LASER-BEAM SHAPING WITH MICRO-OPTICS AND DIFFRACTIVE OPTICS (DOE)

GET YOUR LASER IN SHAPE

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Switzerland

28th April, 2022

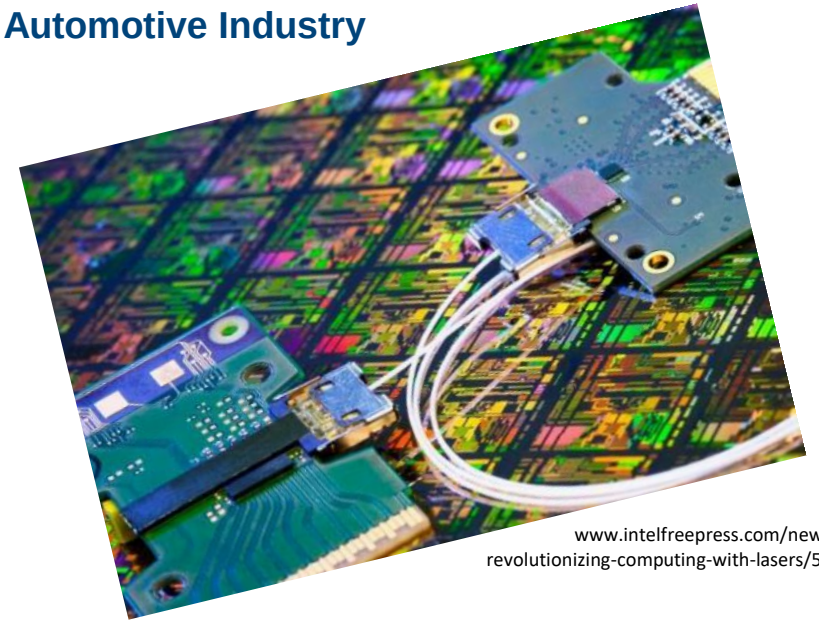
TECHNOLOGY AND MARKETS

Suss MicroOptics

- Fully equipped cleanroom
- 200mm wafer fab
- Optical design and simulations
- System developments

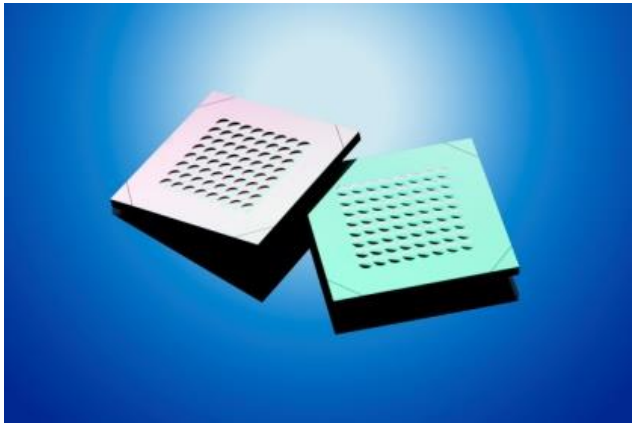
Our customers

- Leading edge R&D departments
- Semiconductor equipment manufacturers
- Datacom and telecom industry
- Laser Applications
- Medical industry
- Automotive Industry

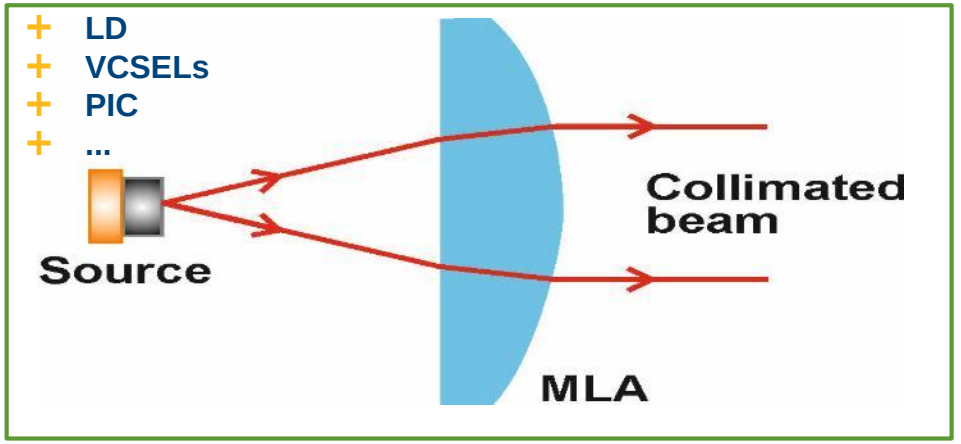


www.intelfreepress.com/news/revolutionizing-computing-with-lasers/57/

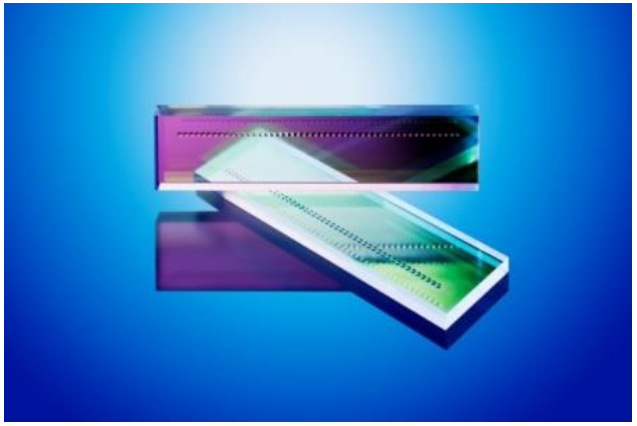
+ Collimators

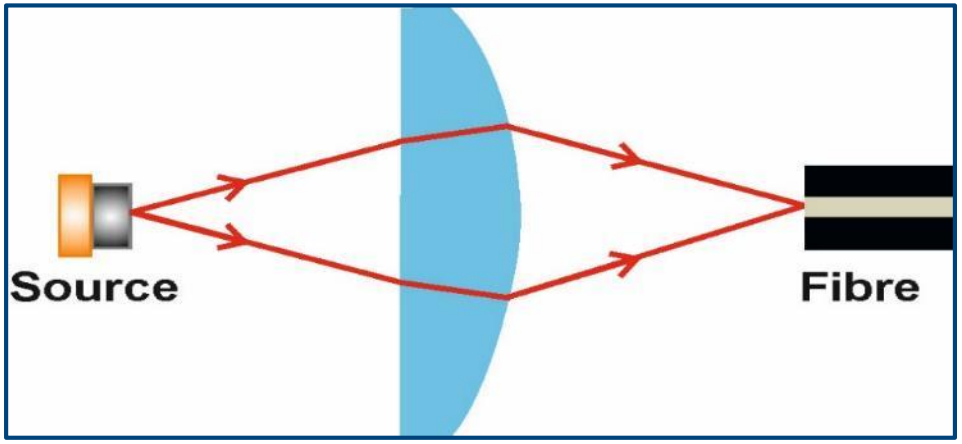


+ LD
+ VCSELs
+ PIC
+ ...



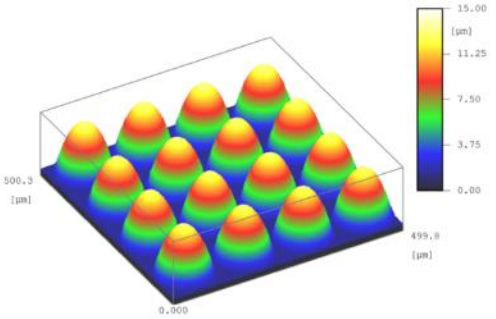
+ Re-Focusing

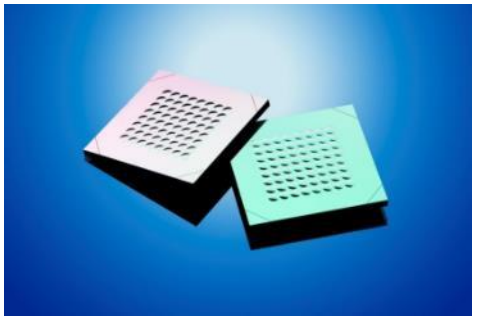


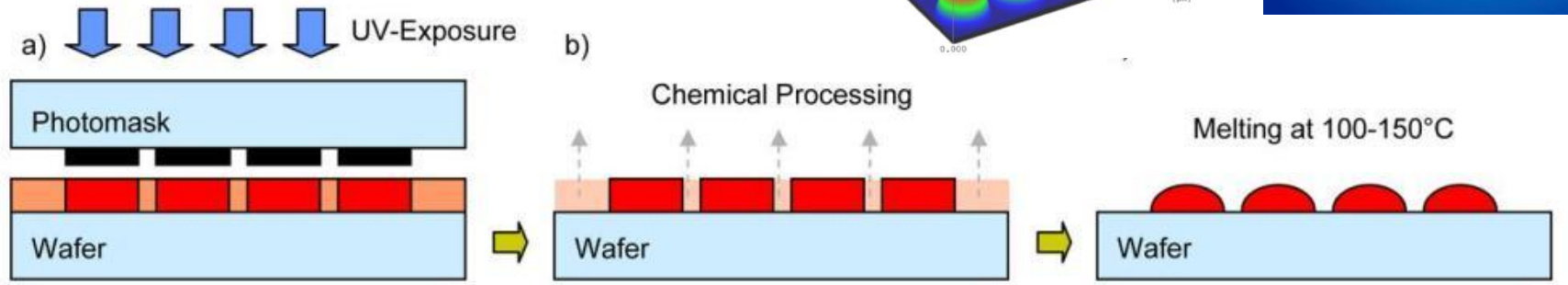


MICROFABRICATION: REFLOW & REACTIVE ION ETCHING

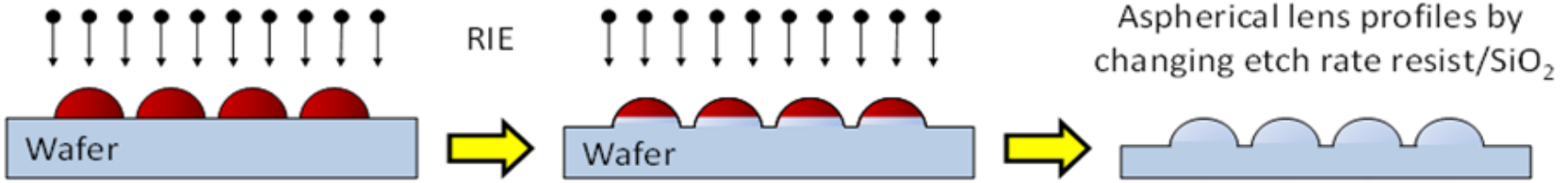
STEP 1: Photolithography & thermal reflow





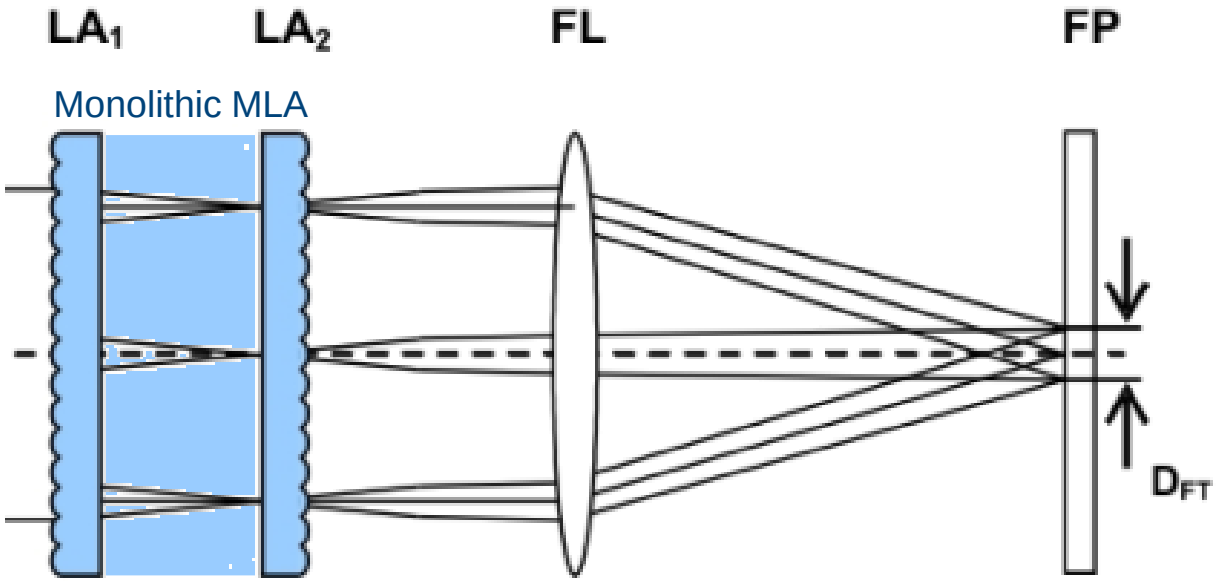


STEP 2: Reactive Ion Etching (RIE):

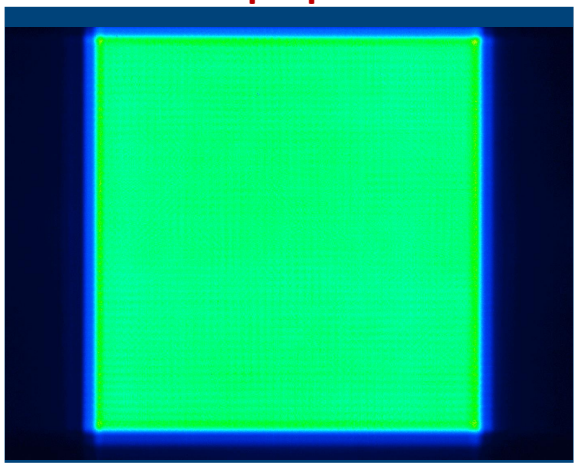


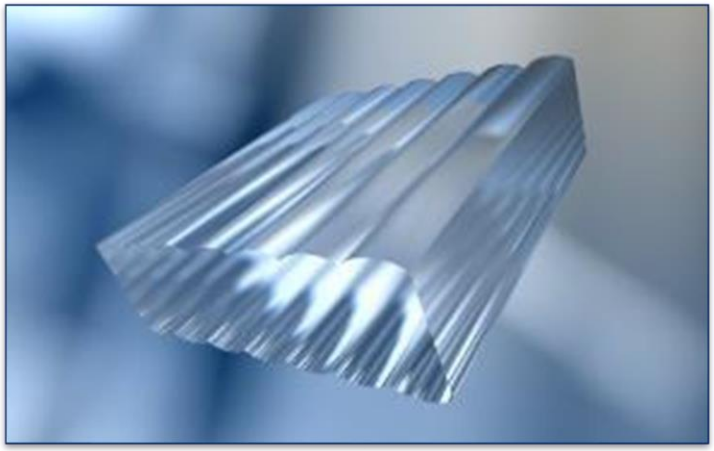
BEAM SHAPING OPTICS

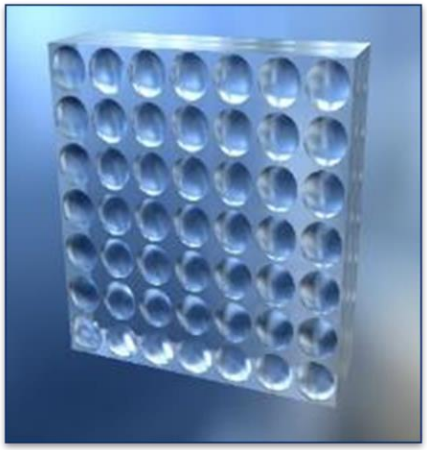
Beam shaping with microlens arrays (MLA) – Imaging configuration



Incoherent superposition





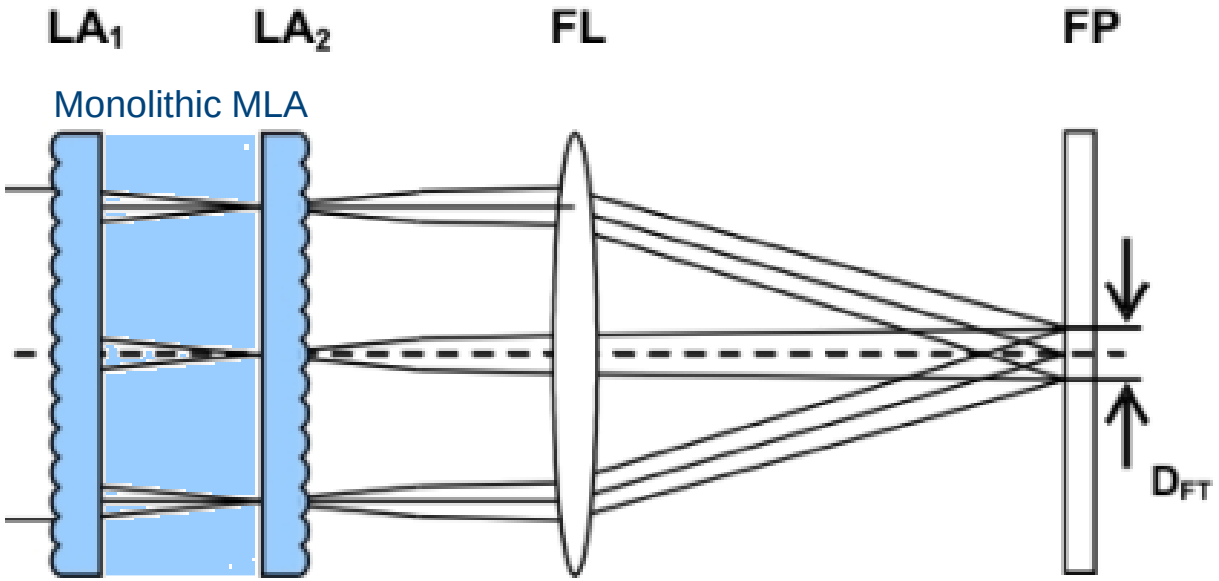


Source: www.palomarmedical.com

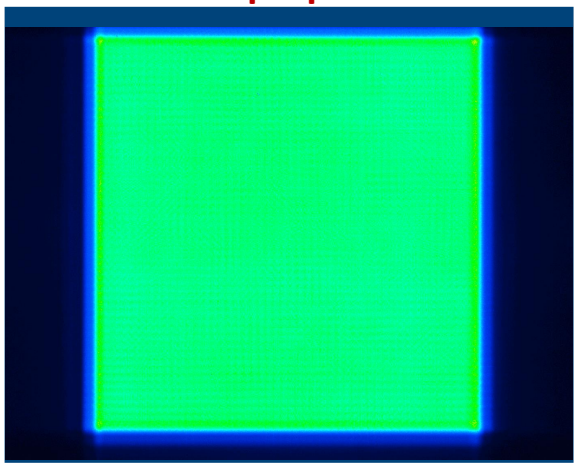
Sources: www.blz.org, Johannes Wangler (CZ SMT)

BEAM SHAPING OPTICS

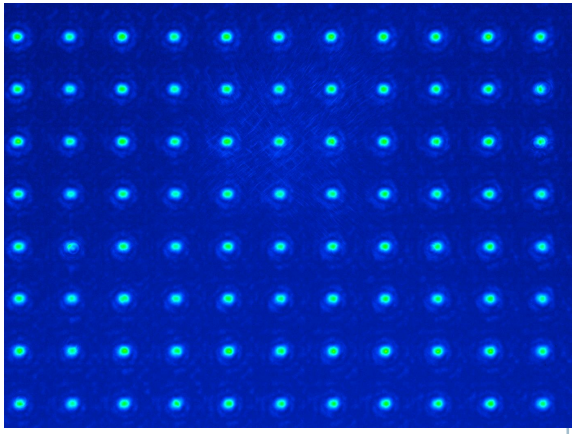
Beam shaping with microlens arrays (MLA) – Imaging configuration

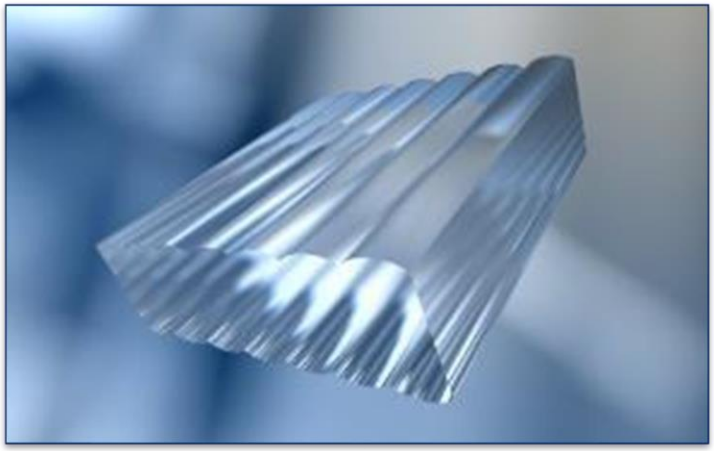


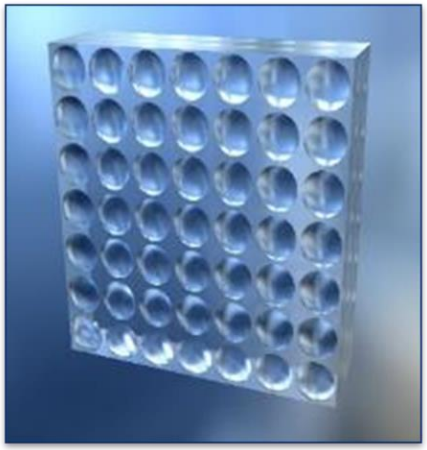
Incoherent superposition



Coherent superposition







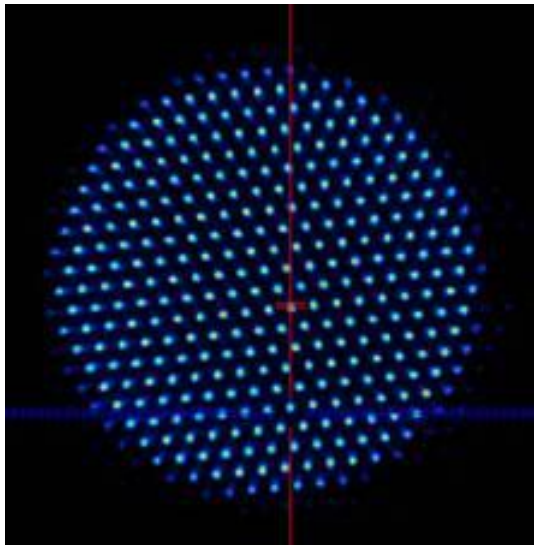
Source: www.palomarmedical.com

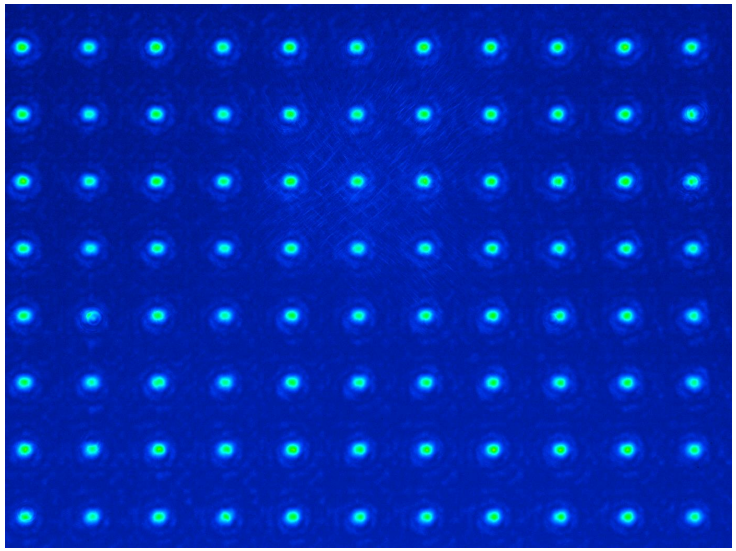
Sources: www.blz.org, Johannes Wangler (CZ SMT)

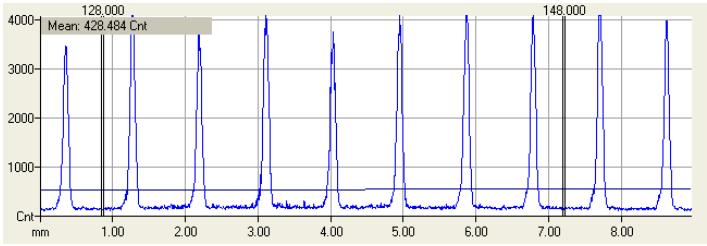
ARRAY GENERATOR FOR MEDICAL APPLICATIONS

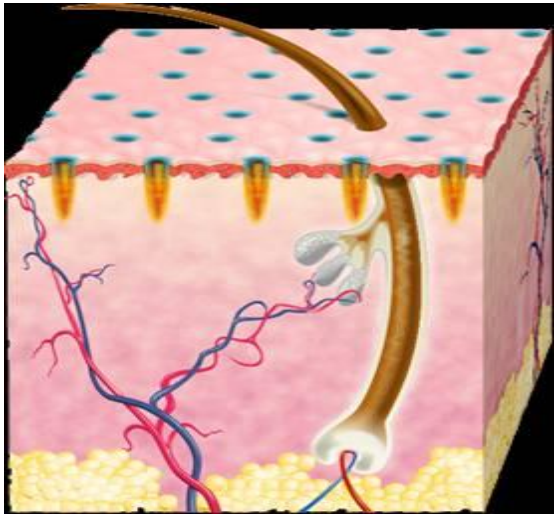
Dermatology

- Hair removal
- Tattoo removal
- Pigment treatment
- Skin rejuvenation



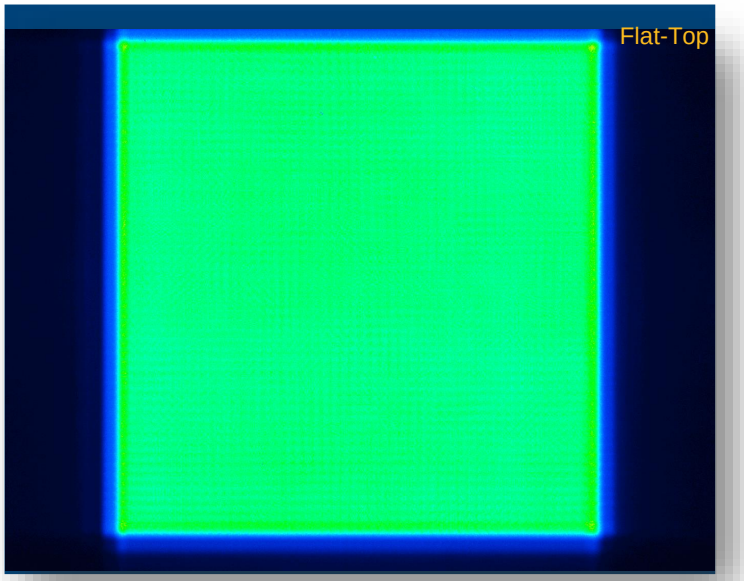


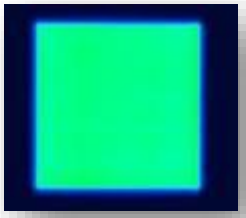




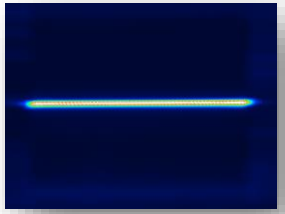
Source: www.palomarmedical.com

LASER BEAM SHAPING

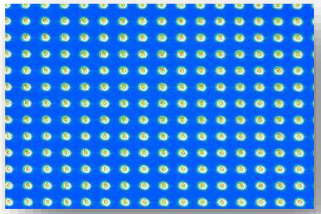




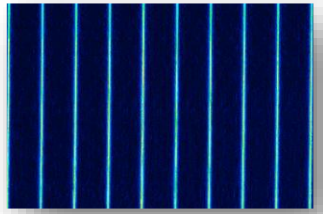
Flat-Top (2D)



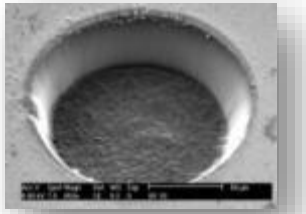
Flat-Top (1D)



Spot-Generator

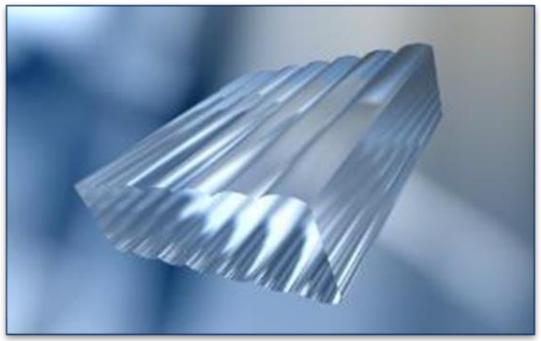


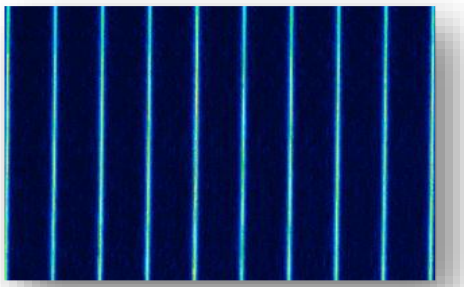
Line-Generator



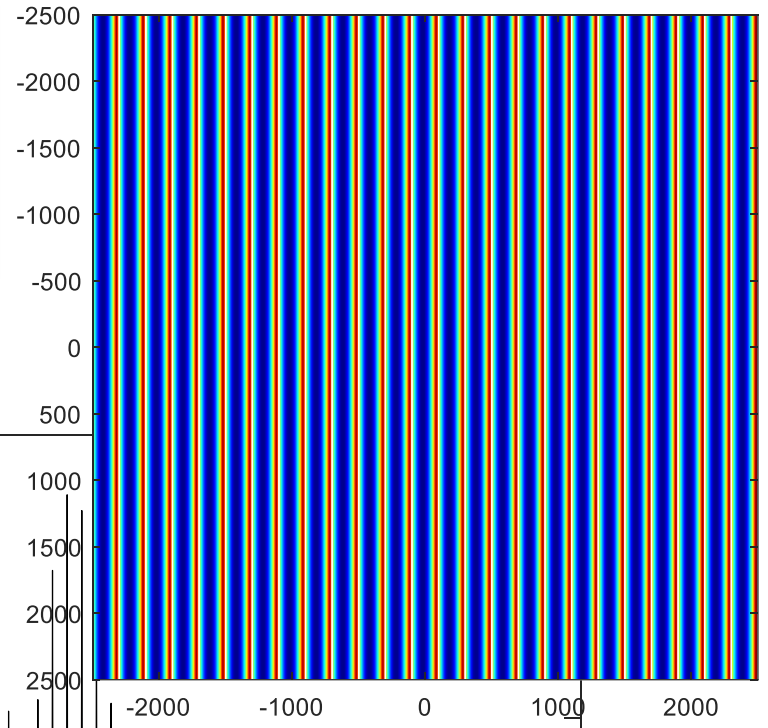
Ablation

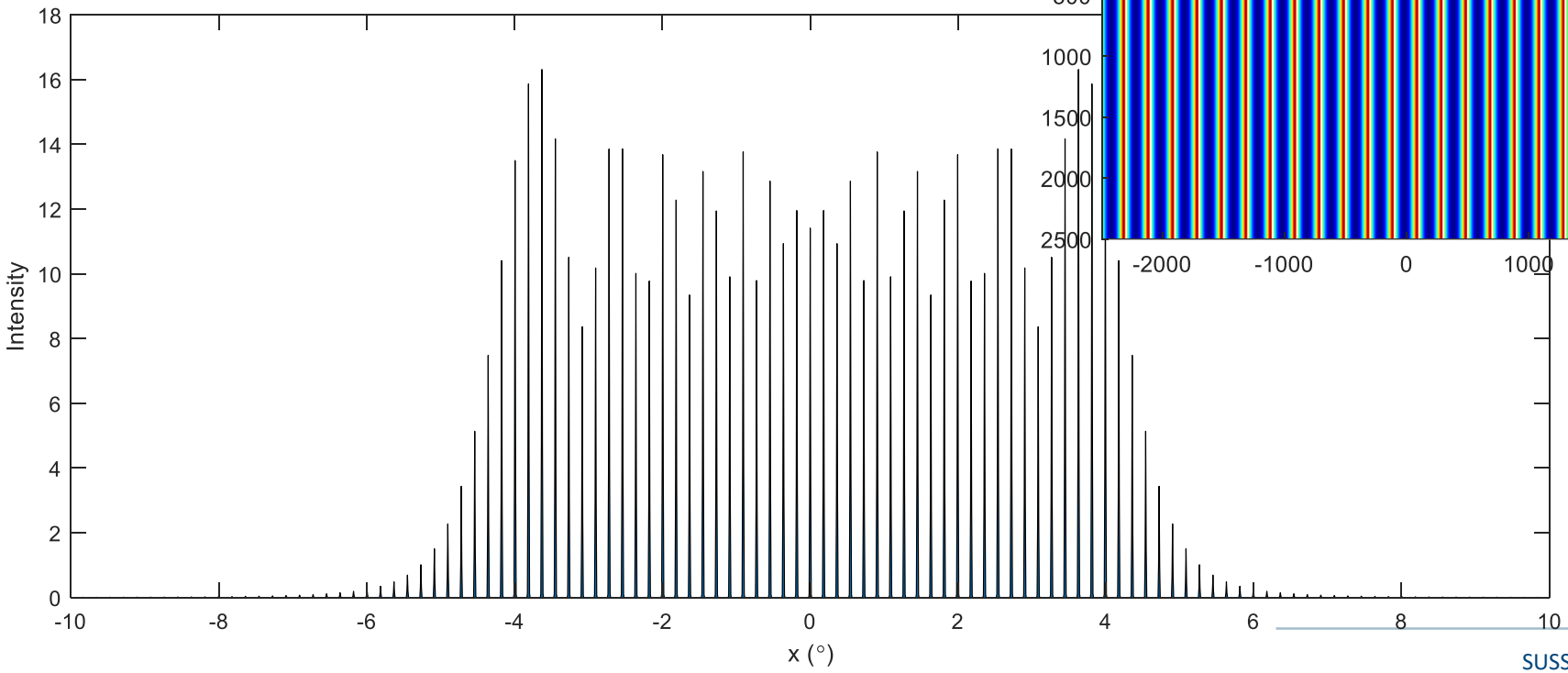
REGULAR CYLINDRICAL MLA → LINE GENERATORS



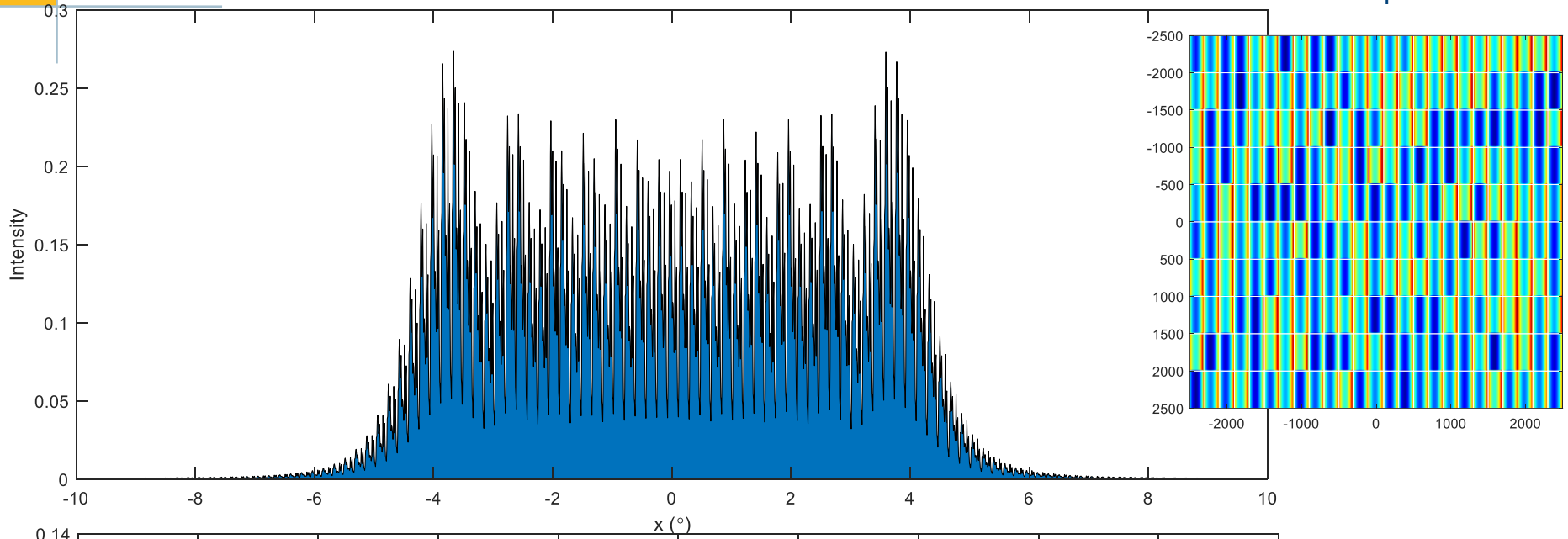


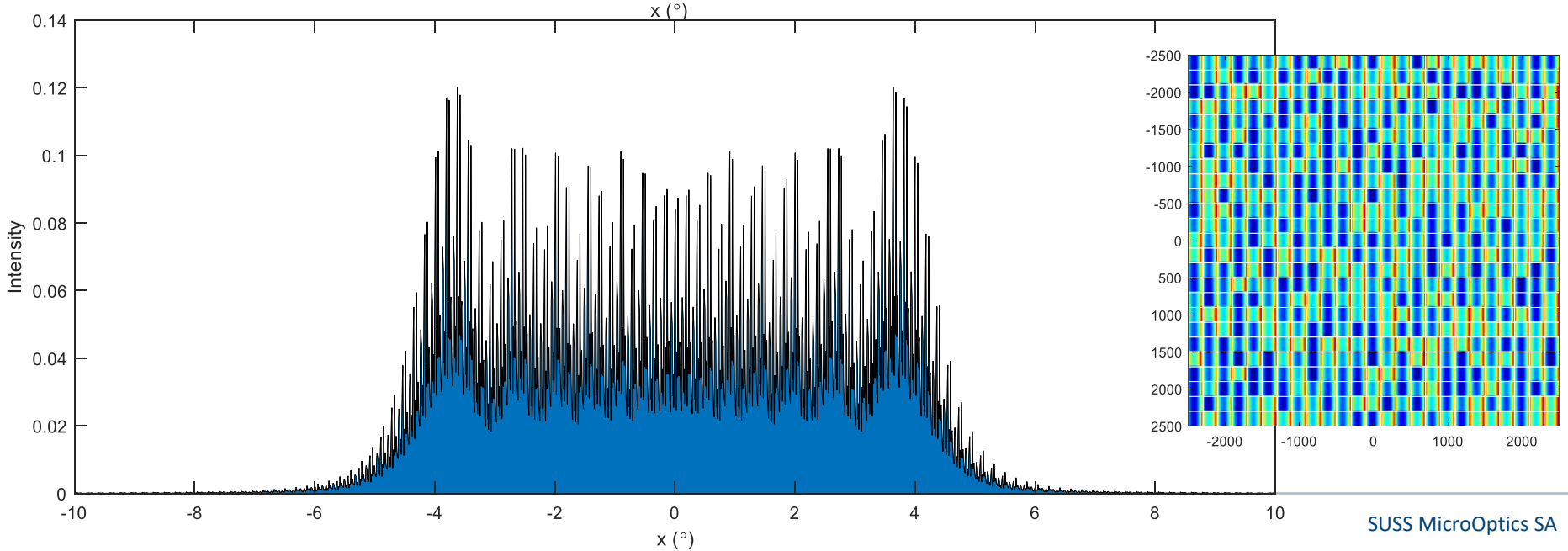
Line-Generator





RANDOM DIFFUSER





MICRO-OPTICS IN HIGH-END LITHOGRAPHY TOOLS

SÜSS MicroOptics

DOEs, microlens and micro-mirror arrays for pupil shaping and coherence forming

Microlens based Köhler Integrator Random Diffuser

ASML Twinscan NXT 1970 Ci

Pupil Shaping (Zoom)

Reticle

Phase-shift Masks

Synthetic Holograms for Asphere Testing

Projection Optics

Wavefront Shaping (FlexWave)

Gratings for Pulse Compression

Beam Delivery

Diffraction-based Overlay and Alignment

Wafer Plane

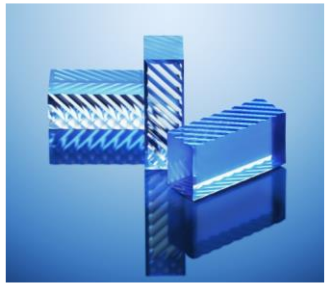
Monitoring of Aberrations (Zernike), Distortion, Overlay

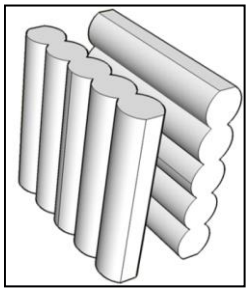
[Graph: Courtesy of Robert Brunner, formerly at Carl Zeiss AG, Germany]

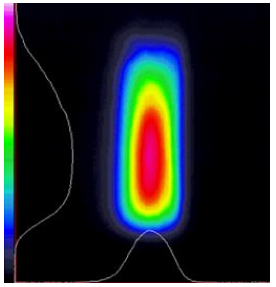
MICRO-OPTICS FOR PHOTOLITHOGRAPHY

SÜSS MicroOptics

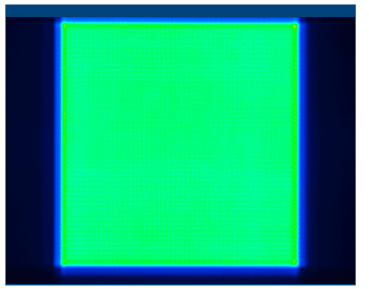
Microlens Arrays (ROE)





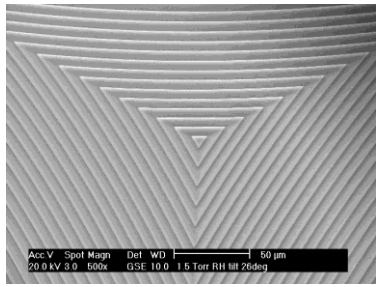


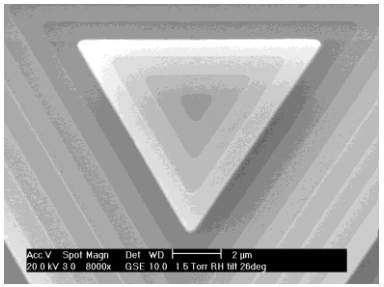
Excimer

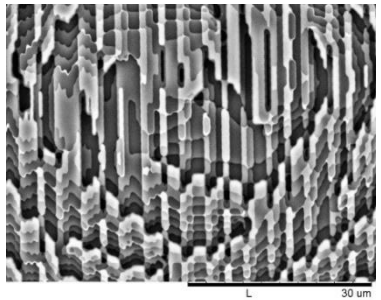


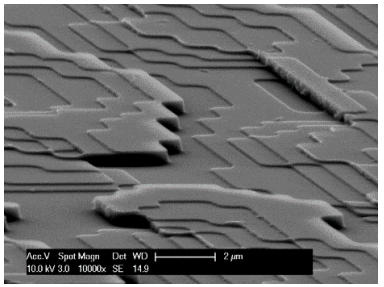
Flat-Top

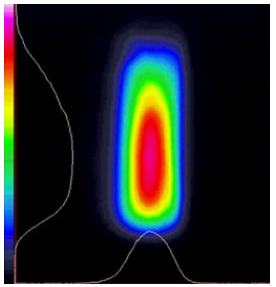
Diffractive Optical Elements (DOE)



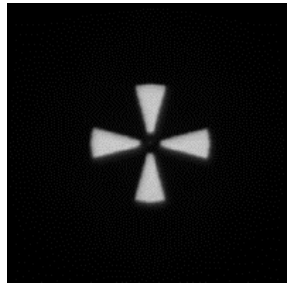


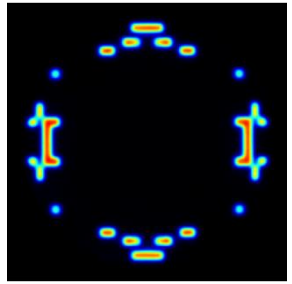






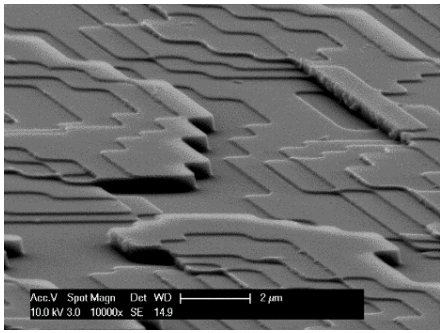
Excimer





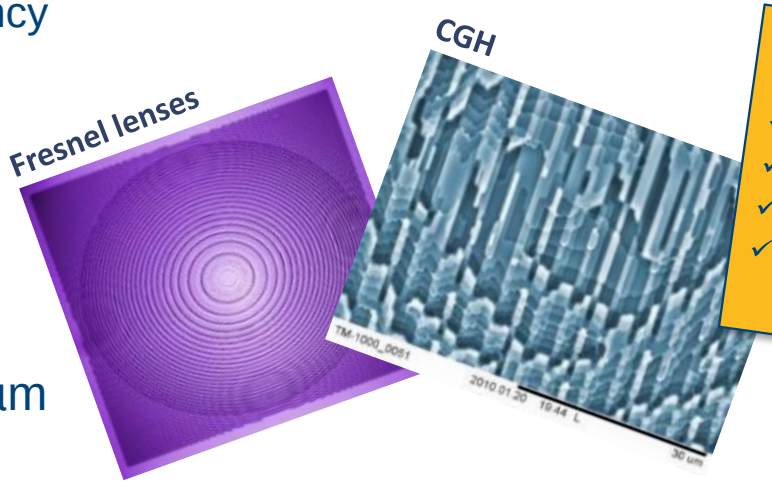
Sources: www.blz.org, Johannes Wangler (CZ SMT)

DIFFRACTIVE OPTICAL ELEMENTS (DOEs)



- DOEs for Fresnel lenses and beam shaping
- Silicon, fused silica (various grades)
- 2 (Binary) to 16 levels
  - 8 levels often offers the best compromise between efficiency and cost / fabrication
- Overlay error: guaranteed ≤ 70 nm, typically much better.
- Minimum feature size ≥ 250, depending on step height, etch depths
- Up to 96% efficiency

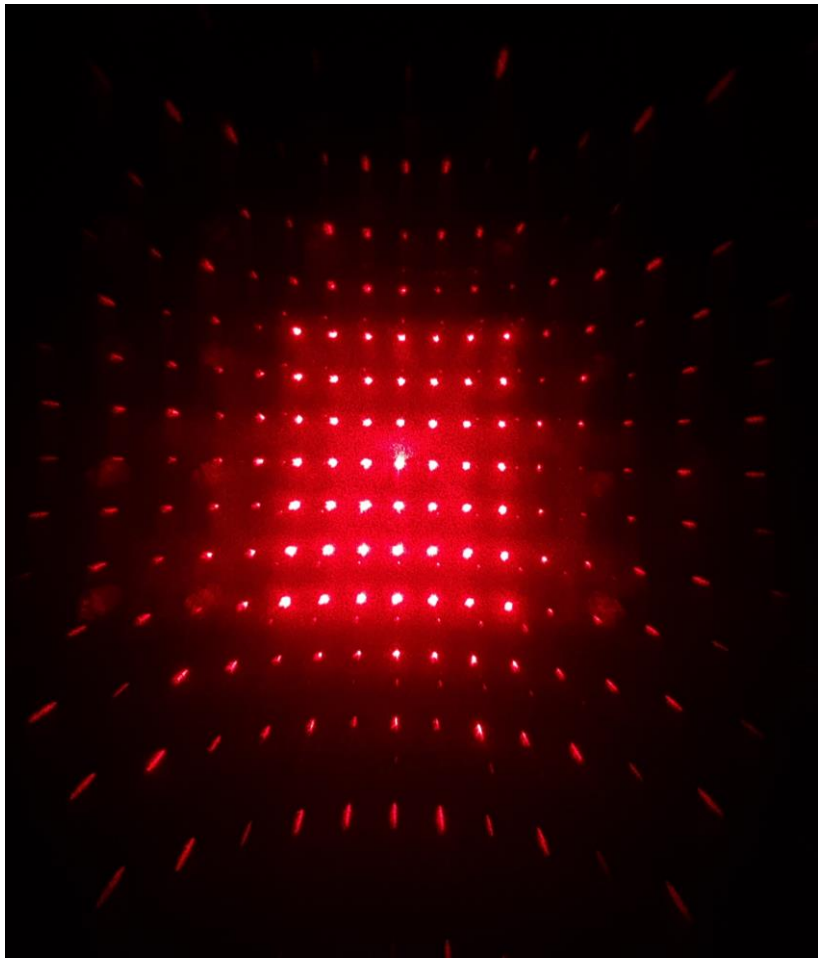
- **DUV stepper:**
  - Binary DOE
  - CD ≥ 250 nm
  - Etch depth: up to ~1 µm



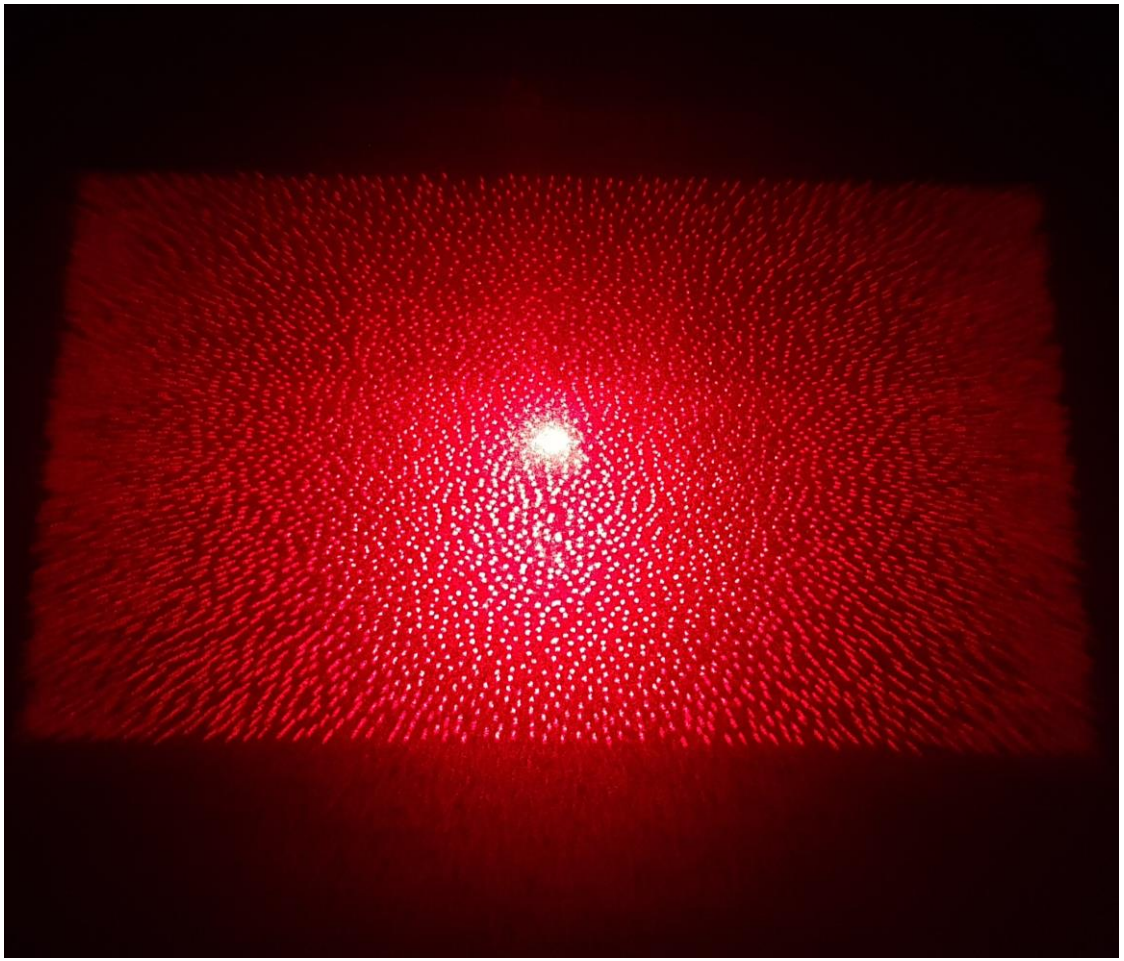
- ✓ MLAs and DOEs on one element
- ✓ Custom designs
- ✓ Fiducials, ID marks
- ✓ Pedestals & trenches
- ✓ AR coatings & metallisation
- ✓ Delivery options

EXAMPLES OF DOEs

+ Regular 7×7 dots array



+ Pseudo random dots array

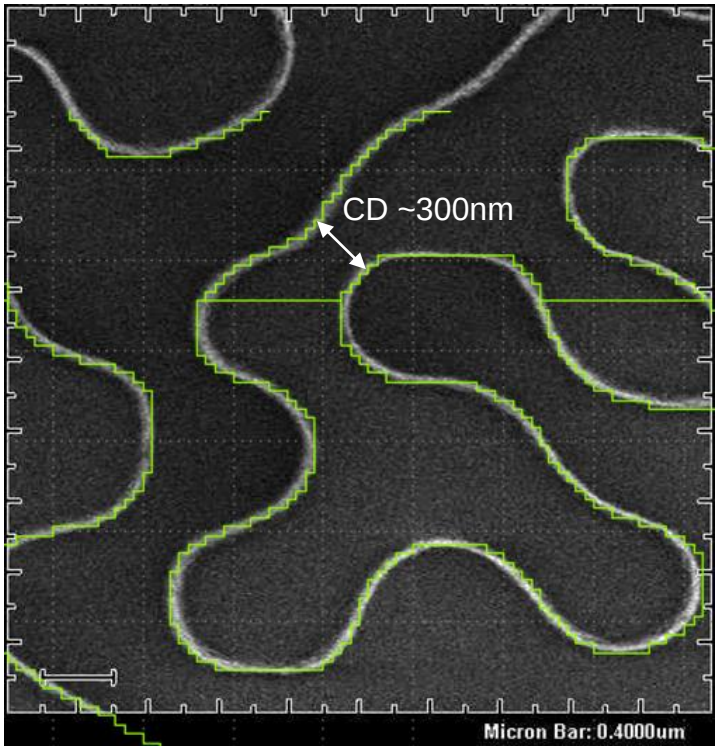


***NOTE**: The optical DOE design was for 940 nm. The optical demos are carried out at 670 nm wavelength*

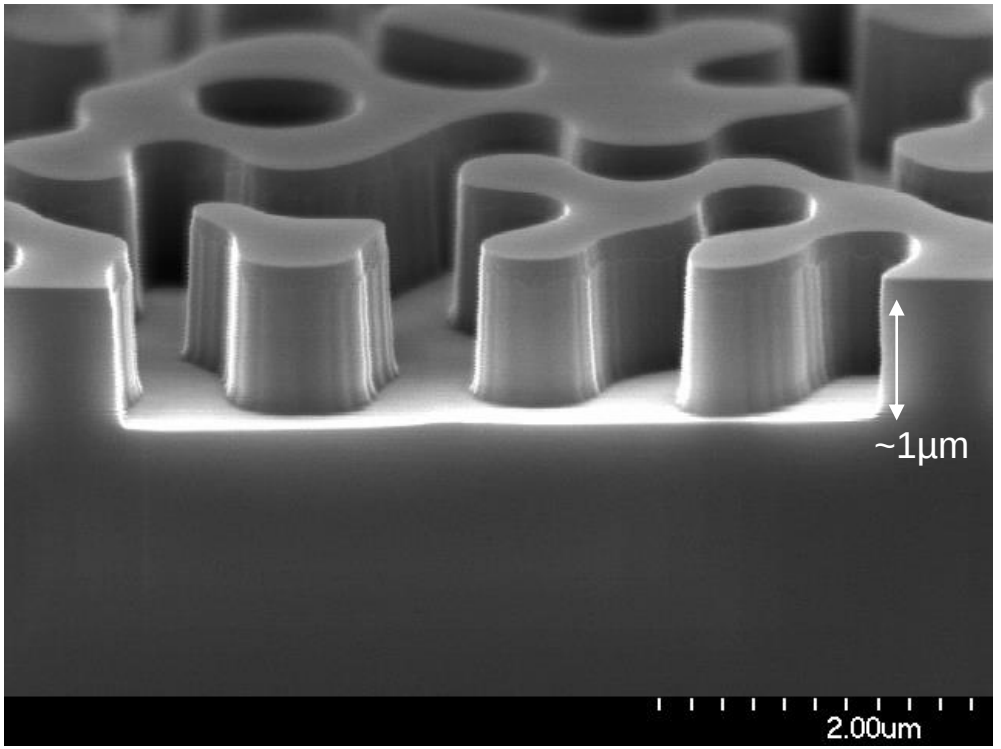
DUV STEPPER : 2-LEVEL MASTER IN SILICON

+ Beam-splitter (9×9)

Top-down images:
Overlay of photoresist and etched pattern



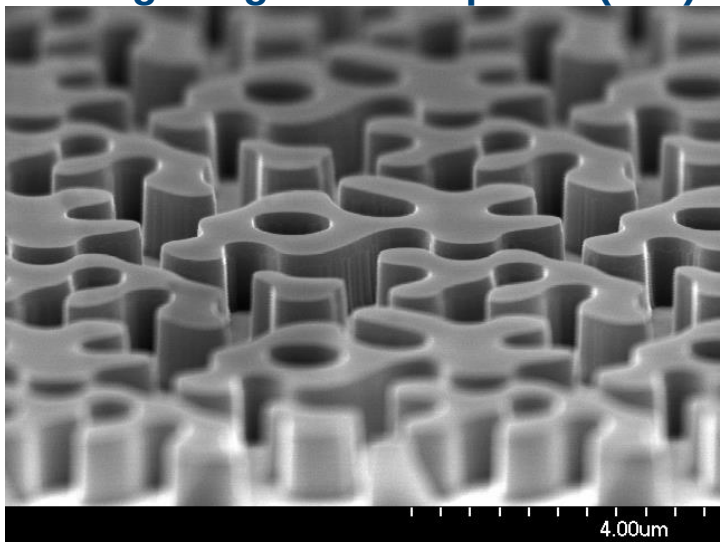
Cross section images:
etching depth and sidewall



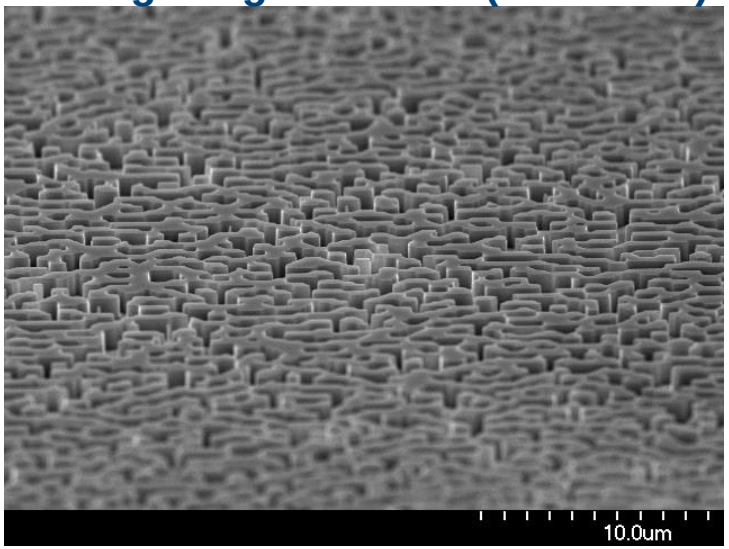
Design sampling size 50nm

DUV STEPPER : 2-LEVEL MASTER IN SILICON

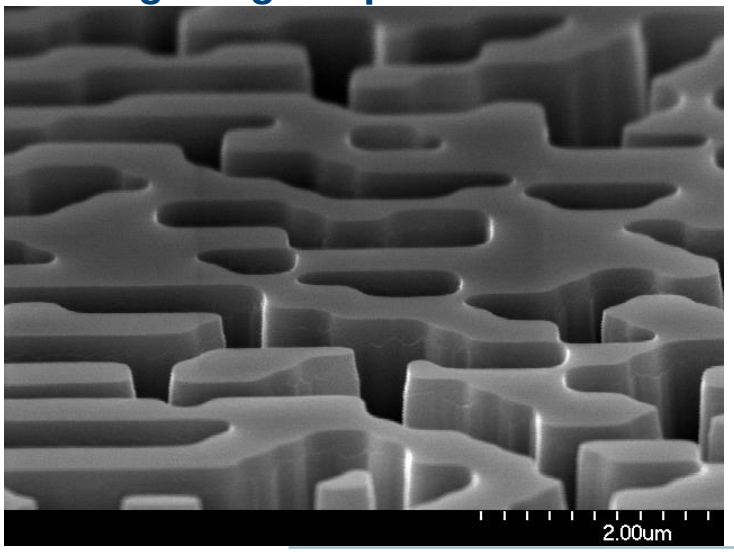
+ Large angle beam-splitter (9×9)



+ Large angle diffuser (5000 dots)

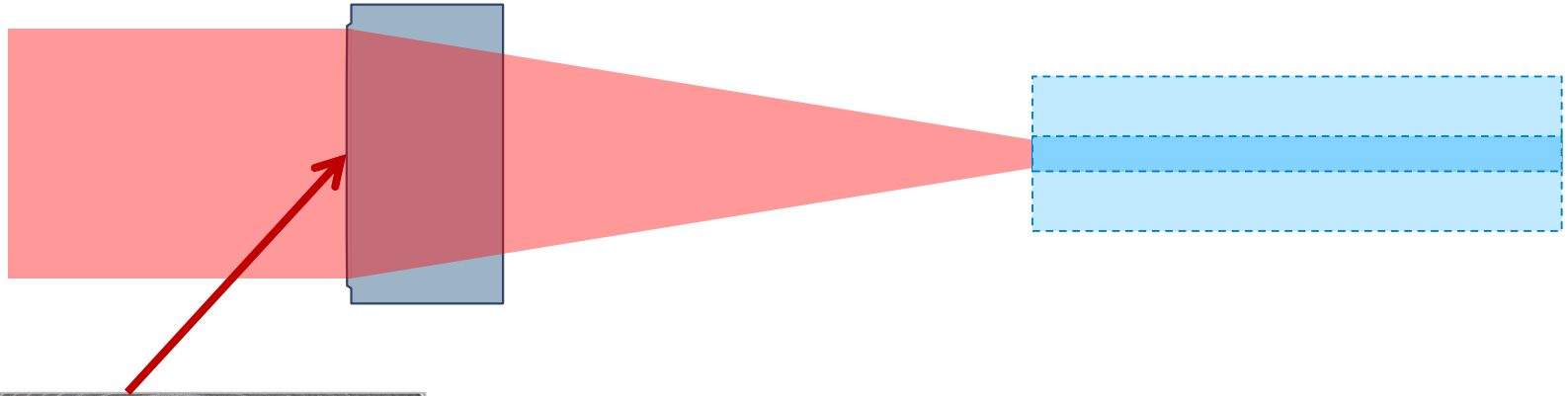


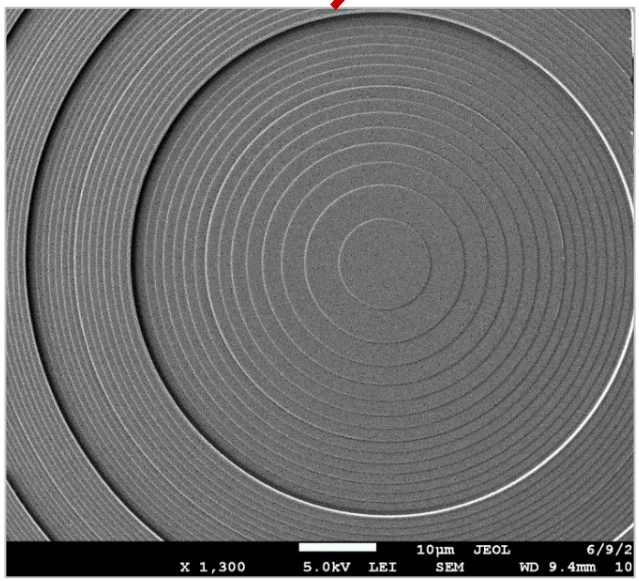
+ Large angle tophat diffuser



DIFFRACTIVE FIBER COUPLERS IN THE NIR

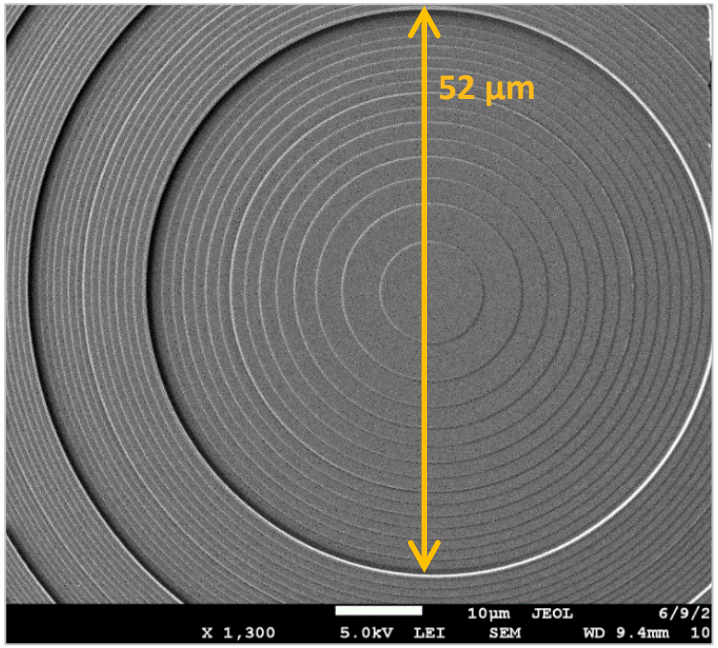
+ Collimation and re-focussing



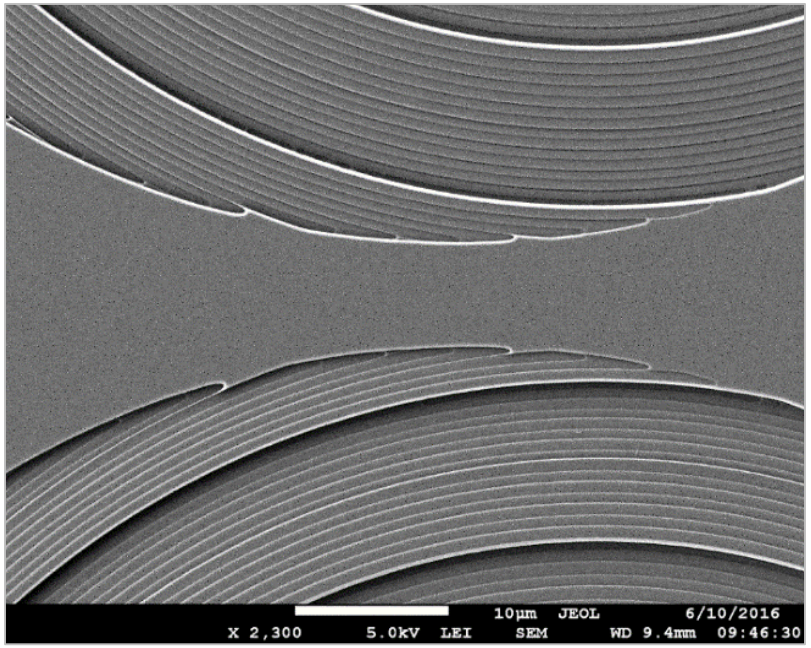


DIFFRACTIVE OPTICS IN SILICON

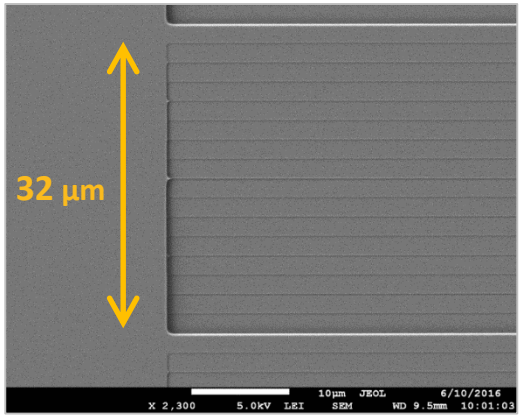
DOE / Fresnel Lens in Silicon for 1.55 µm ...



... with sub-µm features



16-Level Grating > 96% diffraction efficiency



- + **stepper technology**
- + **different radii or curvature in different directions**
- + **no gaps between the lenses**
- + **partial lenses for off axis optics**
- + **design support available**

ARRAYS OF DIFFRACTIVE OPTICS IN SILICON

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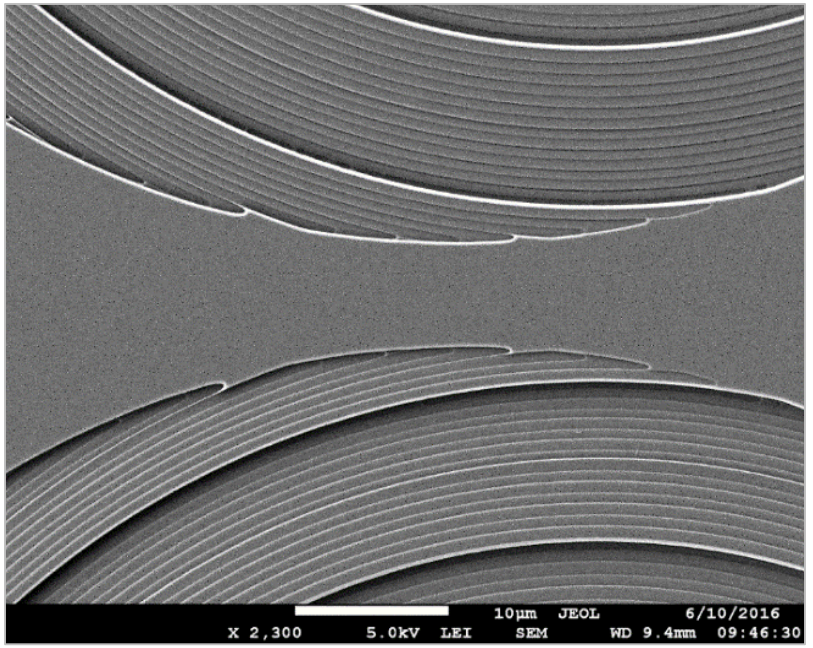
Design option …

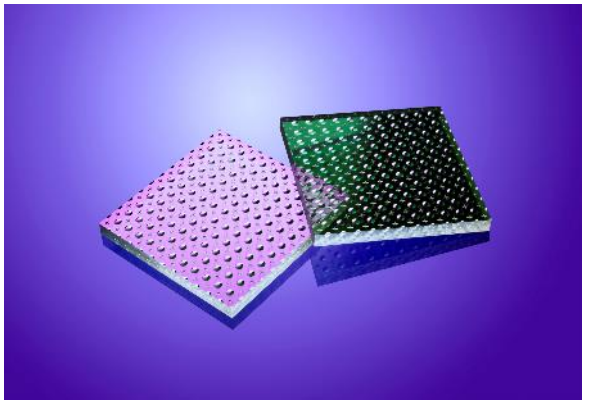
… with sub-µm features

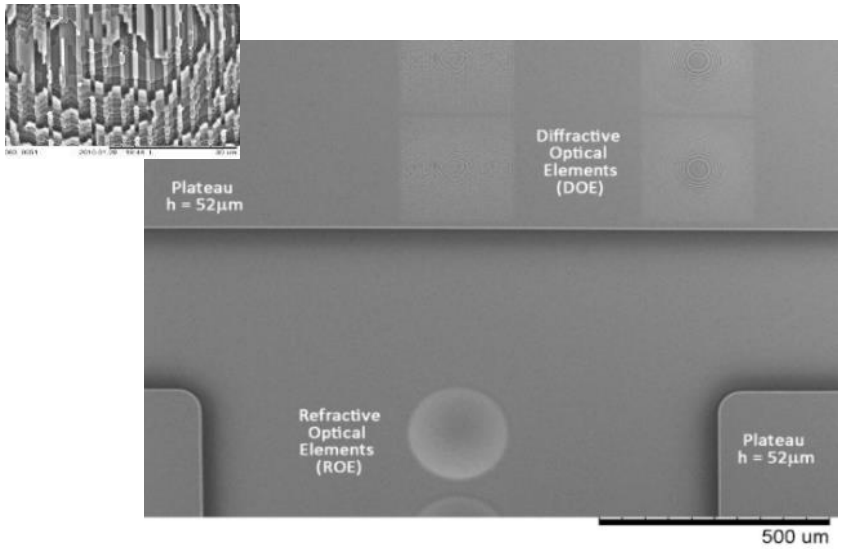


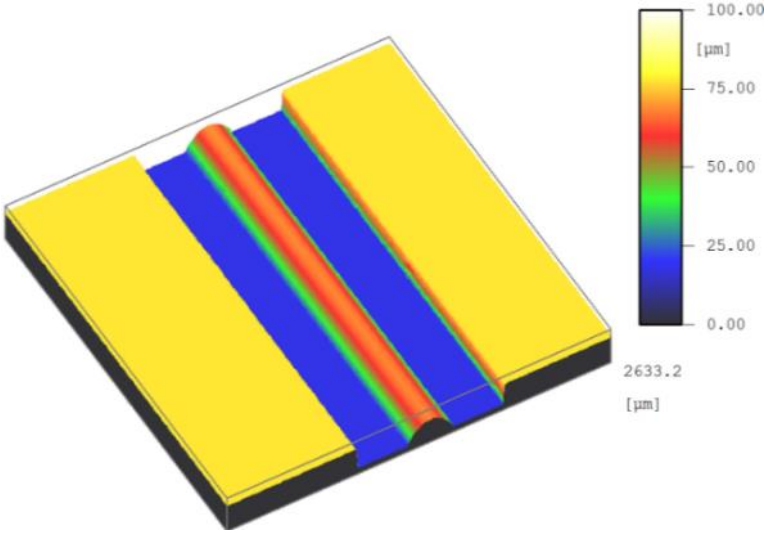
+ no gaps between the lenses
+ partial lenses for off axis optics
+ design support available

HYBRID MICROOPTICS ON WAFER-LEVEL

- Refractive Microlens Arrays
- Diffractive Optical Elements (DOE)
- Trenches, posts, grooves
- Full wafer-level integration







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