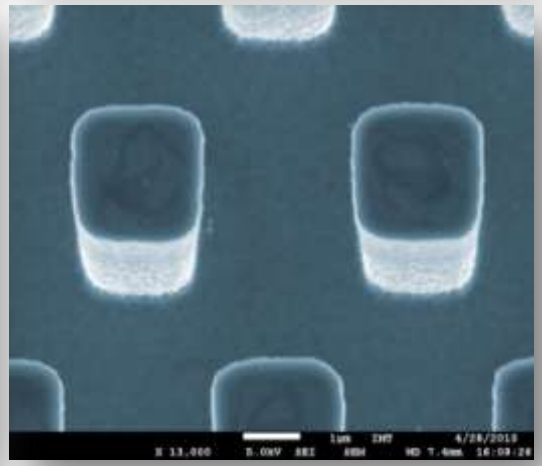
MO Talbot Lithography Periodic Structures (PSS)







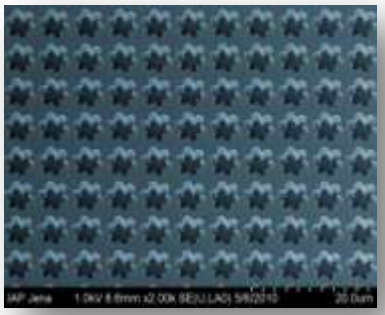


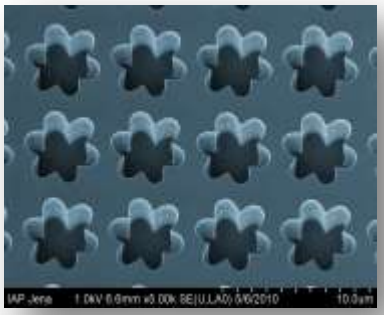


Pitch	*5 µm*
Resist	*2 µm thick*
Etching	*RIE (Bosch) Silicon*

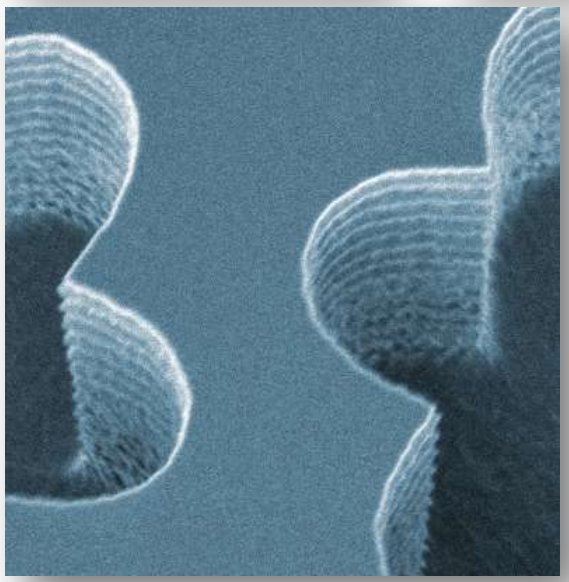
Proximity Gap 102 µm

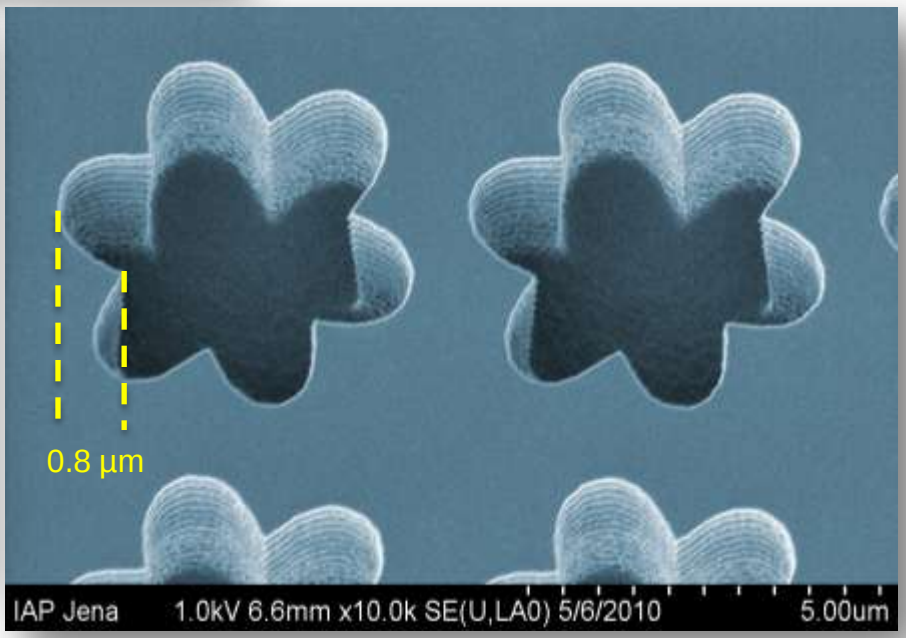
MO Talbot Lithography Periodic Structures (PSS)





Pitch	*5 µm*
Resist	*2 µm thick*
Etching	*RIE (Bosch) Silicon*
Proximity Gap	***102 µm***





SUSS MicroOptics

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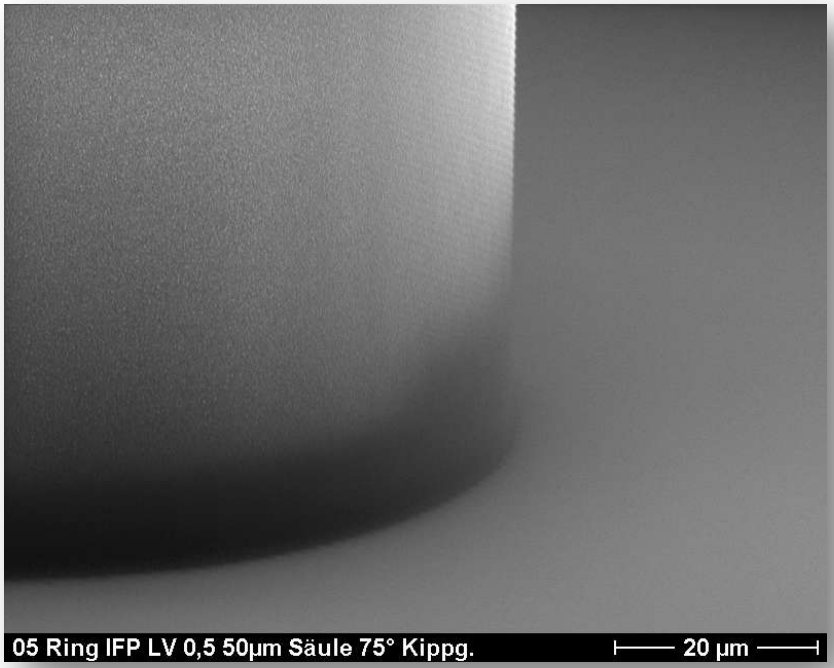
Fraunhofer IOF

SEMICON Taiwan 2010

MEMS
Thick Photoresist (SU8)

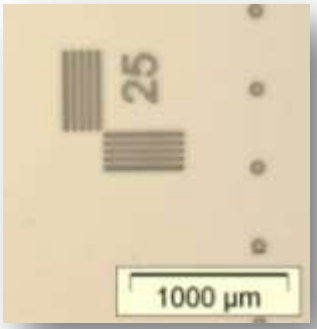
Very thick photoresist

- Improvement of Footing
- Sidewall shaping



Improvement of footing and sidewalls with thick SU8 using MO Exposure Optics

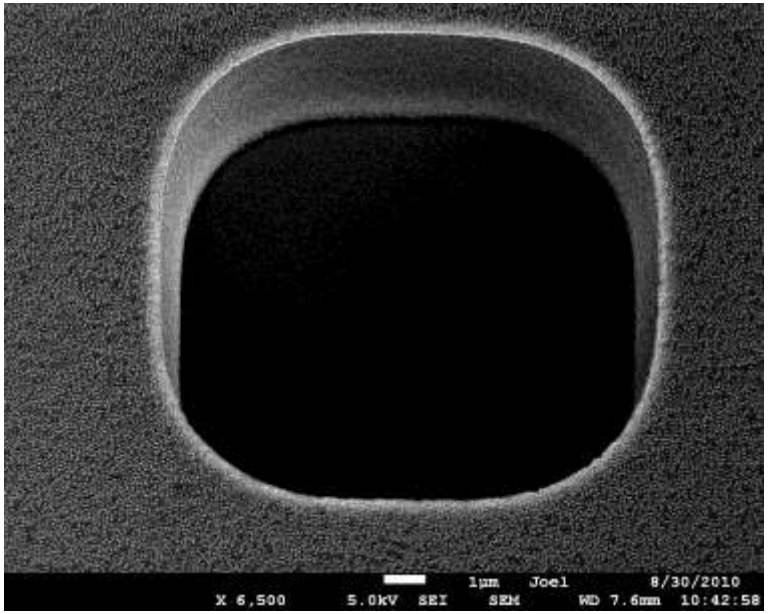
300µm thick SU8
Resolution 25µm



micro resist technology

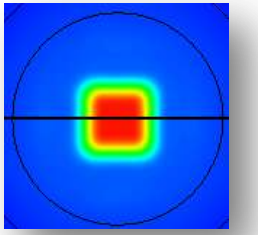
SEMICON Taiwan 2010

Example: ADP, TSV & 3D OPC Fresnel



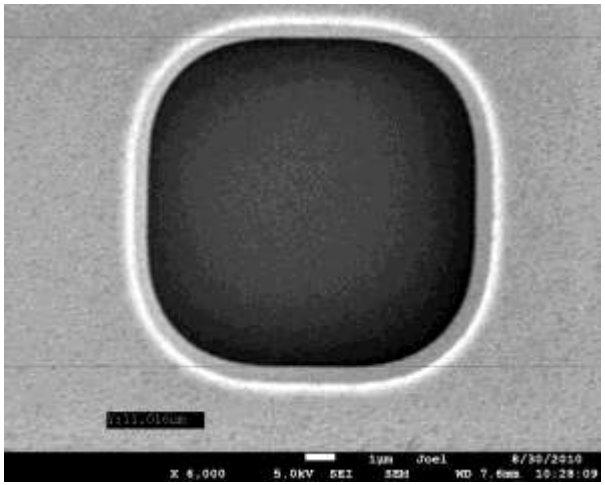
Side view

11µm via
800µm proximity gap



Via shaping

Top view



Photoresist AZ1518, 5µm thick

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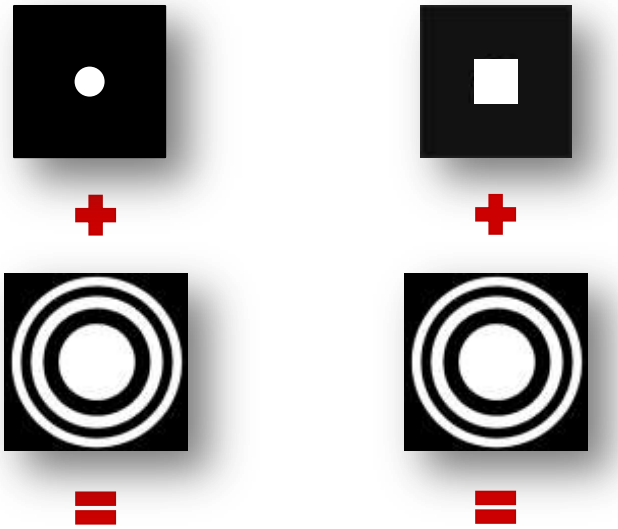
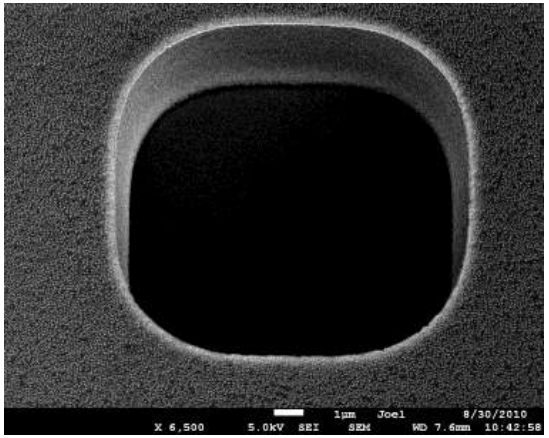
Example: ADP, TSV & 3D OPC Fresnel

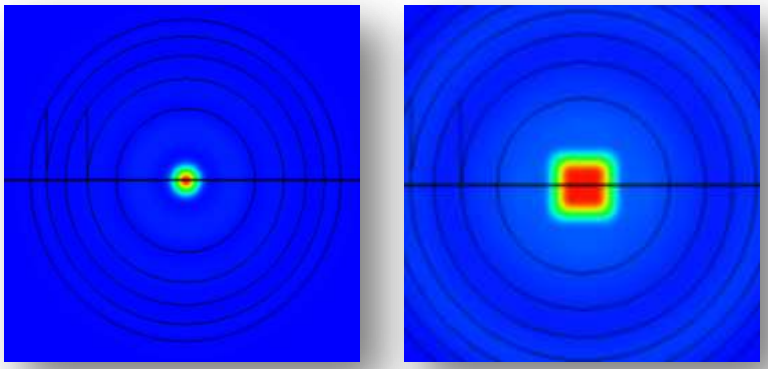


Illumination Filter Plates (IFP)

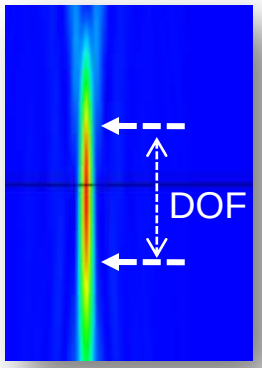
OPC Structure (Fresnel-type)



11µm via at 800 µm proximity gap



Resulting Aerial Image



Depth of focus (DOF)

Example: ADP, TSV & 3D OPC Fresnel

Benefits

- Very large proximity gap
- Via shaping possible
- Extended Depth of Focus (DOF)
- Very short exposure time (throughput)

Typical parameters for via printing using OPC Fresnel Technology

Gap	Ø Via	DOF
100 µm	2 µm	5 µm
200 µm	3 µm	15 µm
300 µm	5 µm	30 µm
400 µm	7 µm	60 µm
500 µm	10 µm	100 µm
700 µm	14 µm	200 µm

MO Exposure Optics
Available for all SUSS Mask Aligners

MA6, MA8

MJB4

LithoPack 300

MA/BA8 Gen3

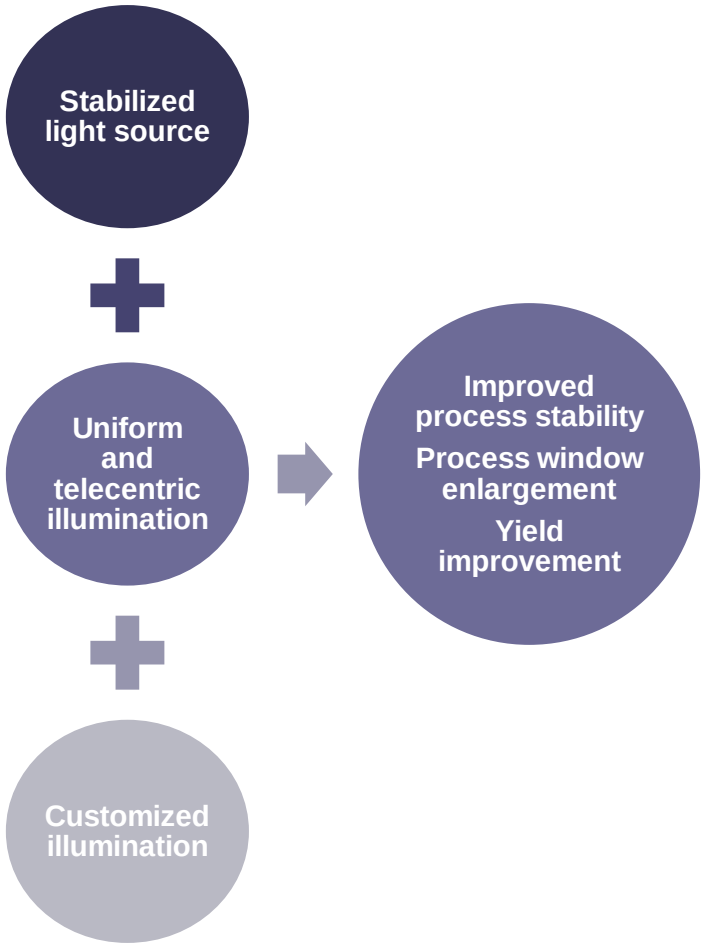
MA200Compact,
MA100e, MA150e

MA300 Gen2

Advanced Mask Aligner Lithography

A Mask Aligner is a Mask Aligner is a Mask Aligner!

Yes! But…



Technology Enhancement

MO Exposure Optics enables

- Customized Illumination
- Optical Proximity Correction (OPC)
- Source-Mask Optimization (SMO)

in SUSS Mask Aligners

Advanced Mask Aligner Lithography

Summary

Quick wins

- Improved CD uniformity
- Higher throughput
- Less downtime

New process parameter: Illumination!

- Customized illumination
- Optical Proximity Correction (OPC)

SUSS.

Our Solutions Set Standards

SUSS MicroTec
SUSS MicroOptics

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