Analysis of Effect of Perturbations in SWHM and Illuminating Optical Scheme Parameters on Aerial Images

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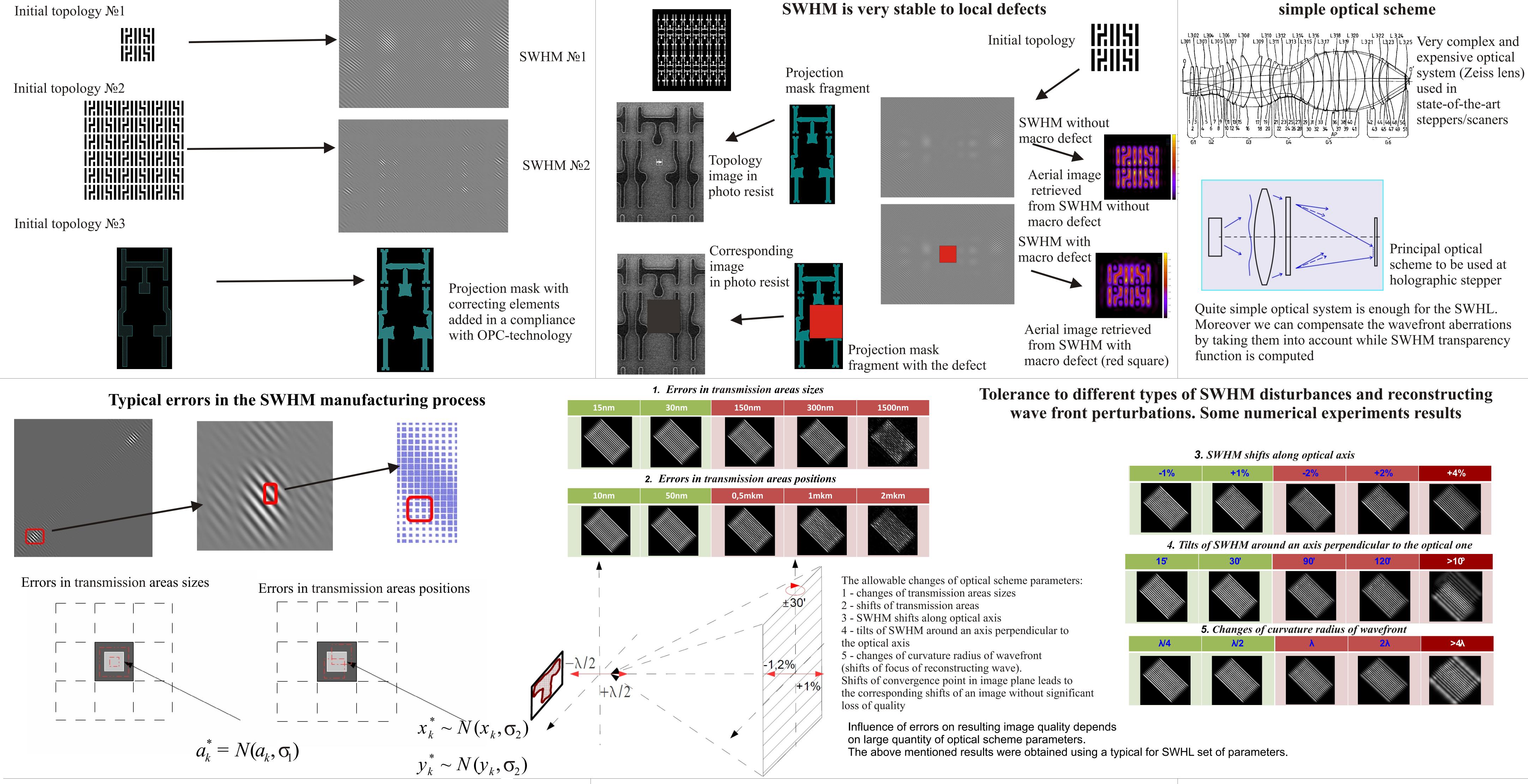
An aerial image created with the help of SWHM is very stable to local defects of SWHM. This radically simplifies the processes of mask production and operation and makes local defects detection and correction unnecessary.

Inaccuracies of modern e-beam lithography systems used for SWHM manufacturing are considerably smaller than the values that are critical for providing the desired quality of aerial image created by SWHM. The only possible exception is disturbance caused by phase noise appearing as a result of substrate non-flatness. However it appears to be rather small if quartz substrate non-flatness varies sufficiently smoothly, which is true for every polished surface. Such disturbances could be completely eliminated by measuring substrate non-flatness profile and taking it into account in computing SWHM transparency function.

Projection mask vs. SWHM

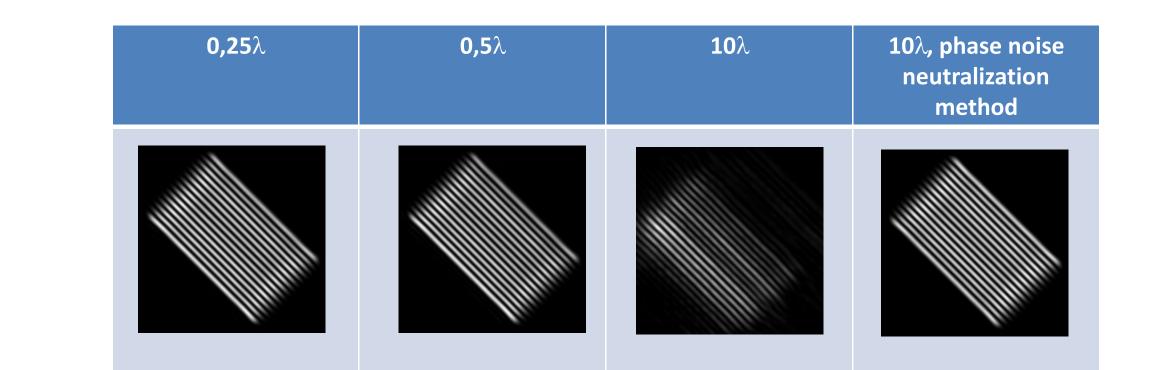
A new method for IC aerial images creation - sub-wavelength holographic lithography (SWHL) is introduced. We propose to use very stable to local defects holographic patterns and very simple optical scheme for photoresist exposure. The paper considers the influence of different disturbances on resulting topology image. Such disturbances could appear ether in the process of SWHM manufacturing or in the process of reconstructing a given topology in photoresist with the help of SWHM.

Numerical simulation of aerial image production process with the use of SWHM under different disturbances shows that image quality is very stable against different typical disturbances. It turned out that acceptable values of the considered disturbances depend on reconstructing radiation wave-length with some coefficient proportional to the SWHM-to-image-size ratio. Meanwhile transparency function disturbances caused by binarization could be minimized by using the developed calculation method. The acceptable rate of local deviations of forms, sizes and centers coordinates for SWHM transmission areas proved to be rather high.



Nonflatness of SWHM's quartz substrate Some results of simulation of reconstruction from perturbed hologram.

This is an example of the SWHM quartz substrate's relief. Any local flatness deviation leads to random changes in rays' optical paths. As a result so-called "phase noise" appears. Value of phase noise influence on image depends on the maximum of variation of the substrate's thickness. We have developed the method to eliminate phase noise right in a process of SWHM computation. The substrate's relief map should be known for implementing this method.



Synthesizing SWHM for real IC layer's topology using modern parallel HPC-computing systems

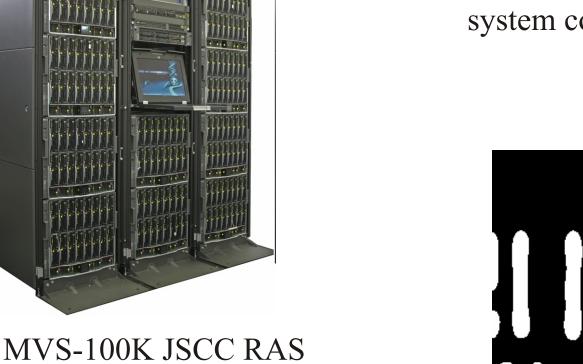
The initial topology contains 150'944'944 elementary topology pieces shown at the figure and situated periodically about 10¹⁰ elementary pixels. Linear dimension of each pixel is equal to 0.65 of wavelength. SWHM consists of about 1500 transmission areas. One of these areas is shown below (bottom-right). At bottom-center it is also shown a result of image fragment reconstruction (threshold level is 0.2 from the maximum intensity).

The main SWHM advantage -



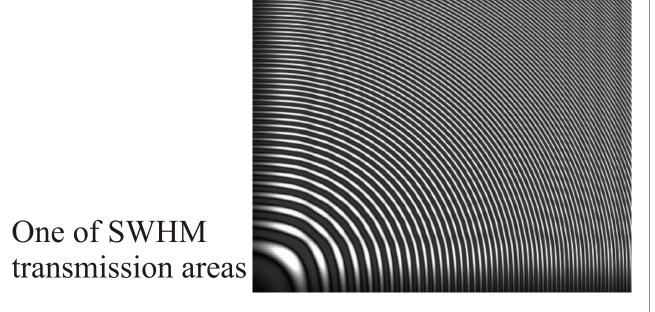
The computations were performed on MIIT T4700 and MVS-100K JSCC RAS parallel computing systems. Simulation results showed that revealed image quality does not significantly depend on reconstructed fragment position.

A project of specially designed computational system for calculation of real IC layer containing 10¹² elementary pixels is under development. This system will contain 8 nodes. Each will have one quad-core Opteron CPU and 8 GPUs. This computing system could perform SWHM synthesis for real IC layer in 8 hours.



MIIT T4700

Fragment of reconstructed aerial image

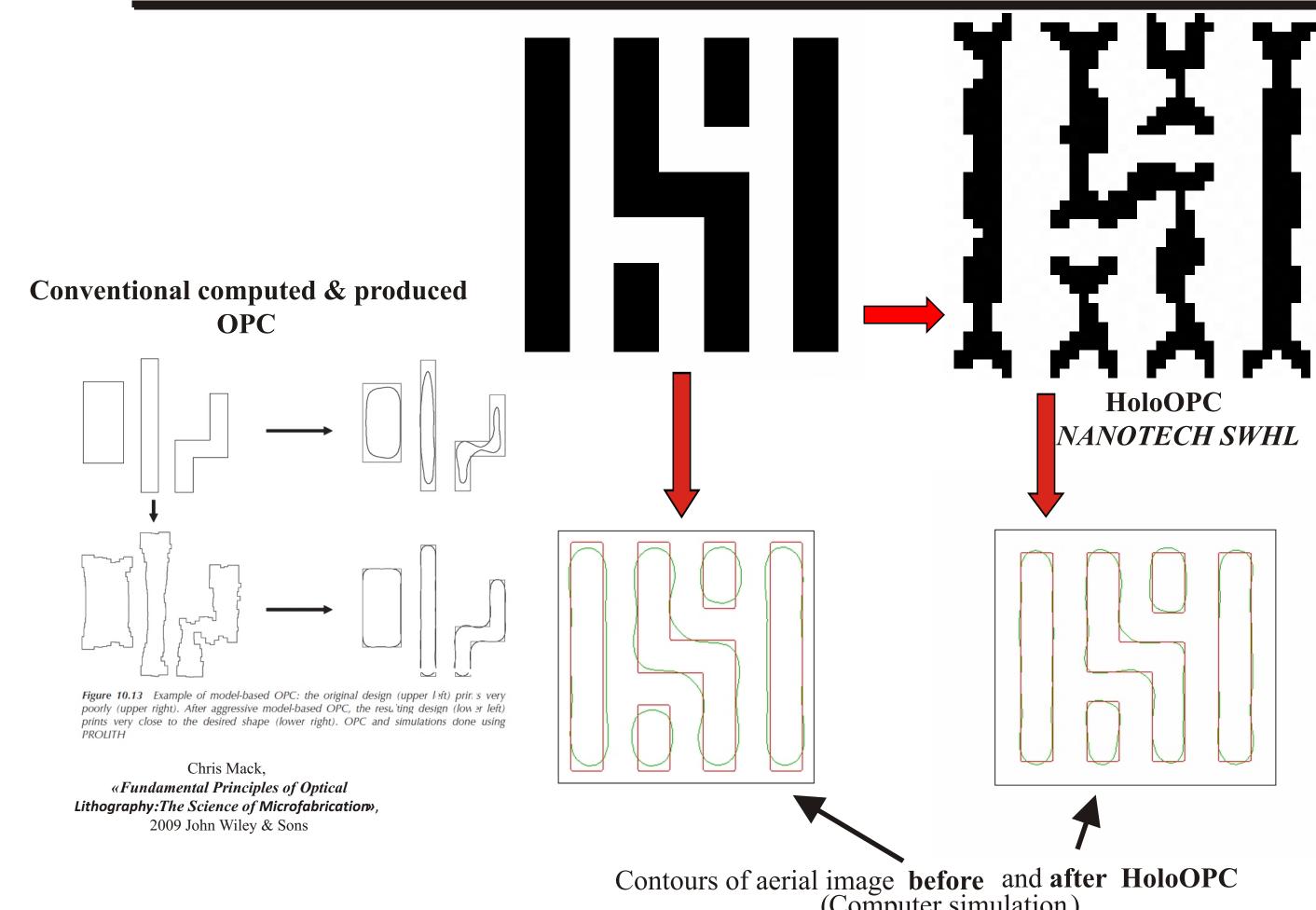


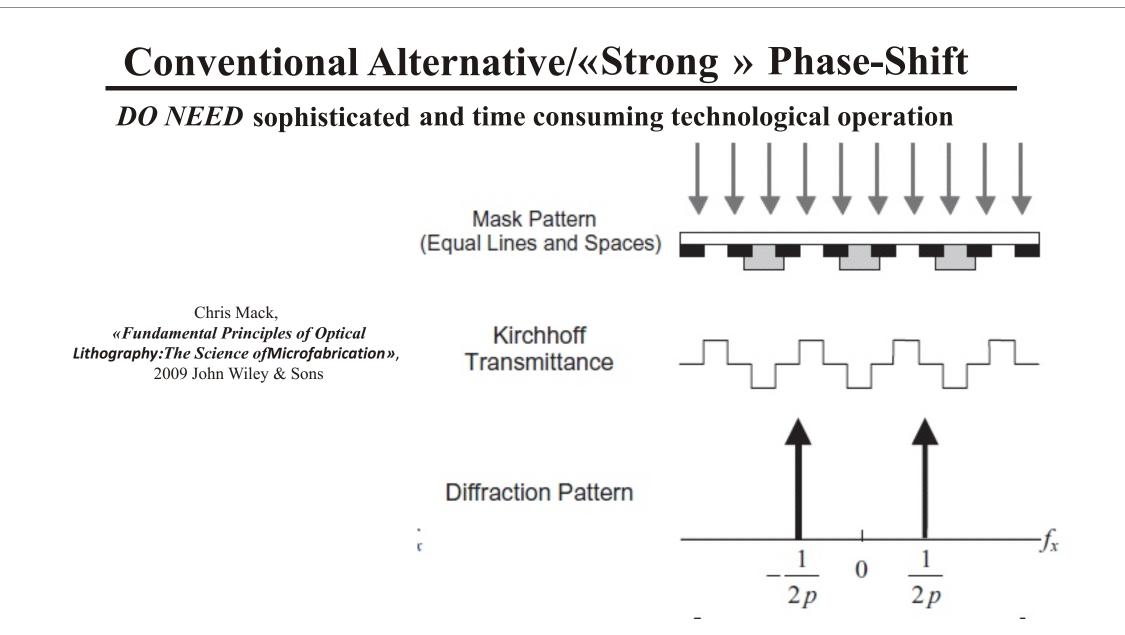
References

Possibility to use

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Conventional OPC and Virtual HoloOPC





Virtual «Strong» Phase-Shift

NO NEED for any technological operations !!!

Phase 0°

Phase 180°

SWIIM

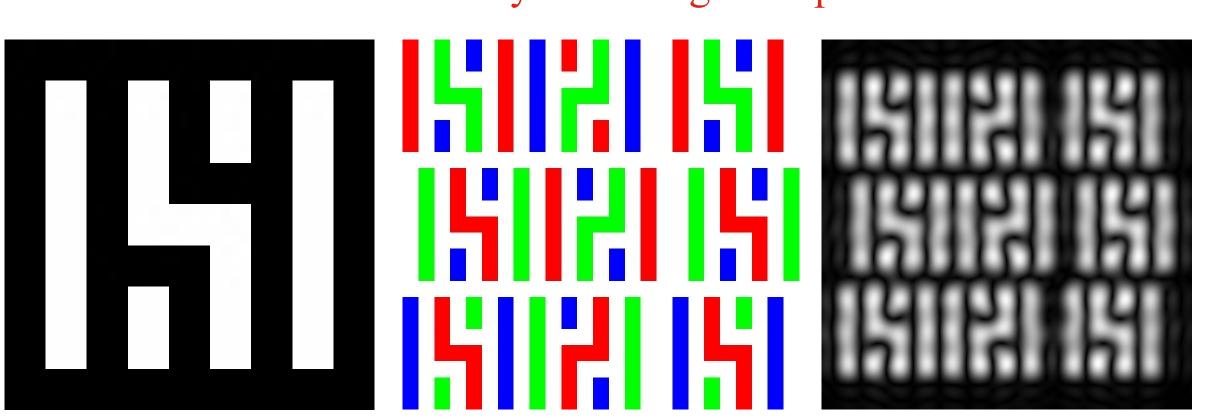
Contour of topology

Contour of topology

Virtual «Weak» Phase-Shift

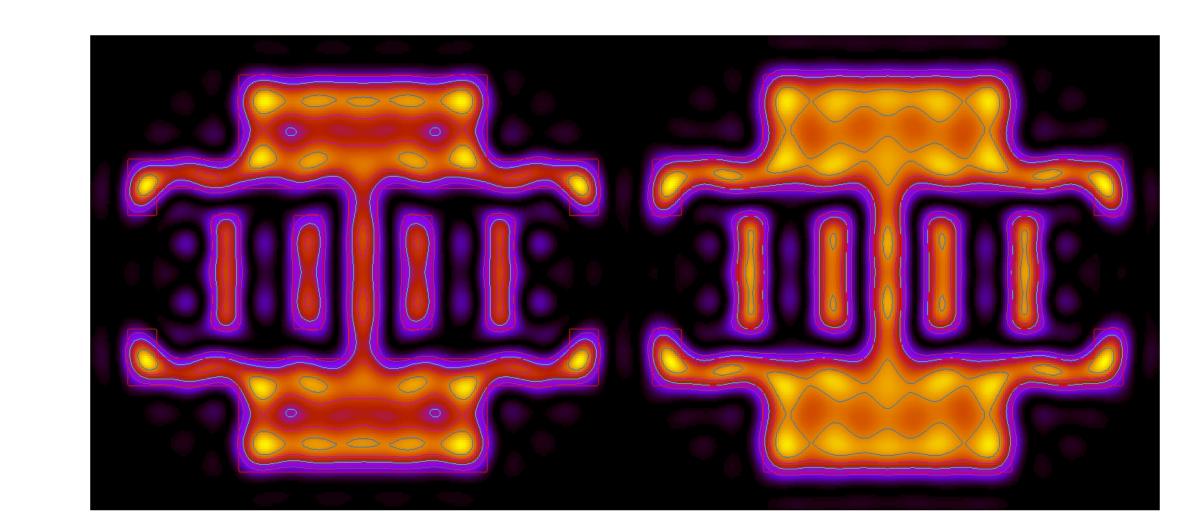
NO NEED for any technological operation!!!

Aerial image of topology



This example of a topology doesn't allow 180° Phase-Shift implementation, but allows «weak» Phase-Shift, where phase is being shifted by 120°. Disregarding whether it is possible to create such a Phase-Shift by a conventional technology, it is possible to realize it «virtually» for almost any topology.

VIRTUAL OPTIMIZATION



Initial aerial image and aerial image after 9th iteration
(Computer simulation)