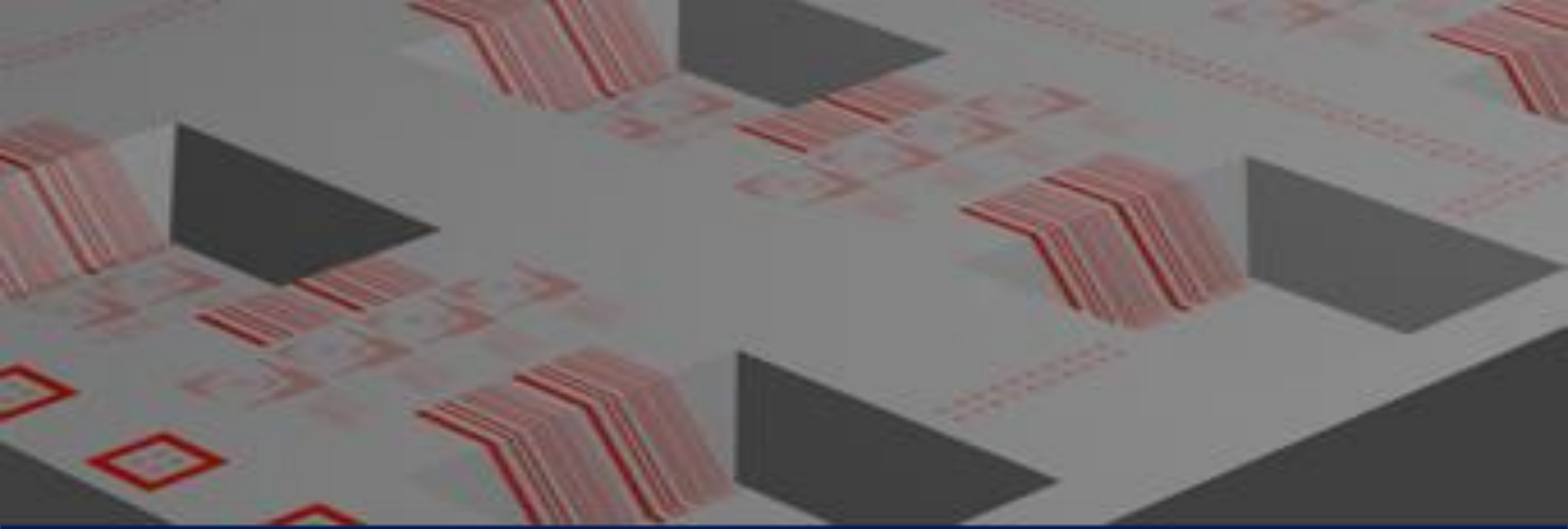


HoliSTEP

Sub-Wavelength Holographic Lithography Stepper for Integrated Circuit Production

Natasha Ivanova, SWHL GmbH

HoLiSTEP

Co-funded by the European Union

- HoLiSTEP aims to demonstrate the potential of sub-wavelength holographic lithography (SWHL) as a disruptive lithography for high-resolution 2D and 3D patterning for semiconductor and micro component devices manufacturing
- During the project we are building and validating an industrial prototype of holographic stepper operating at a wavelength of 345nm with 200nm resolution

HoliSTEP Partners

Fraunhofer ENAS

SWHL GmbH

Mimotec
Microparts for great ideas

FLEXIBLE OKO OPTICAL

Tampere University

AMPLICONYX

Capgemini engineering

EKSPLA

MODUS
Research and Innovation

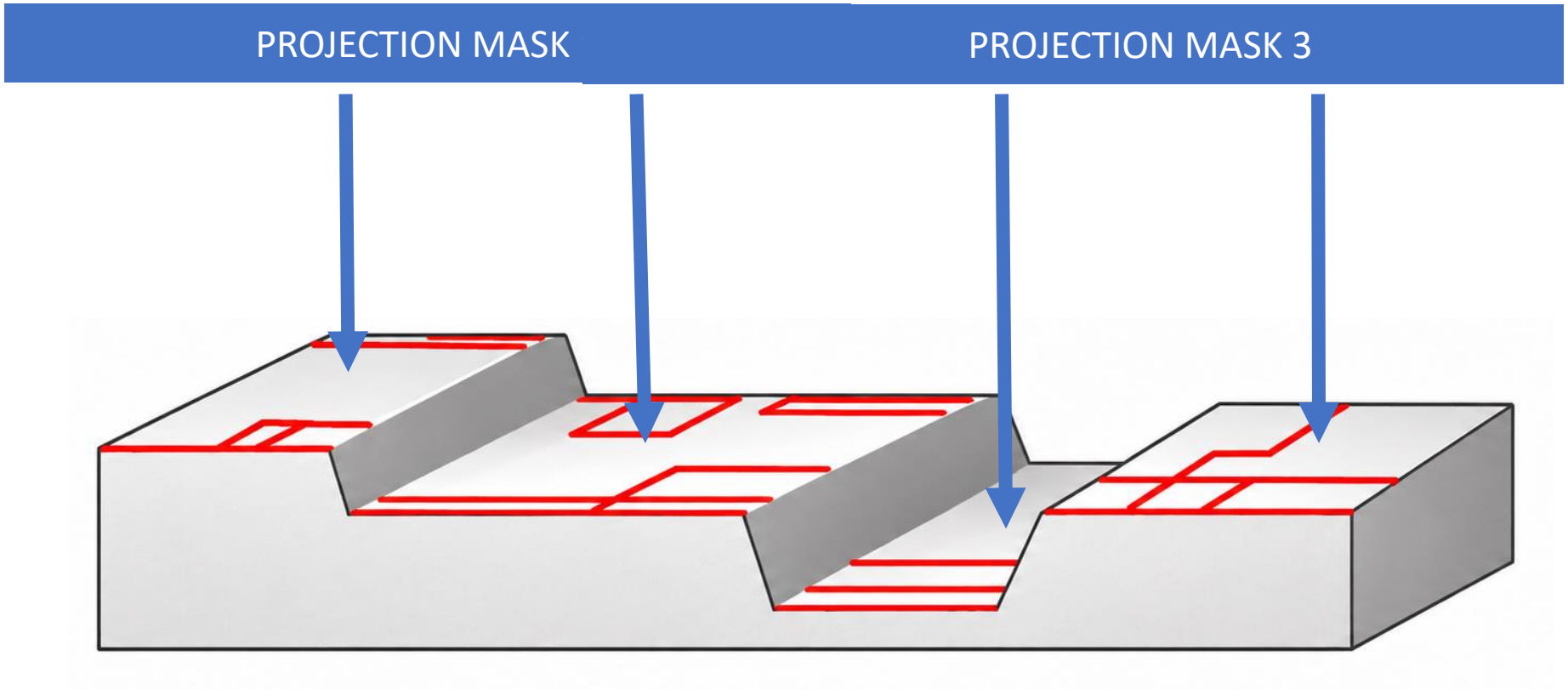
UNIVERSITY OF EASTERN FINLAND

SWHL

SWHL has the potential to overcome limitations of projection lithography:

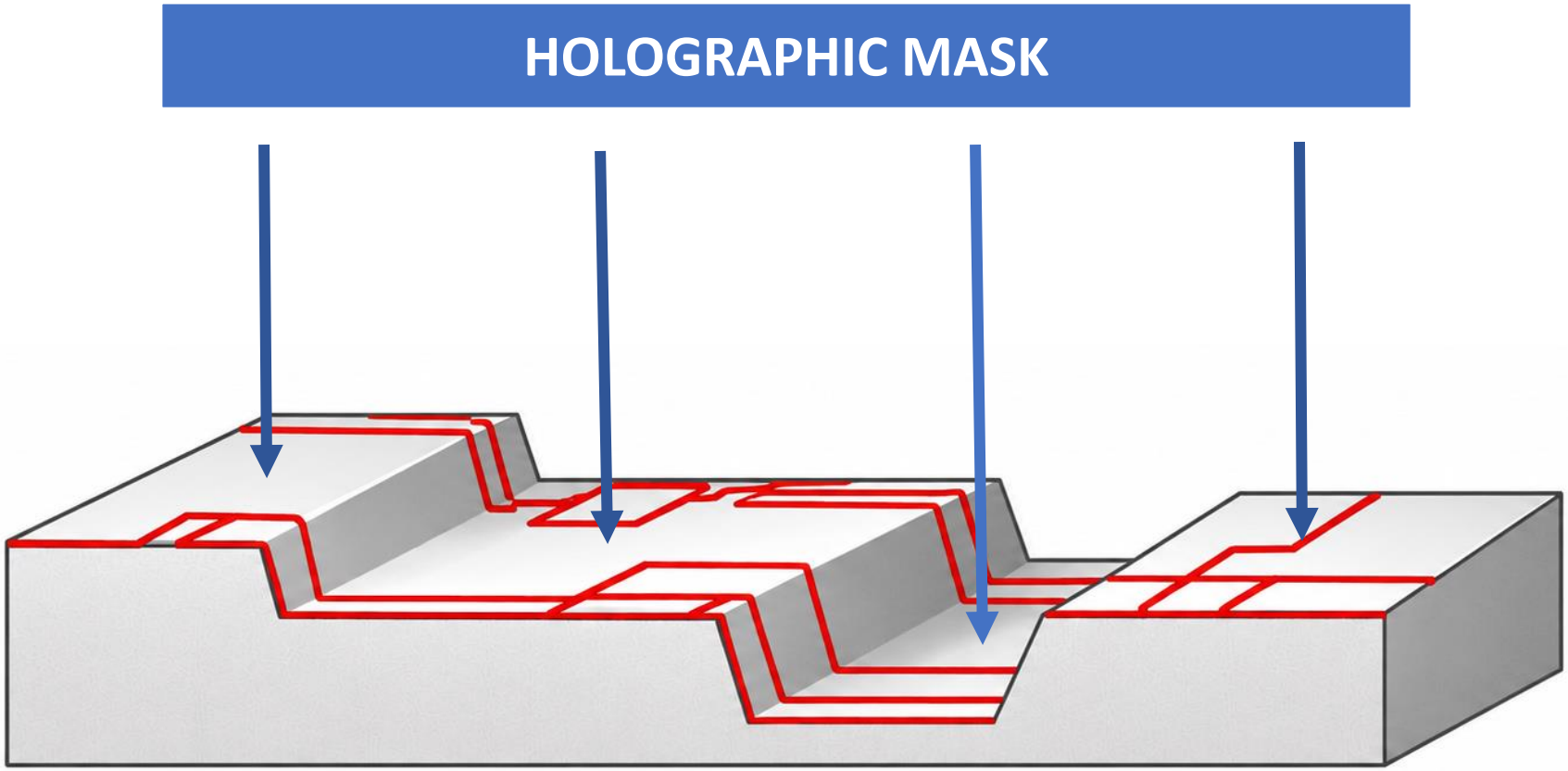
- Unique capability to produce high-resolution 3D structures in one single exposure
- Significant cost reduction for photomasks and equipment production
- Infinite lifetime of holographic masks
- Applicability across all technology nodes

PROJECTION LITHOGRAPHY



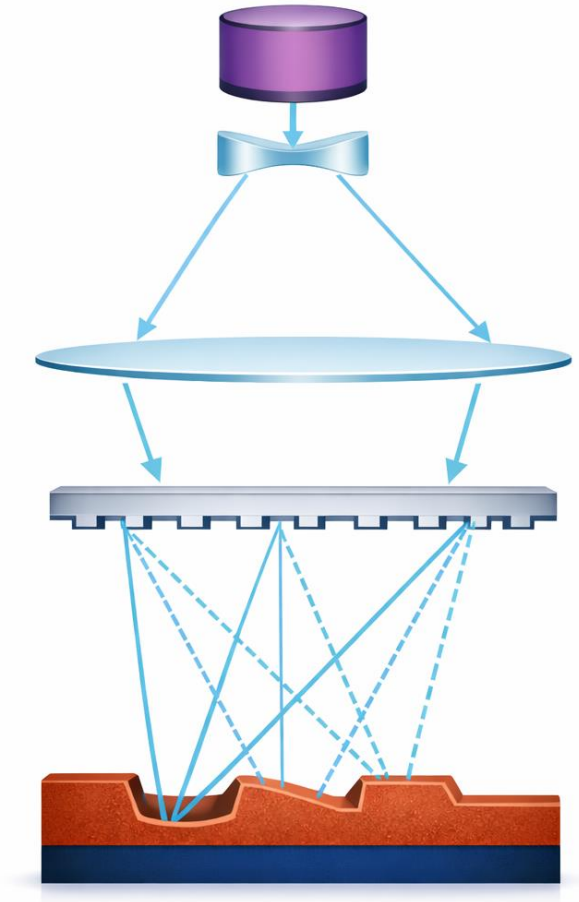
3 projection masks, 3 exposures, 3 alignment steps,
patterning on leaning walls required even more exposures

SWHL



1 holographic masks, 1 exposure, 1 alignment step, simultaneous patterning on leaning walls

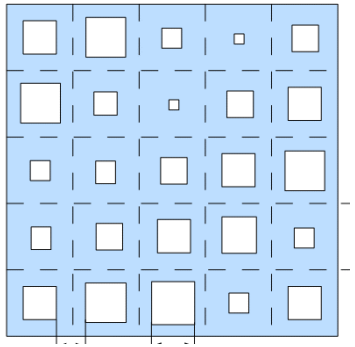
SUB-WAVELENGTH HOLOGRAPHIC LITHOGRAPHY (SWHL) PRINCIPLE



Source of coherent light

Illumination optics

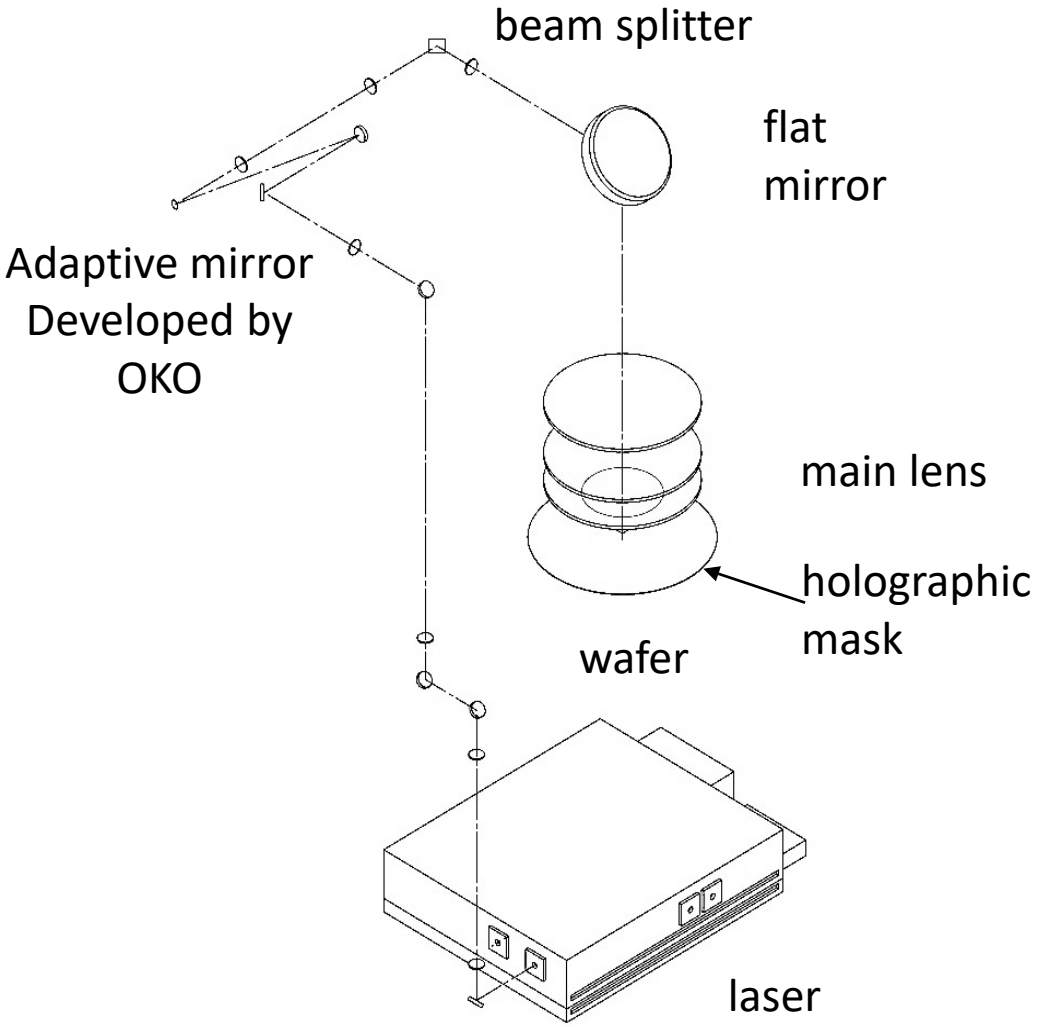
Holographic mask

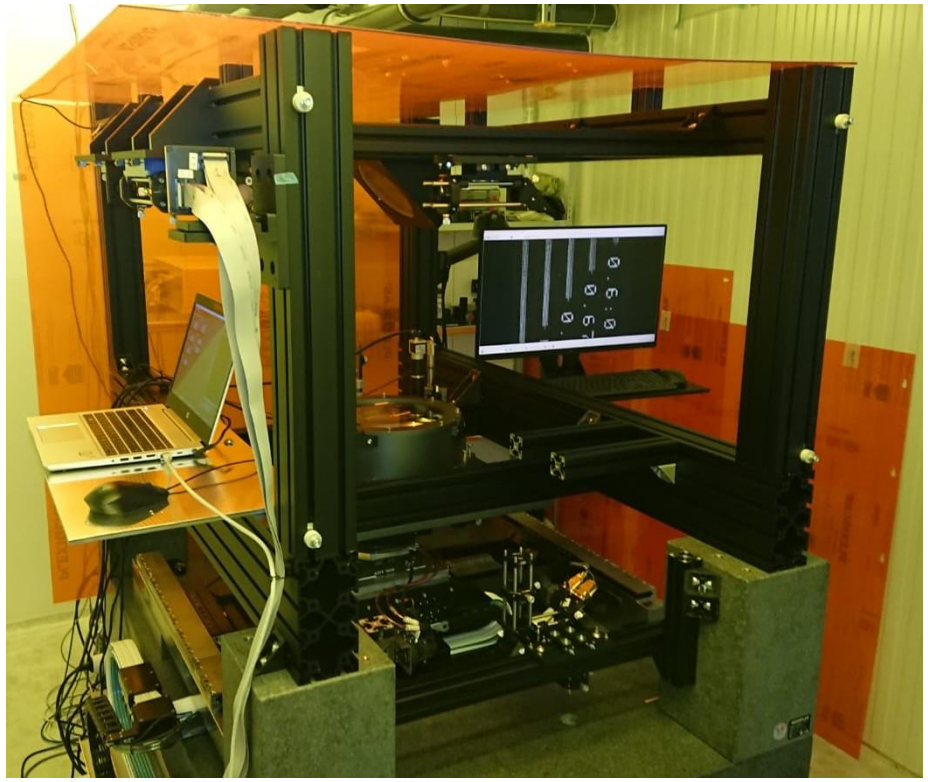


No projection lens

Images on flat and non-flat wafers at one exposure

HOLISTEP STATUS - ALFA-TOOL HS-500 BUILT AND IS BEING VALIDATED

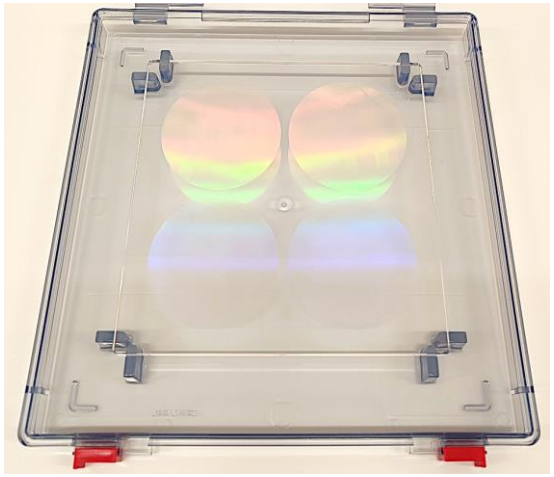




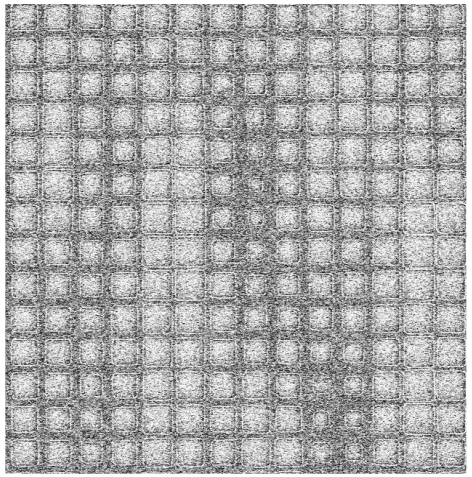
Wavelength 388nm, optical resolution 500nm

HOLISTEP STATUS - BINARY PHASE HOLOGRAPHIC MASK

Fused silica substrate with 4 x Mask Set produced by FH ENAS



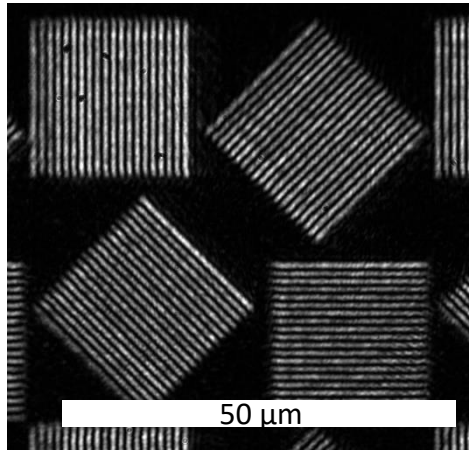
SEM image of holographic mask structure



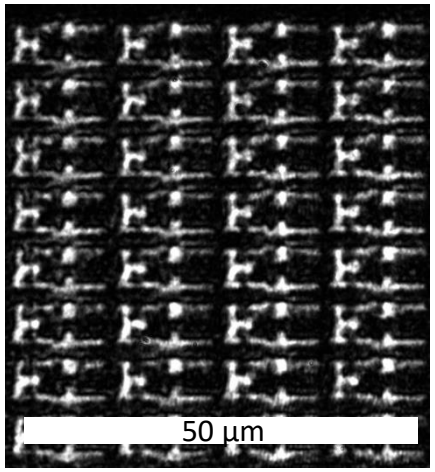
Mask size	circle 63mm in diameter
Mask grid pitch	1um
Mask element size	270 – 900 nm
Phase modulating layer thickness	407nm
Mask element shape	square
Min CD on the mask	100nm

HOLISTEP - EXPERIMENTAL RESULTS – AERIAL IMAGES

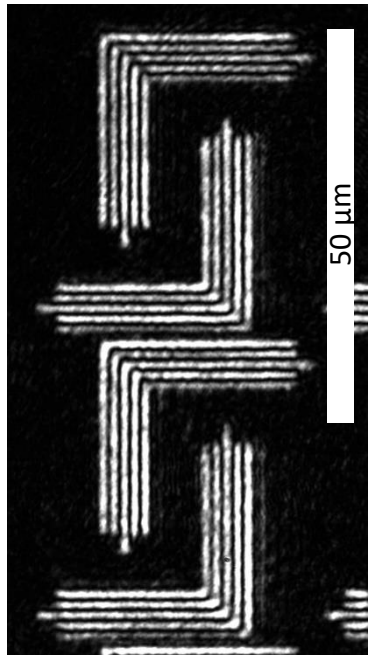
line 0.5/ gap 0.5



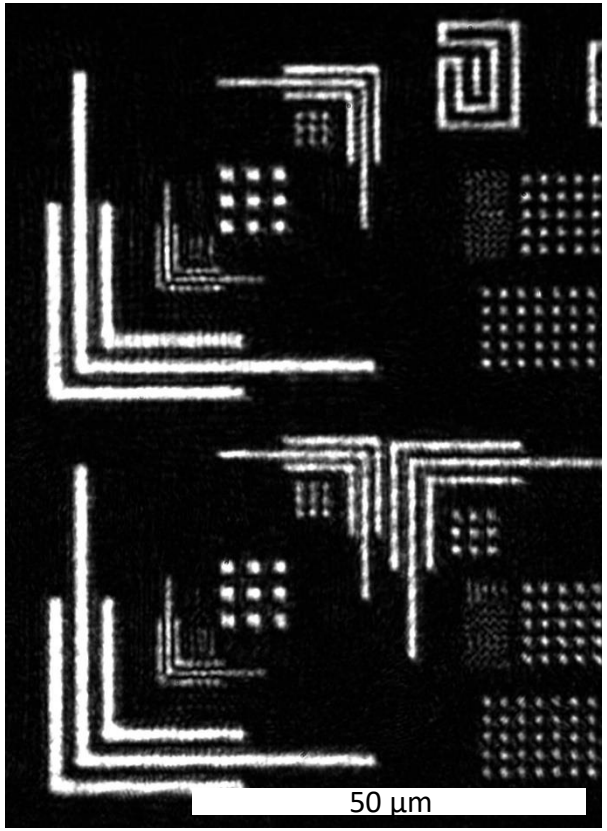
line 0.5/ gap 0.7



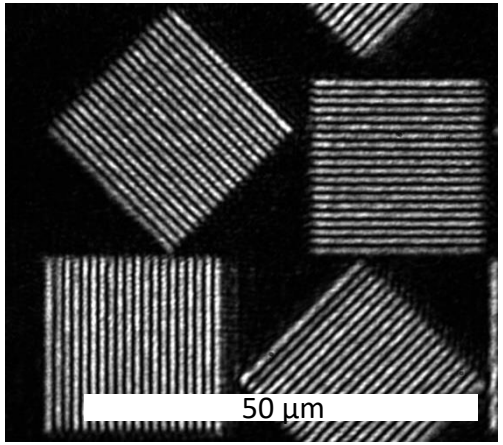
line 0.7/ gap 0.6



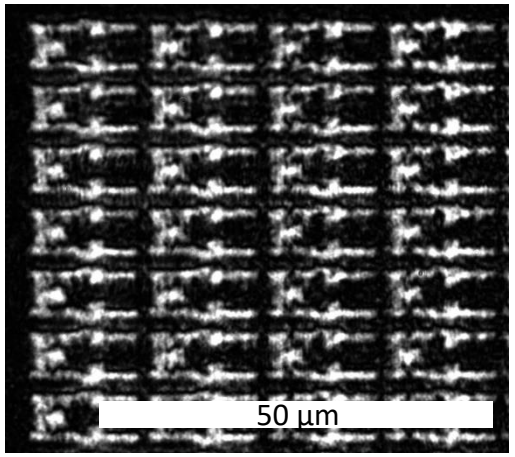
line 0.5/ gap 0.6



line 0.6/ gap 0.5

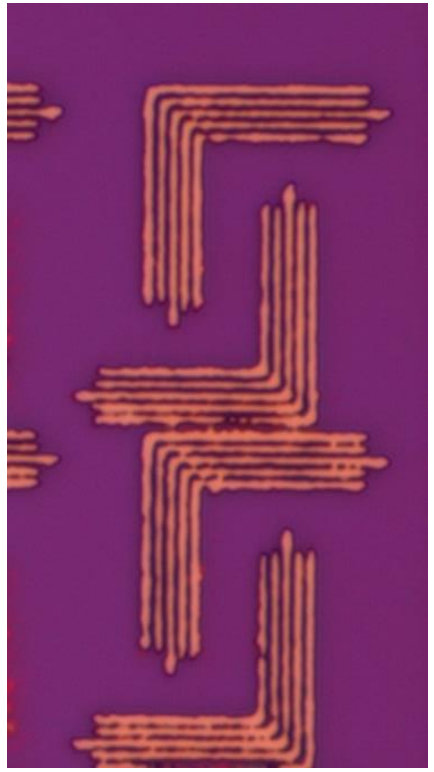


line 0.7/ gap 0.55



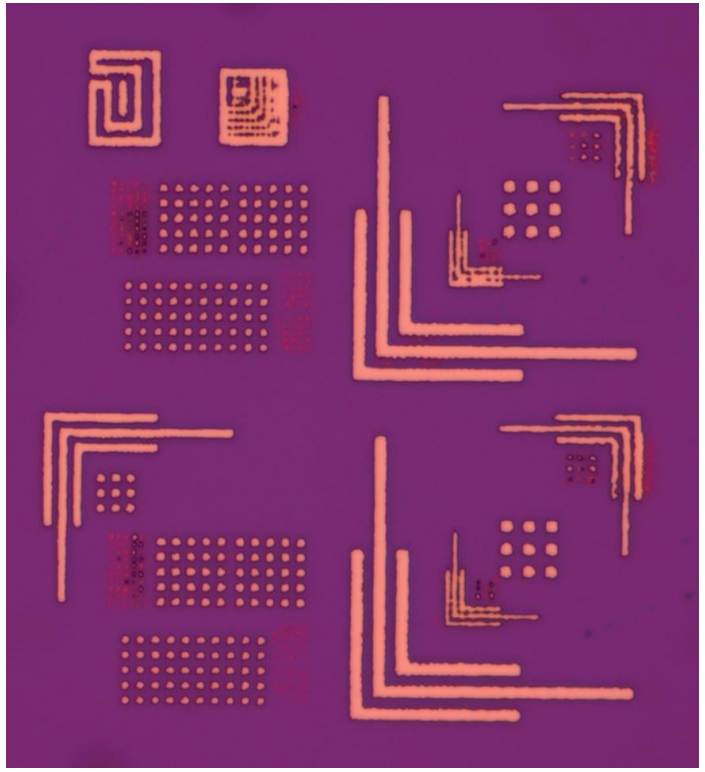
HOLISTEP - EXPERIMENTAL RESULTS – PATTERNS IN RESIST ON FLAT WAFER

line 0.7/ gap 0.6



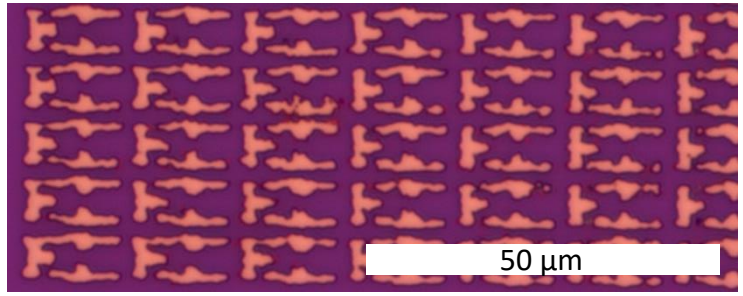
50 µm

line 0.7/ gap 1.0

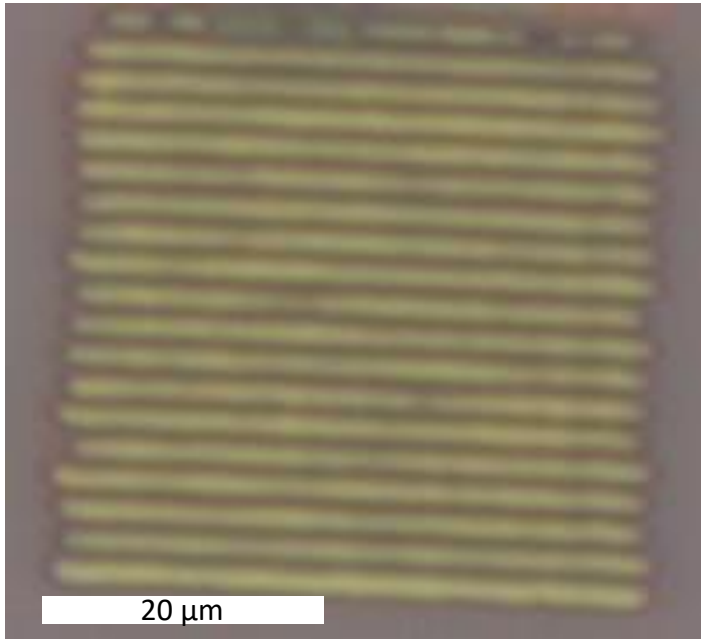


50 µm

line 0.7/ gap 0.7



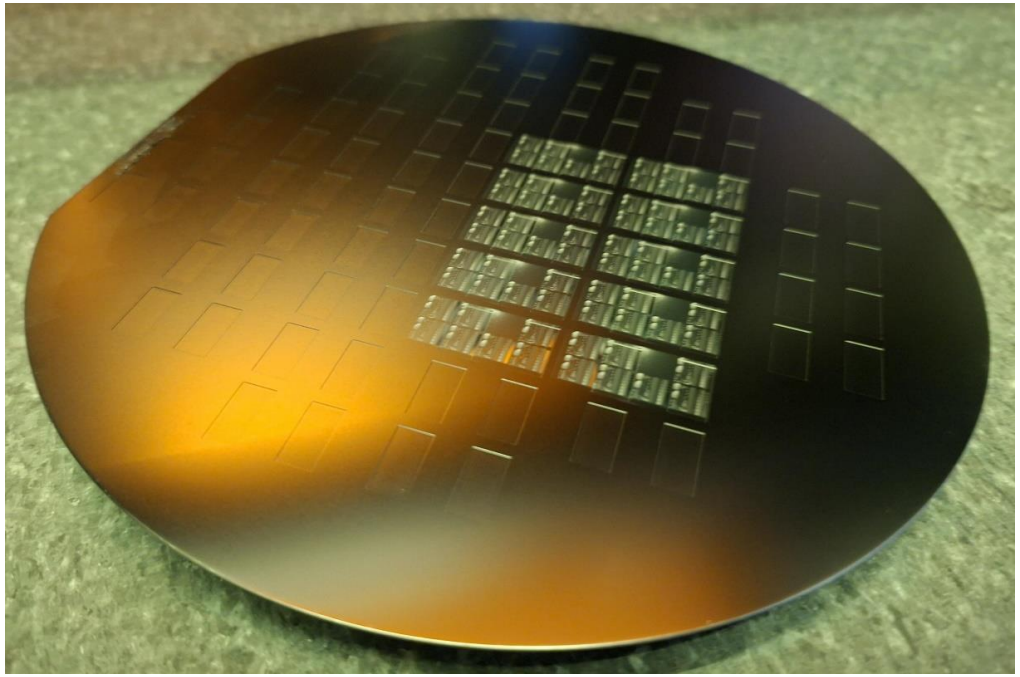
line 0.55/ gap 0.55

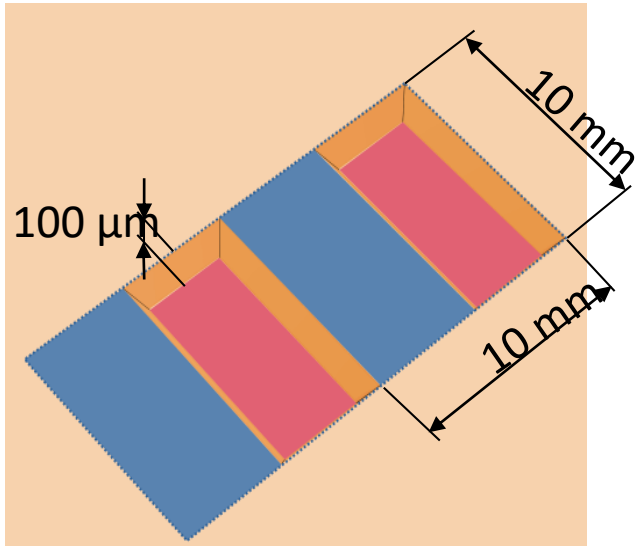


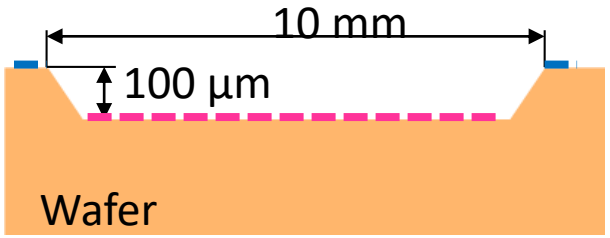
- 150 mm flat wafer spin-coated with mr-P 1201 LIL resist with 0.1 µm thickness delivered by ENAS
- Exposures performed by SWHL

HOLISTEP – EXPERIMENTAL RESULTS ON WAFERS WITH TOPOGRAPHY

- 150 mm structured wafer
- topography has two tiers with vertical distance 100 µm
- AZ4999 resist, resolution 1-2 µm CD
- spray coated with 3.6 µm thickness
- delivered by FH ENAS

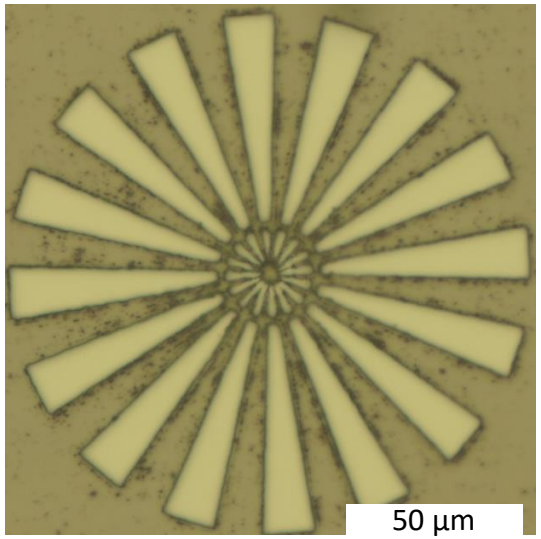


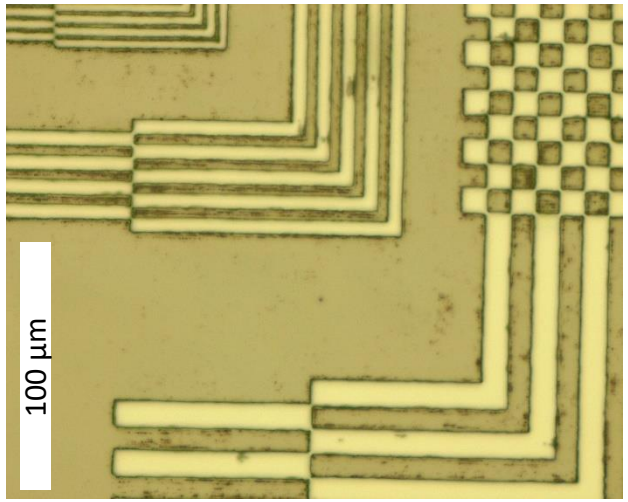




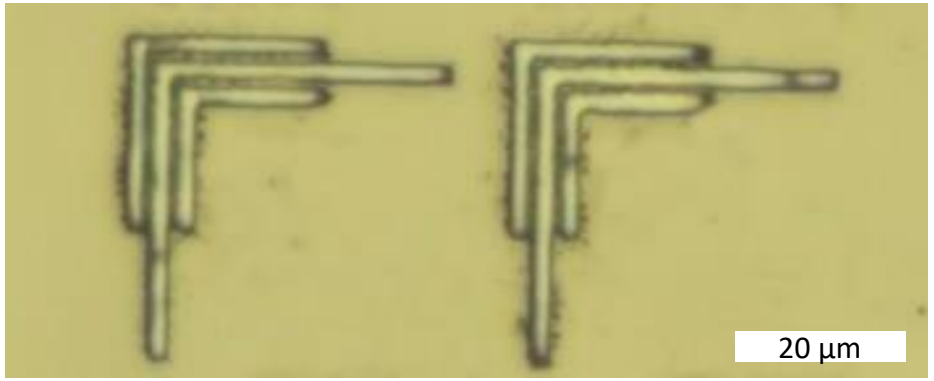
EXPERIMENTAL RESULTS – PATTERNS IN RESIST ON WAFER WITH TOPOGRAPHY

Bottom tier

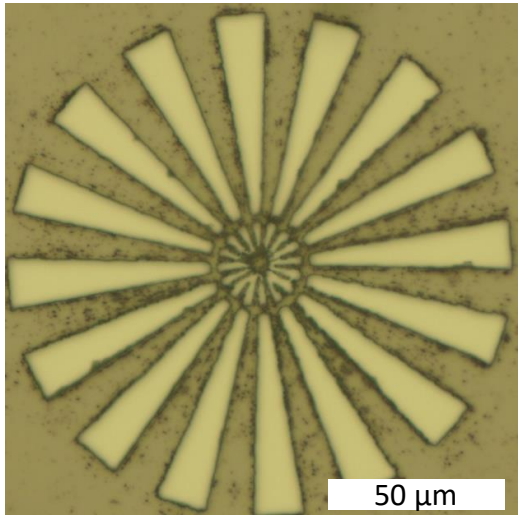


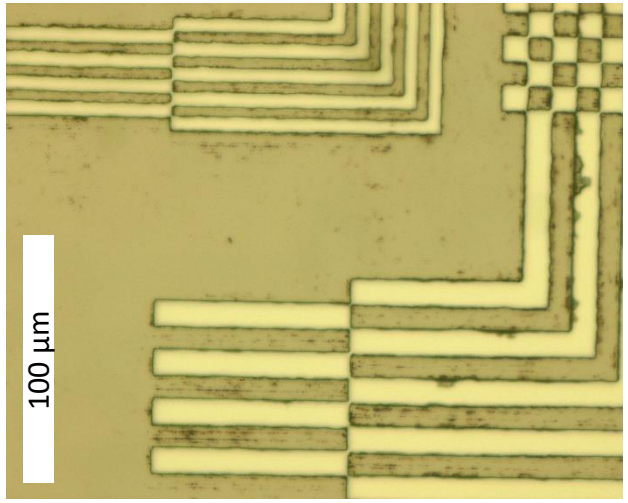


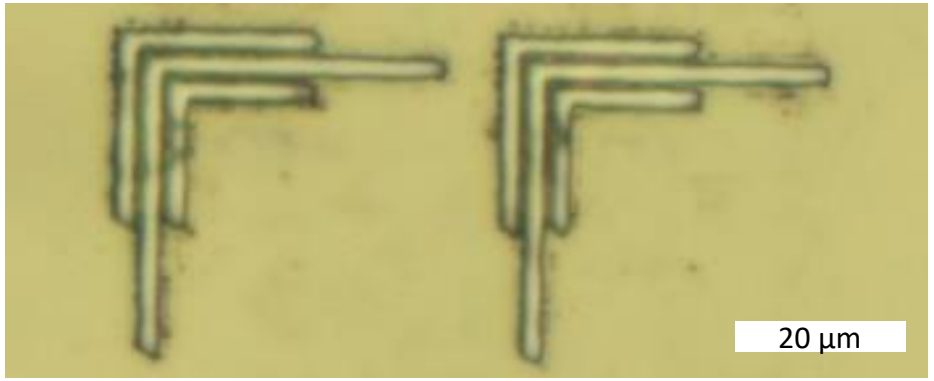
Half-pitch 1.5 µm



Top tier

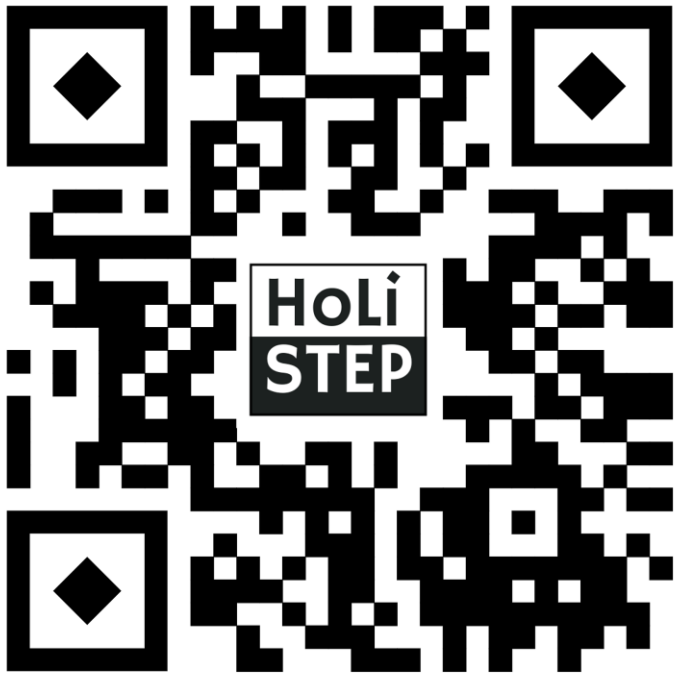






HOLISTEP – NEXT STEPS

- HS-500nm tool to be transformed into HS-200nm tool
- 354nm laser to be finalised and integrated into holographic lithography tool
- Alignment system to be integrated into the HS-200nm tool
- Further experimental exposures to be performed to validate HS-200nm tool performance for 2D and 3D patterning



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State Secretariat for Education, Research and Innovation SERI