Sub-Wavelength Holographic Lithography technology for production of non-planar 3D holographic images

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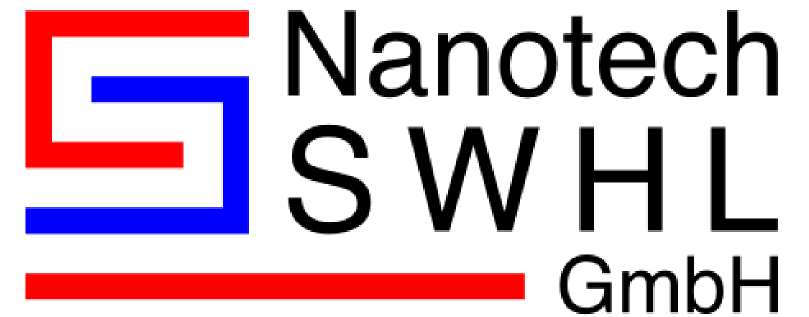
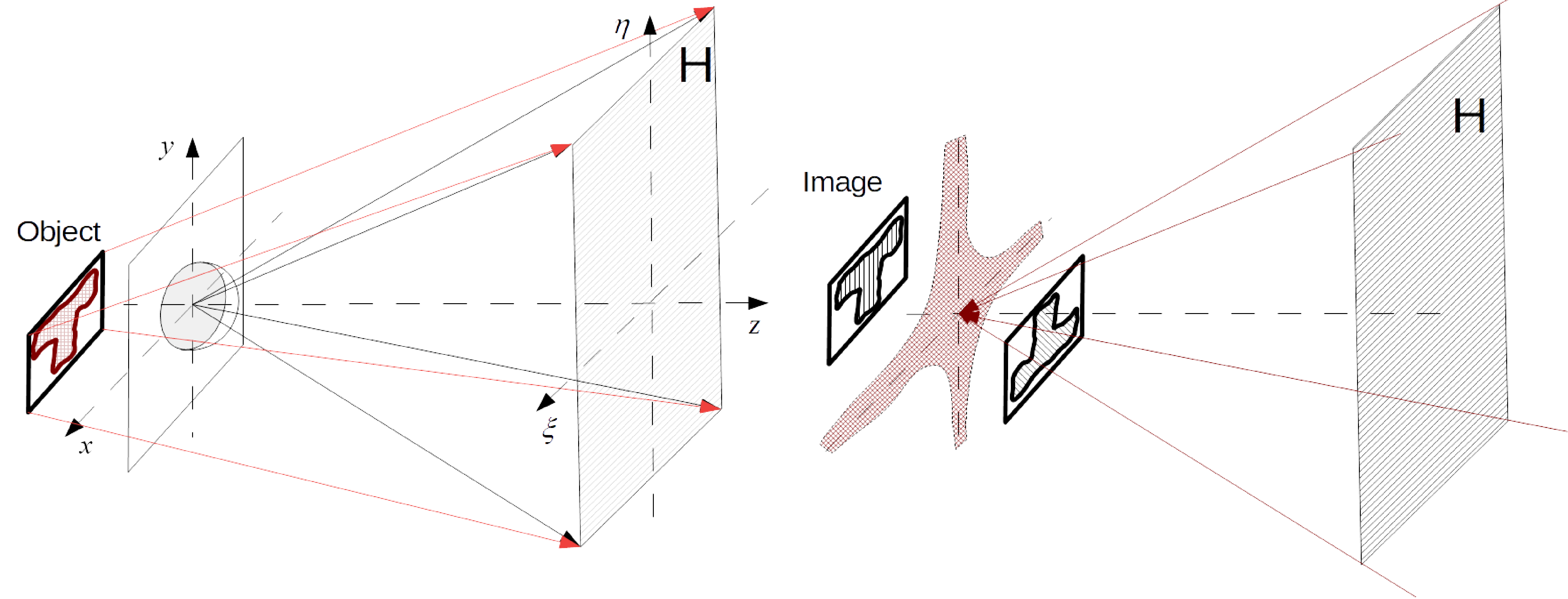


Why Holography?

- Native non-flat imaging with flat mask and one exposure
- Both holographic mask and forming lens are simple and inexpensive
- Image quality is resistant to holographic mask defects

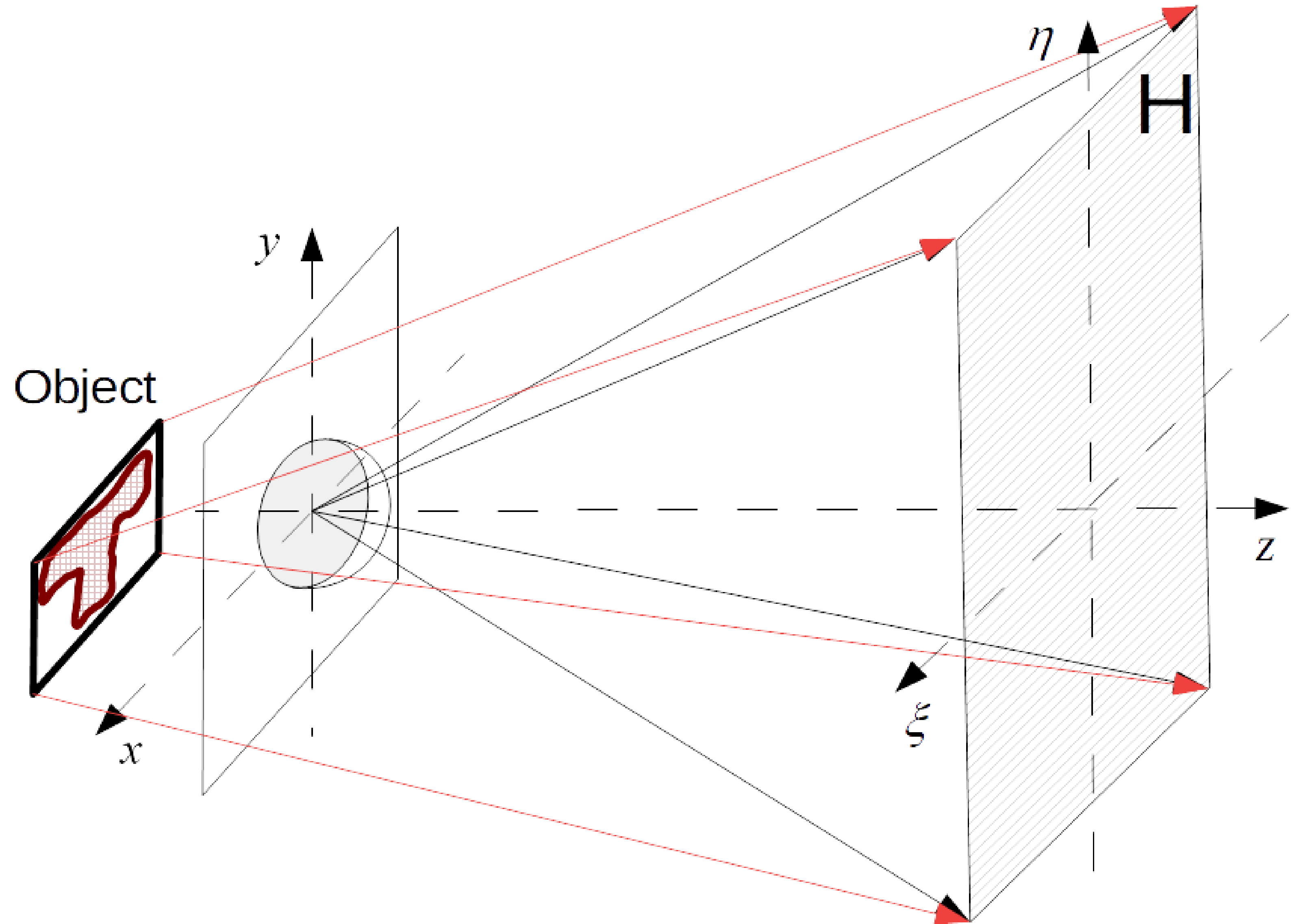
Holographic Imaging Approach



Simple Holographic Mask Synthesis Scheme

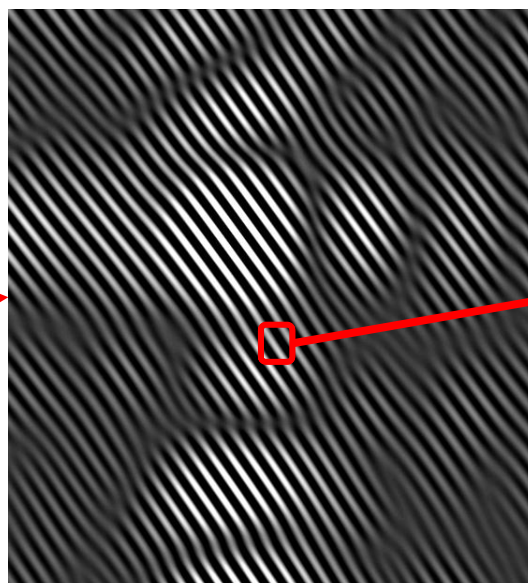
The object does not have to be flat!

- It can be piecewise flat,
- can be located on some curvilinear surface,
- or even completely three-dimensional.

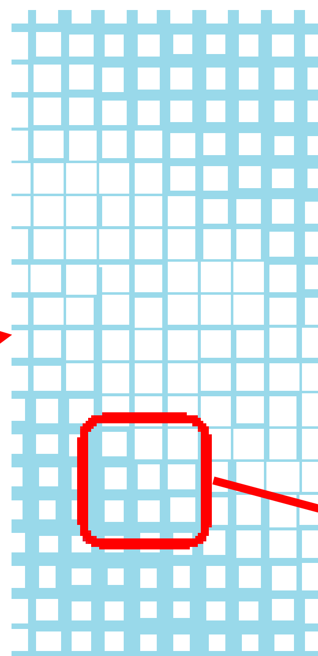


Sub-Wavelength Holographic Mask (SWHM) common structure

Typical SWHM



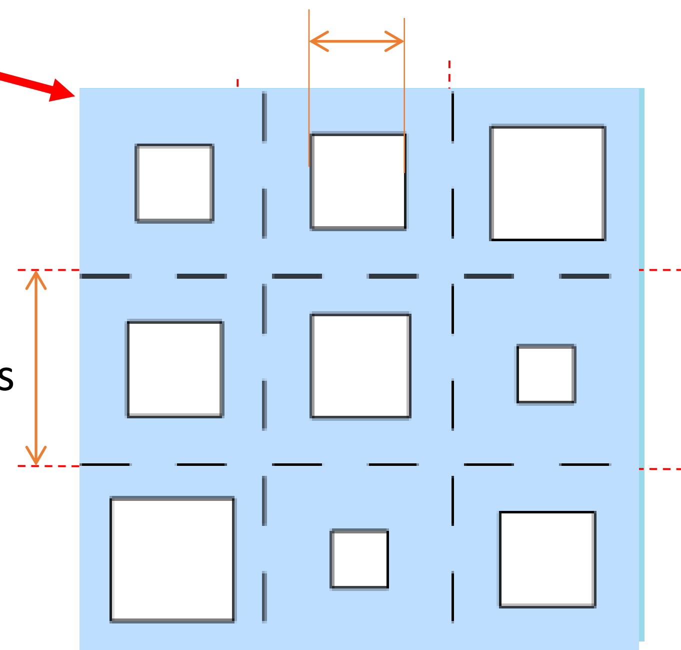
Small part of SWHM



The small part of band

Linear size of each transmission area varies from 1.7λ to the cell size

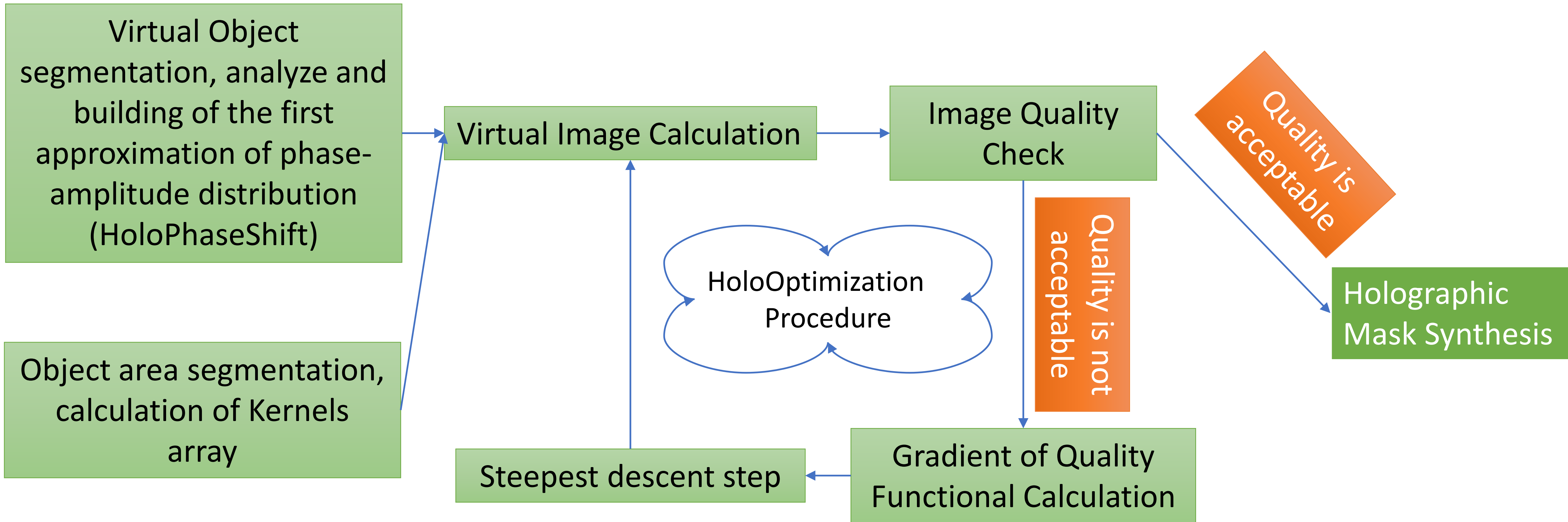
The linear size of a hologram cell is constant an can around 5λ.



9 cells with 9 transmission areas (TA)

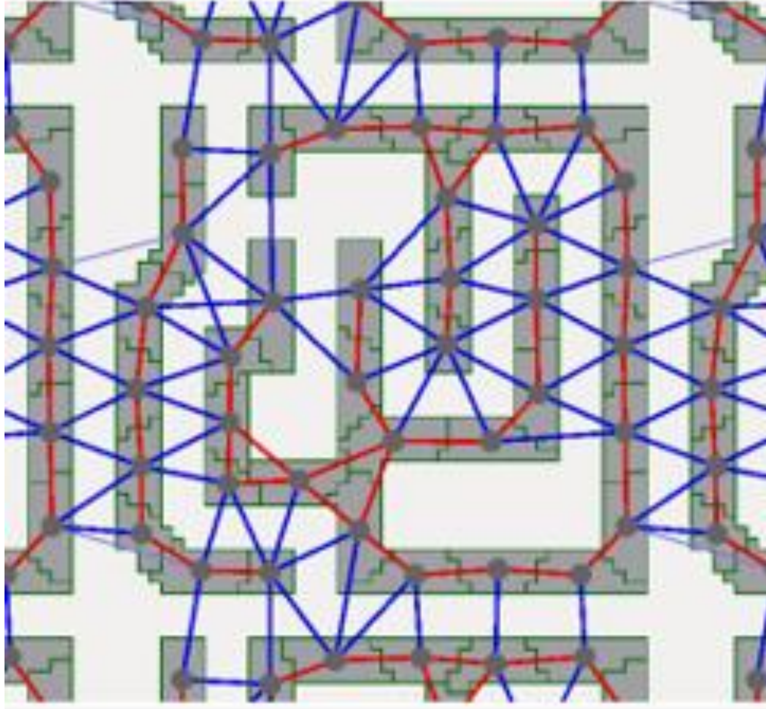
Cross section of the Sub-Wavelength Holographic Mask (SWHM)

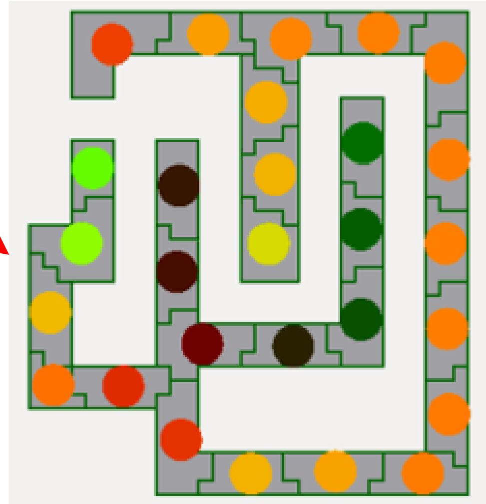
Simple Mask Synthesis Process Scheme*

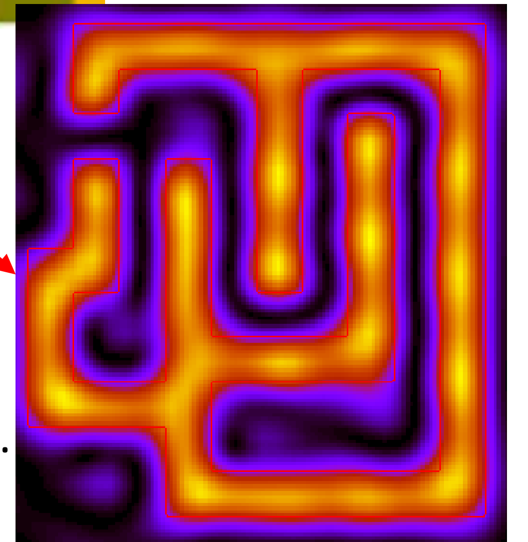


*Patent No. US 9,310,768 B2. Date of Patent: April 12, 2016. Method for synthesis and formation of a digital hologram for use in microlithography

HoloPhaseShift

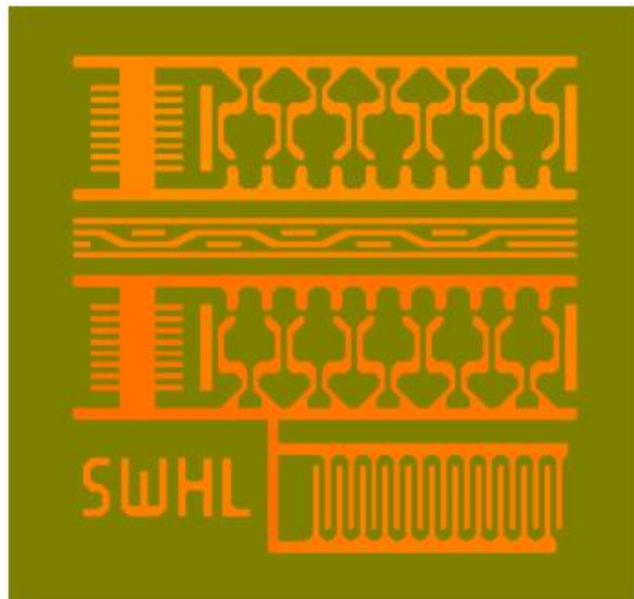
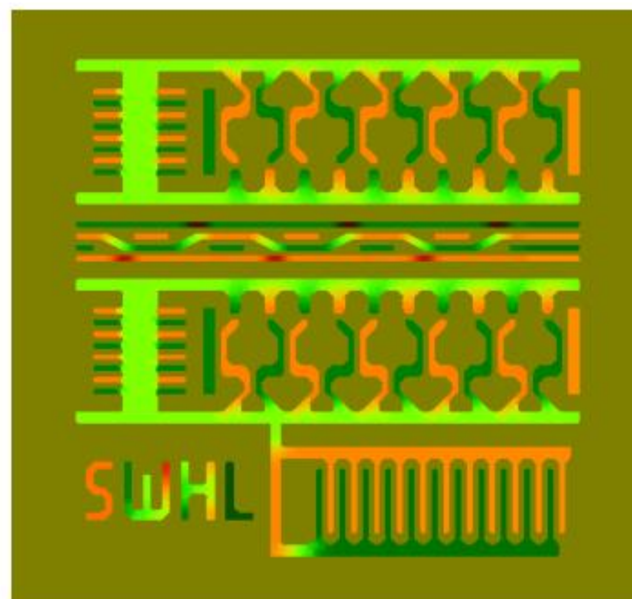
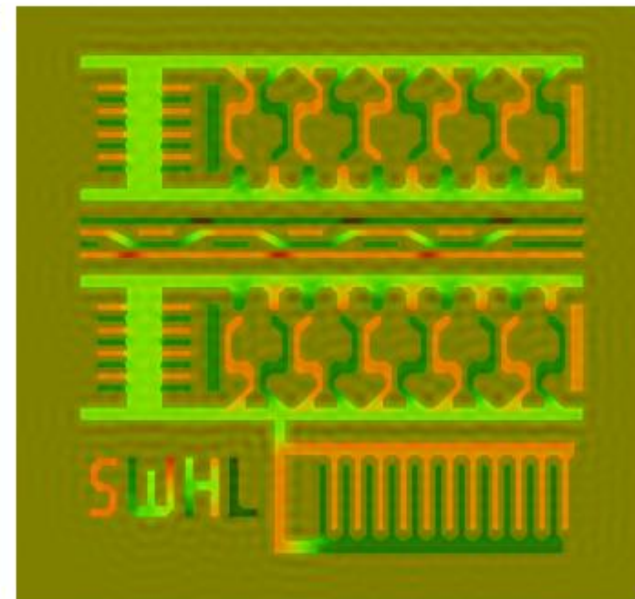
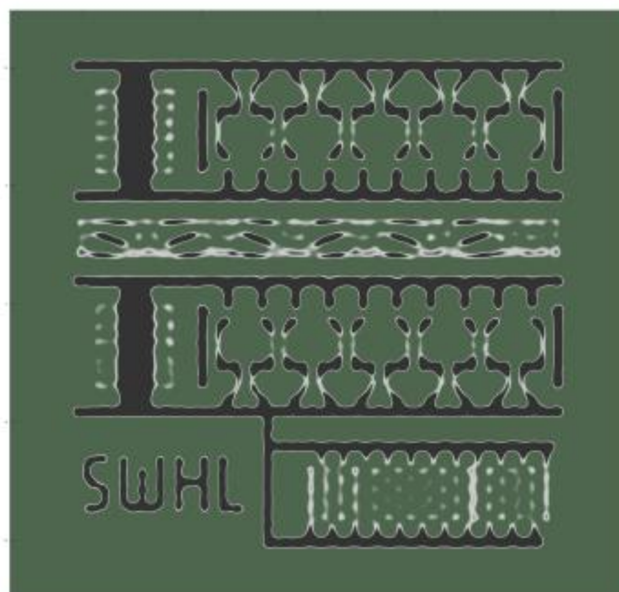
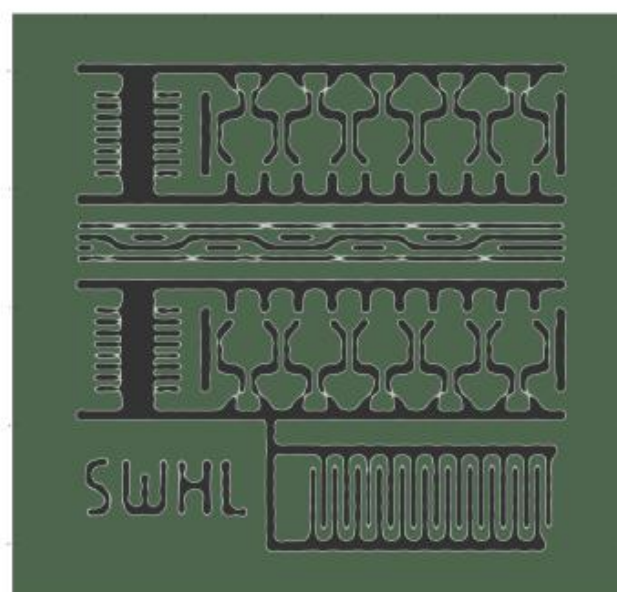
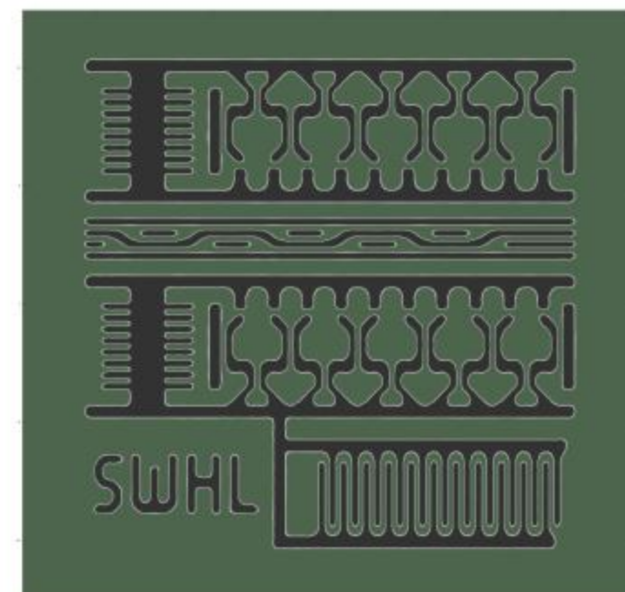




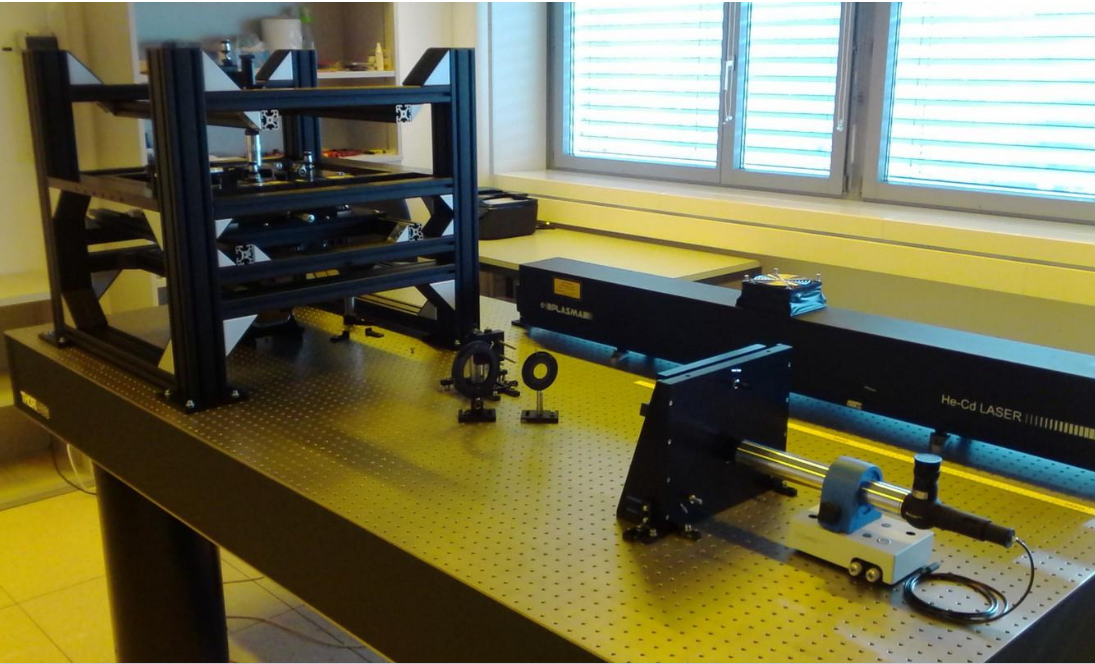


Topology graph with two levels of detail is constructed to generate the phase distribution.

HoloPhaseshift module provides phase contrast between the neighbouring topology elements.

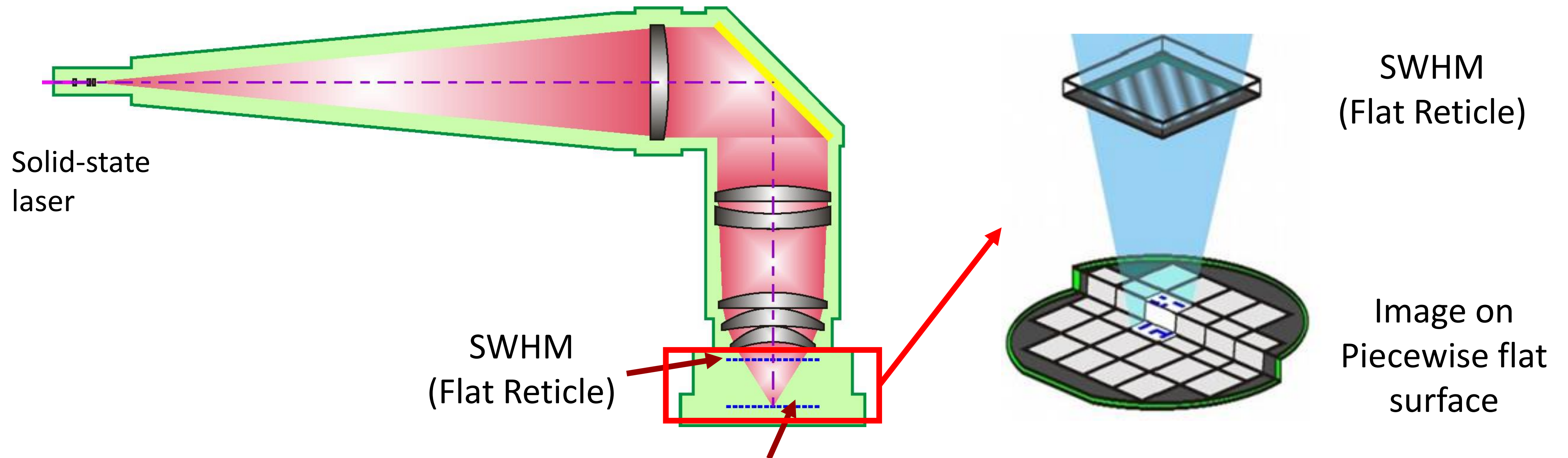
	No Optimization	HoloPhaseShift	HoloOptimization
Object			
Image in resist (model)			

Schematic of the Demonstrator located in **Swiss Federal Laboratories for Materials Science and Technology** (**Empa**) **in Dubendorf, Switzerland.**



Microscope lens
Microscope camera
Lens
Wafer
Bare board camera
Illumination unit
Mask substrate
Flat Mirror
Main Lens
Micro objective
Mirror
Pin hole
Parabolic Mirror
Laser
Mirror

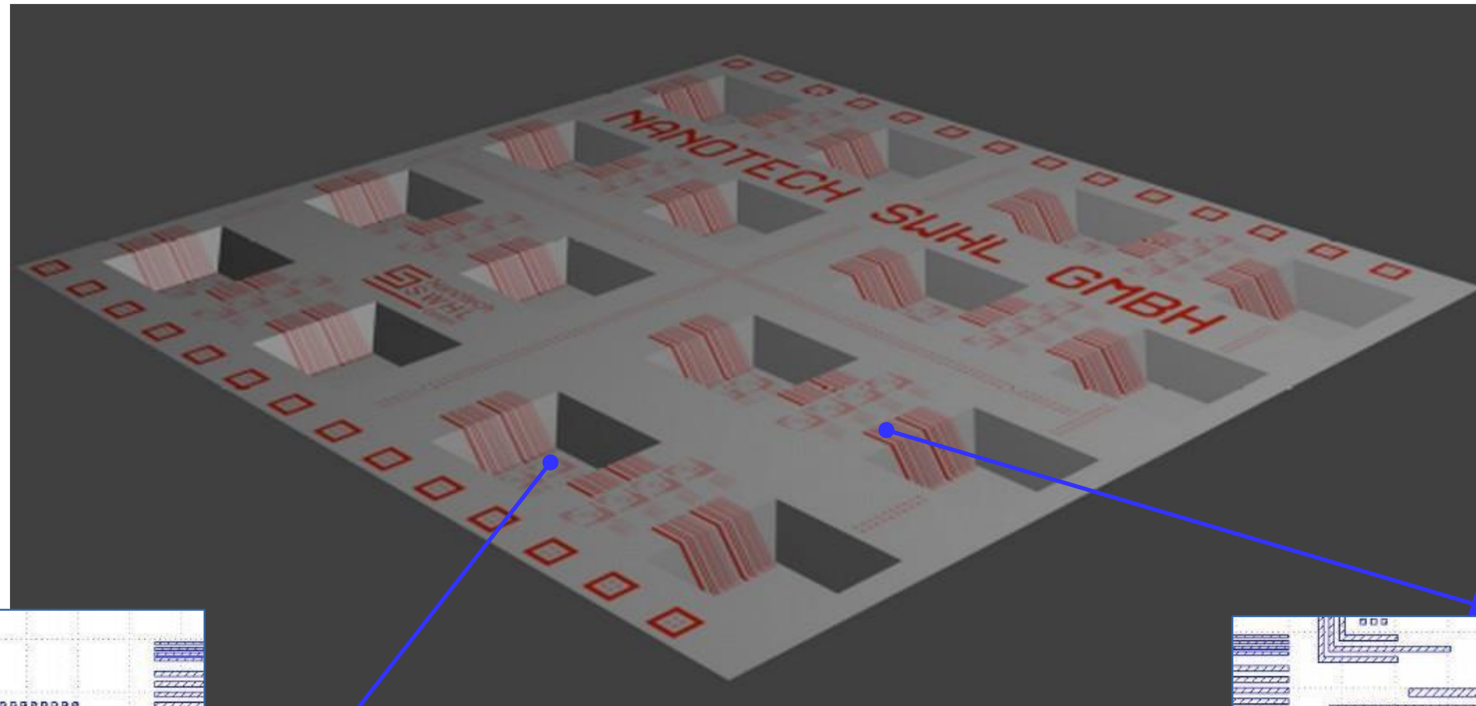
Simple Optical Setup Overview

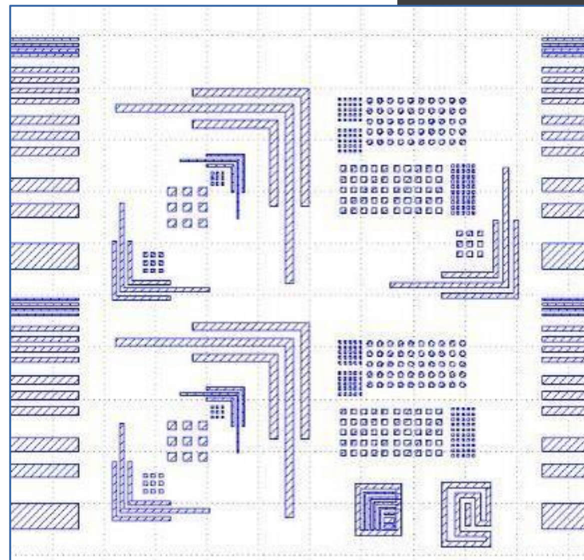


Wavelength	441.6nm
Numerical Aperture	0.24
Mask Size	Circle with diameter 43.5mm
Mask Grid Step	2mkm
Mask Elements	Squares with sizes varying from 0.75mkm to 1.9mkm

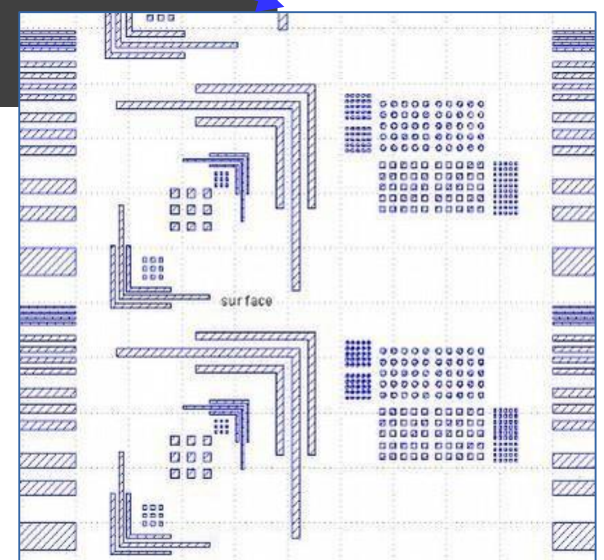
Image size	2.5x2.5mm
Critical Dimension	1mkm
Distance between Planes	100mkm
Depth of Focus	2mkm

Test Object on Piecewise-Flat Surface



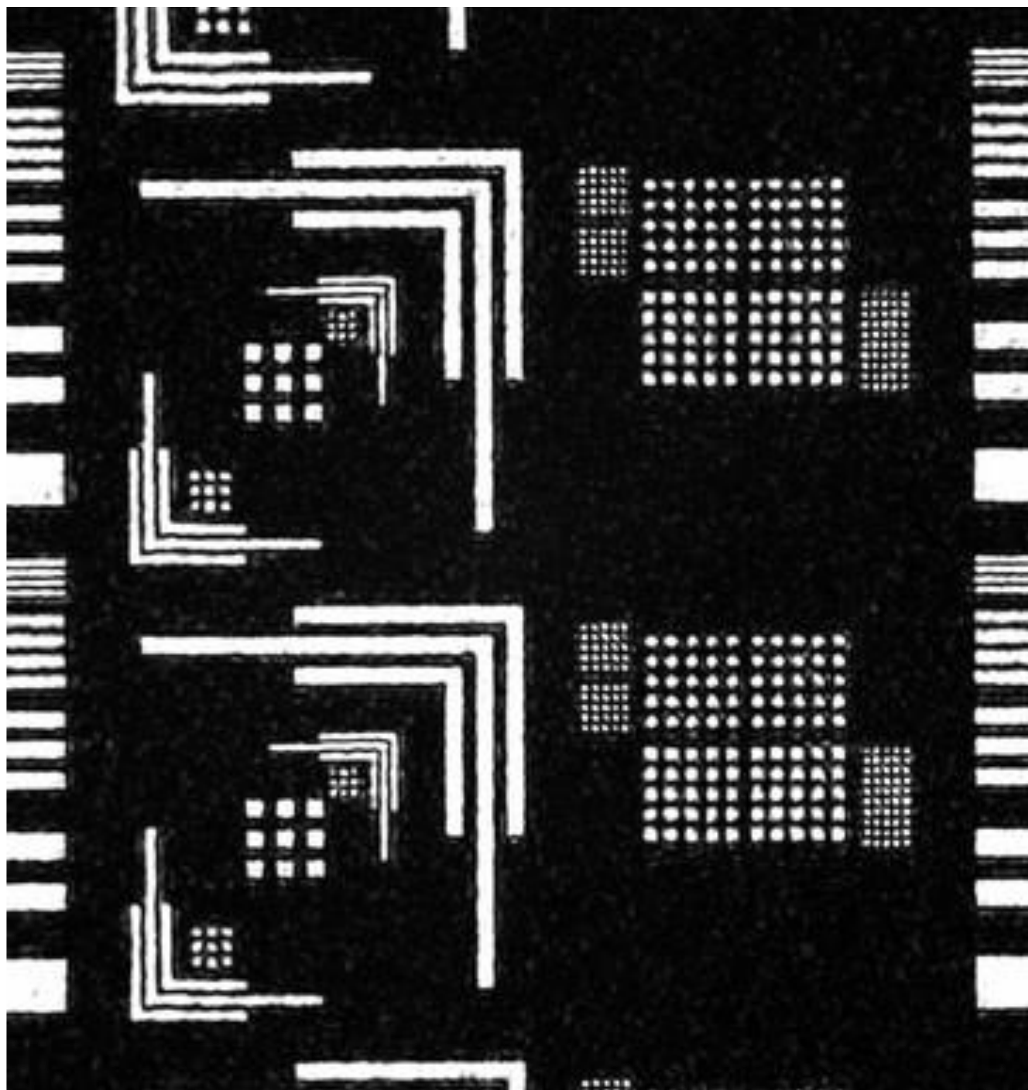


Test topology on piecewise flat surface. *The distance between face plane and bottom plane is 100μm, slope angle is 54.74º.*

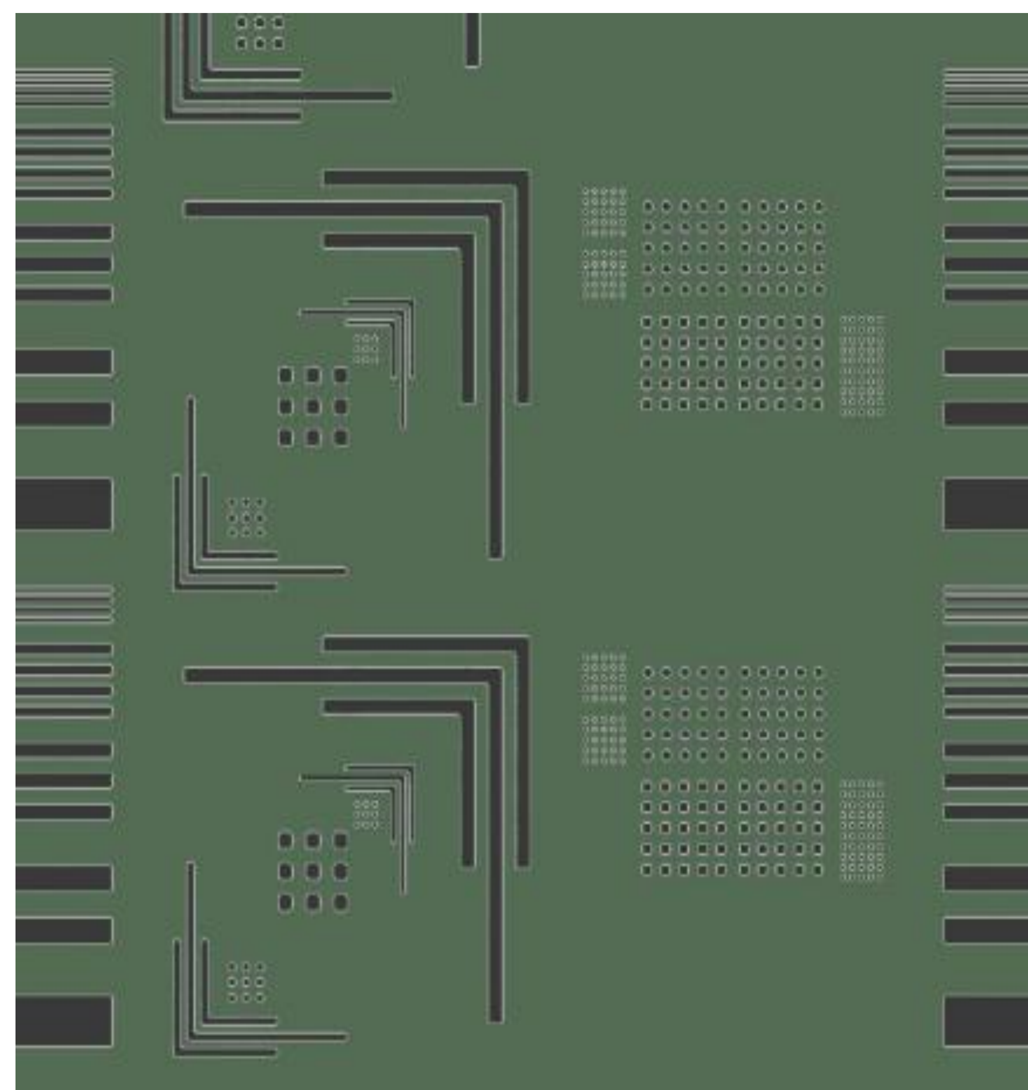


Test Topology on Non-Flat Surface. Fragment of Image.

Experimental results, registration on CMOS-camera



Simulated resist image



Thank you for attention!

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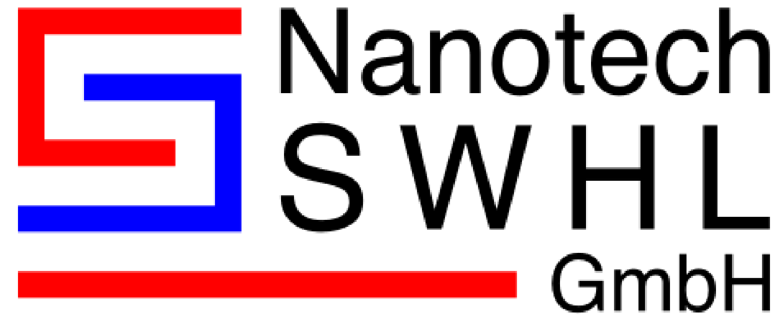

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Materials Science and Technology