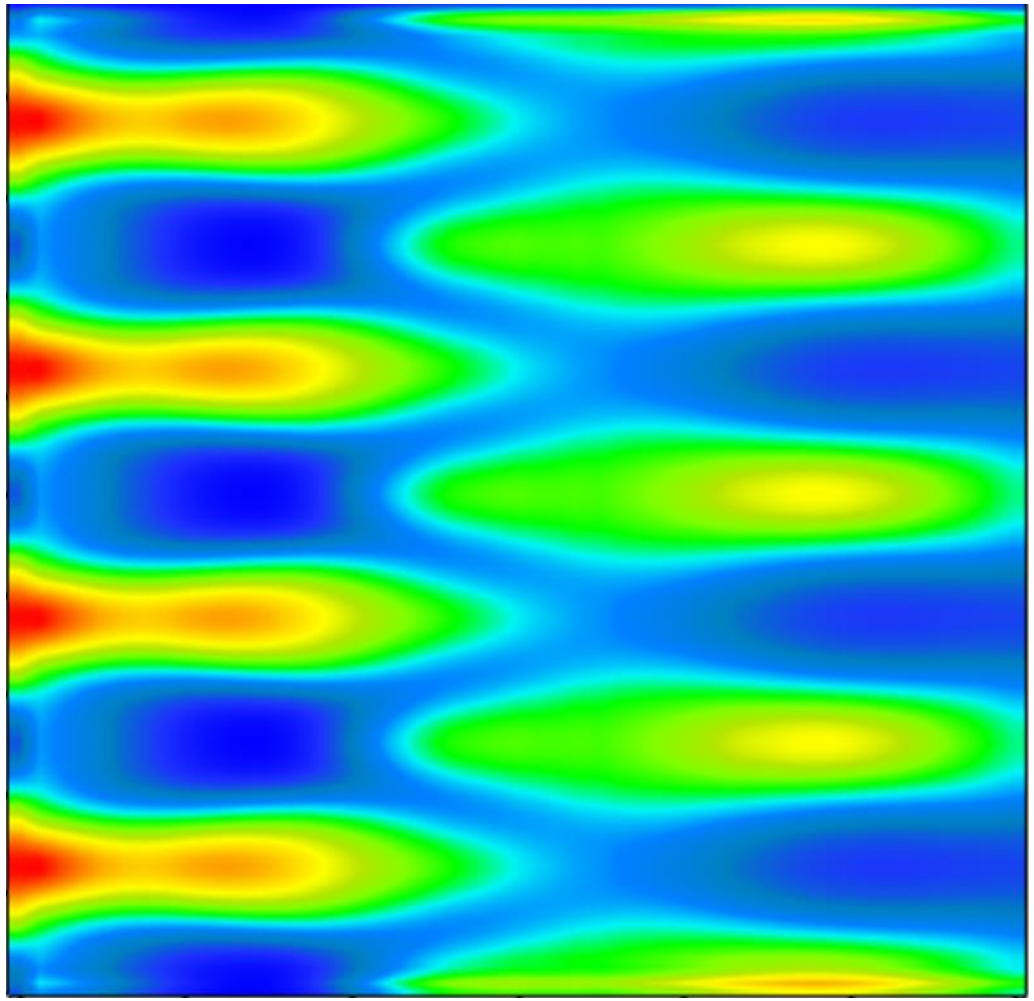
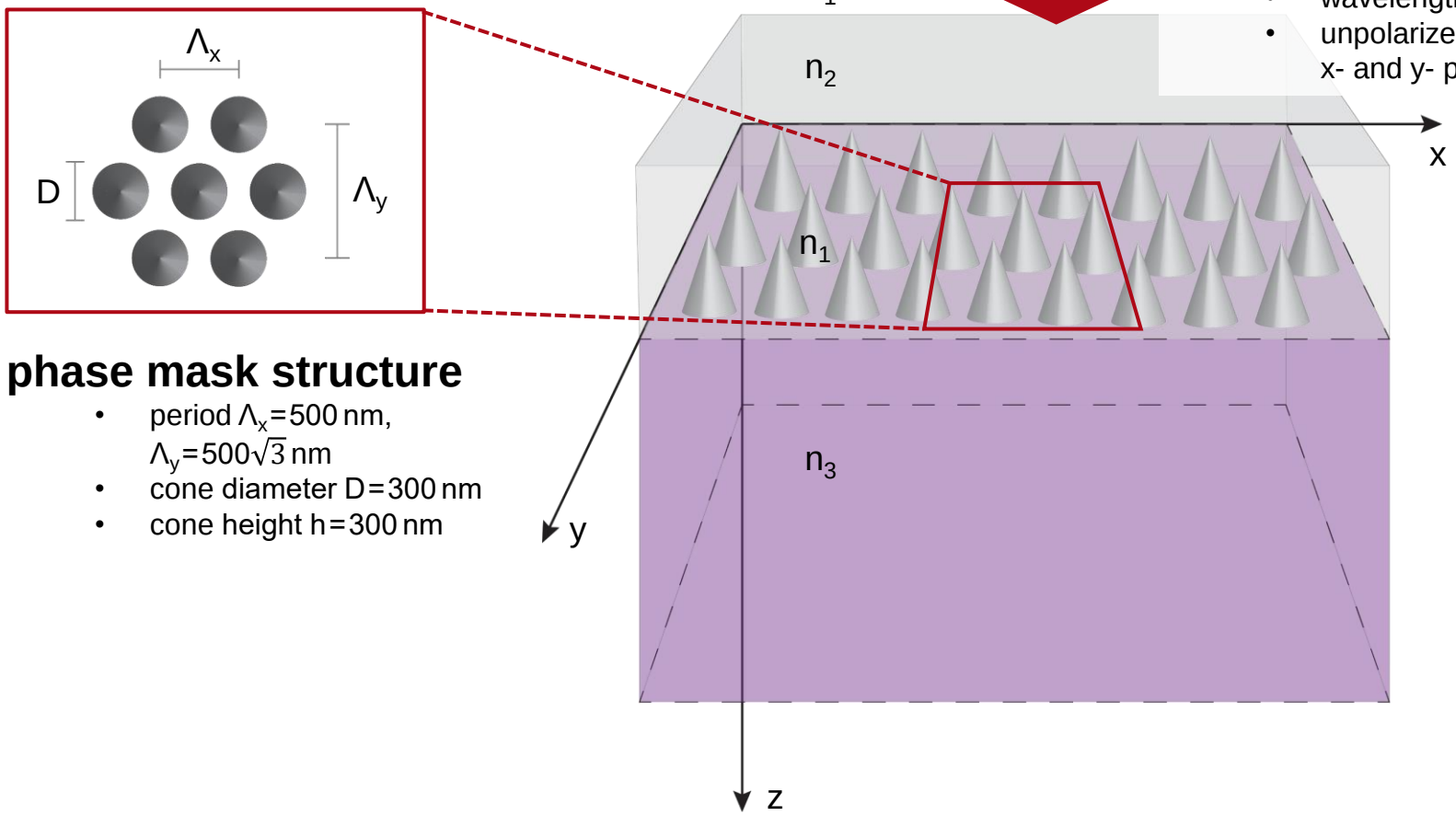
Talbot Images of A Conical Phase Mask

Abstract



In conventional Talbot lithography, only one image is employed in the photoactive layer. However, it is possible to produce two images of the phase mask in a depth-wise manner using a special phase mask. In this example, following the work of I.-H. Lee *et al*., a phase mask with a layer of cones is modeled in VirtualLab Fusion with the Fourier modal method (FMM, also known as RCWA). Different Talbot images are detected, such that the pillar pattern is reproduced in the primary image plane, while the hole pattern in the secondary.

Modeling Task



input plane wave

- wavelength $\lambda = 365$ nm
- unpolarized (modeled as average of x- and y- polarizations)

phase mask structure

- period $\Lambda_x = 500$ nm, $\Lambda_y = 500\sqrt{3}$ nm
- cone diameter $D = 300$ nm
- cone height $h = 300$ nm

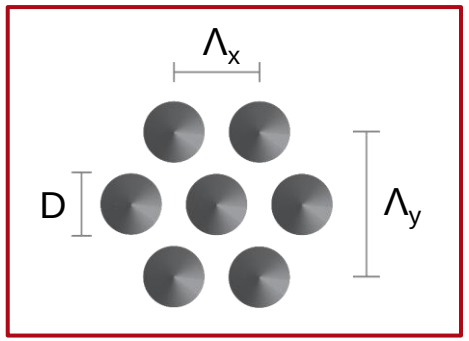
media

- incident medium: $n_1 = 1.0$
- polydimethylsiloxane medium: $n_2 = 1.4$
- conical void: $n_1 = 1.0$
- photoactive medium: $n_3 = 1.7 + 0.0358i$

How to model the phase mask structure, and calculate the Talbot patterns at different positions within the photoactive medium?

structure and material parameters from I.-H. Lee, *et al*., Opt. Express 23, 25866-25873 (2015)

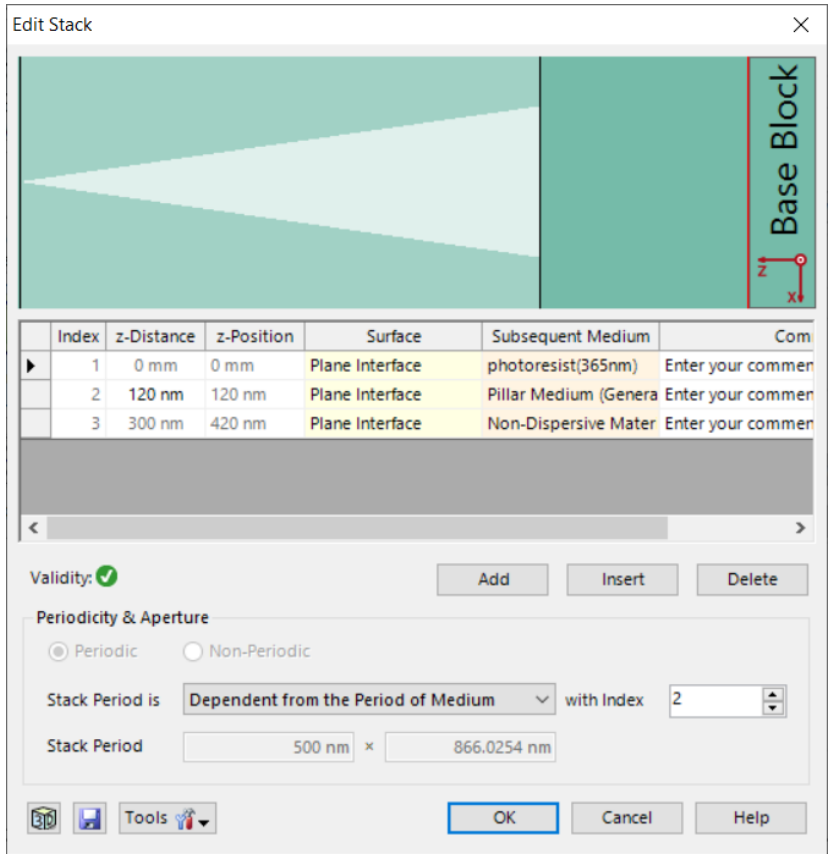
System Building Blocks

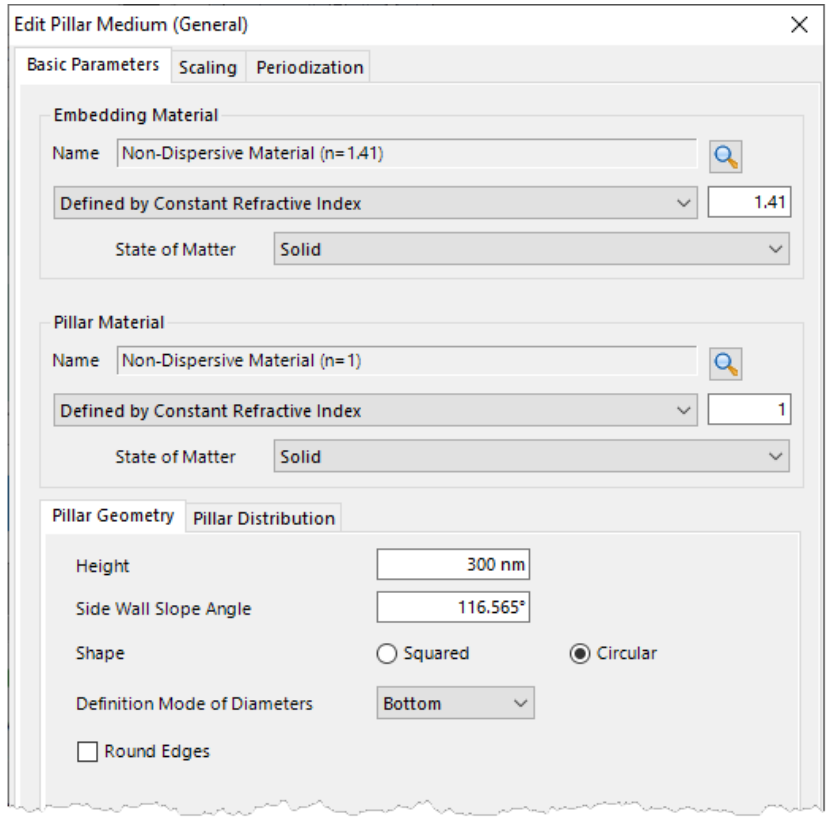


phase mask structure

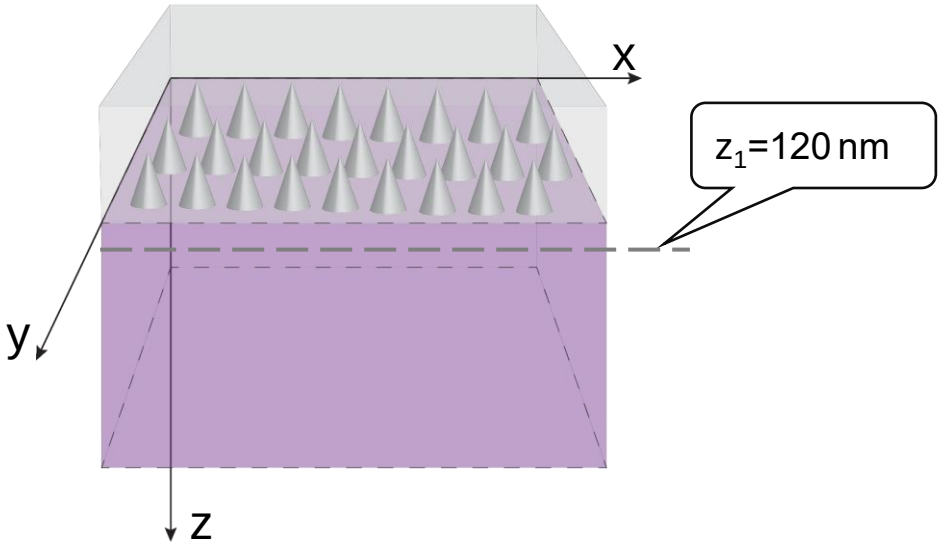
- period $\Lambda_x = 500\,\text{nm}$, $\Lambda_y = 500\sqrt{3}\,\text{nm}$
- cone diameter $D = 300\,\text{nm}$
- cone height $h = 300\,\text{nm}$

The phase mask is modeled with the 2D grating component in a grating-specific optical setup, using a *Pillar Medium* sandwiched between the embedding medium and the photoresist.



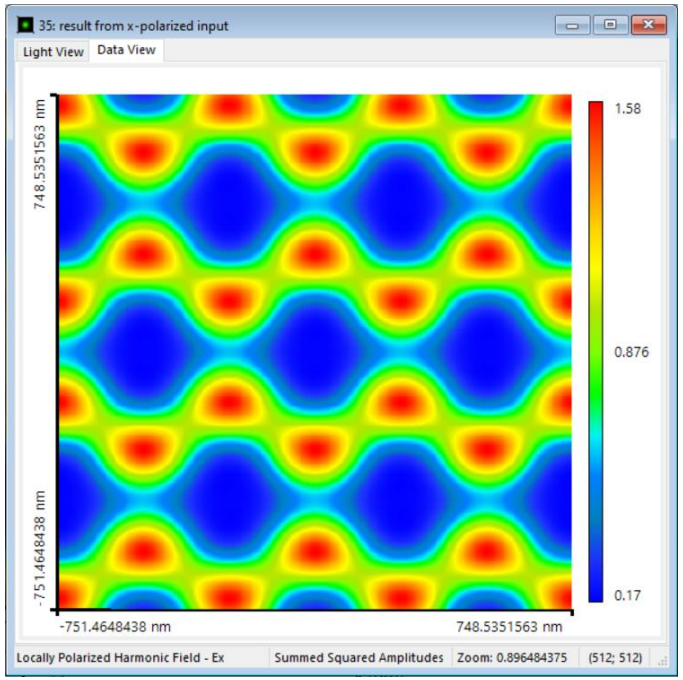


Talbot Pattern at a Certain Position

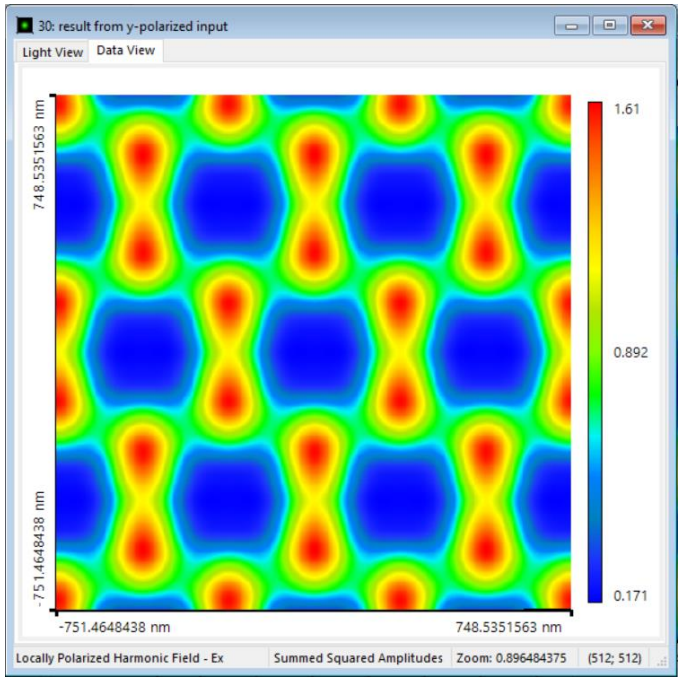


The intensity at a certain z-position is calculated separately for the input beams with different polarization states (linear x- and y-polarization).

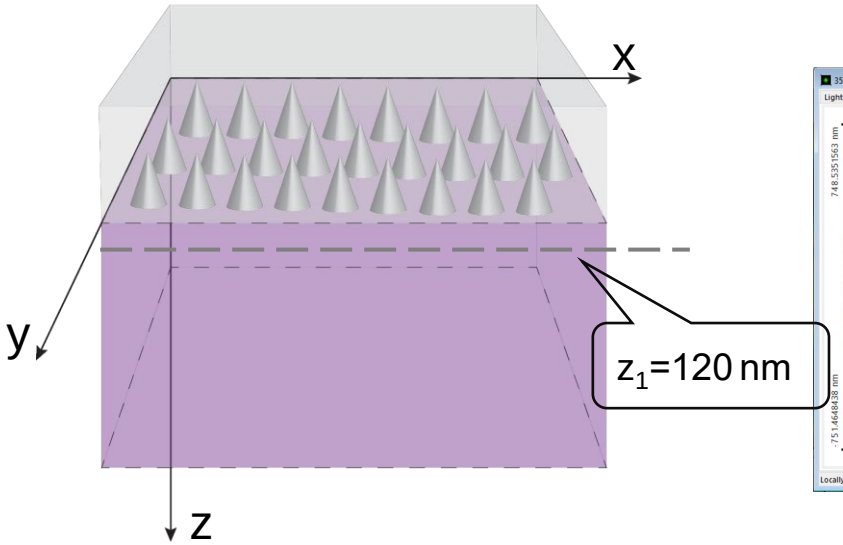
result from x-polarized input



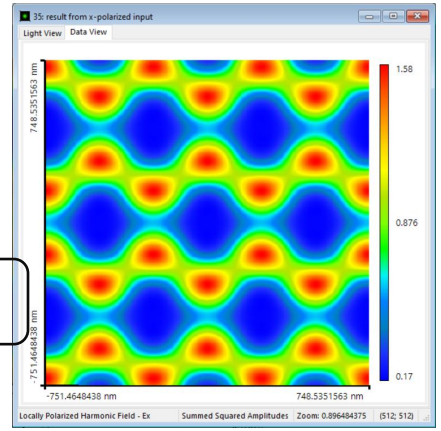
result from y-polarized input



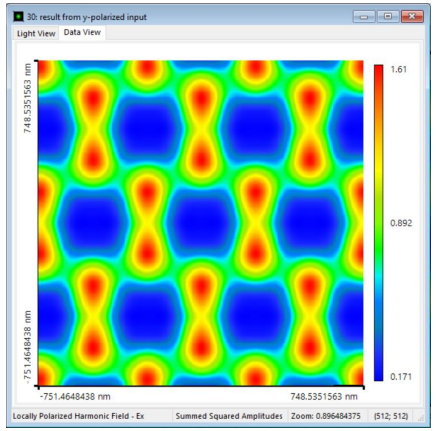
Talbot Pattern at a Certain Position



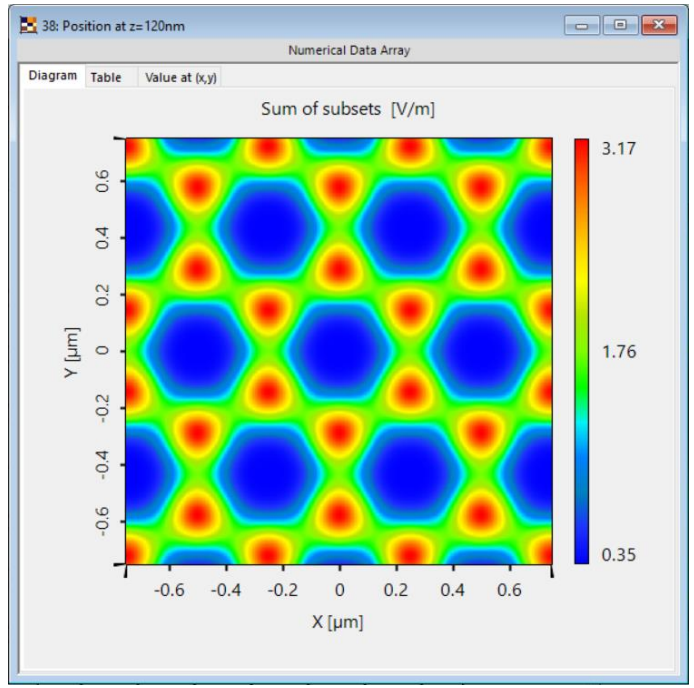
x-polarized



y-polarized

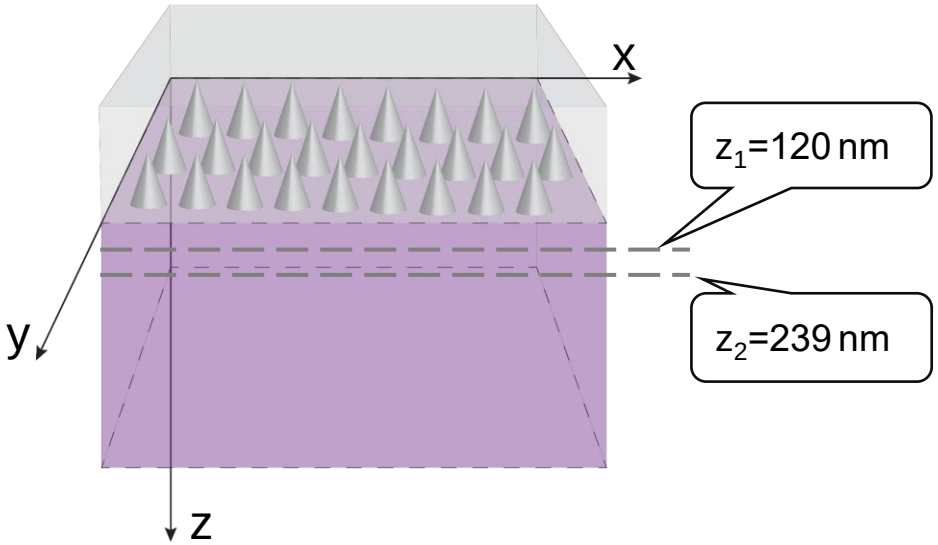


unpolarized

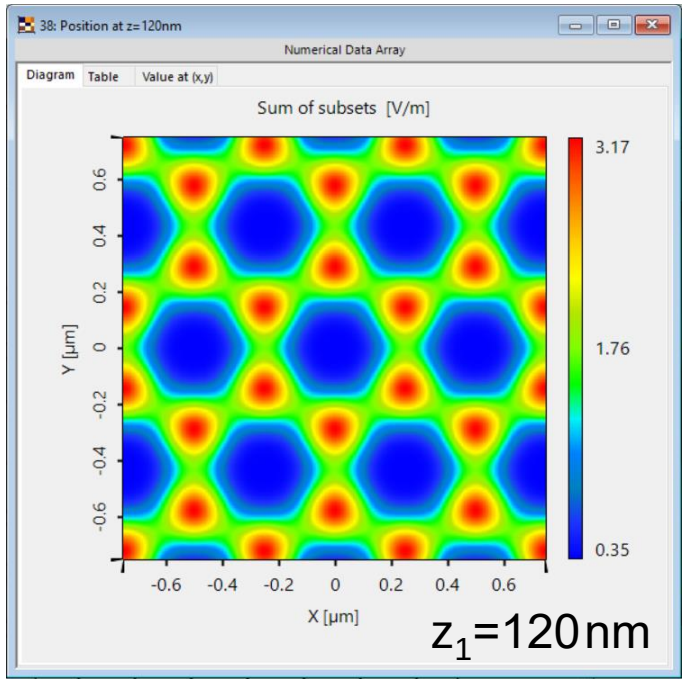


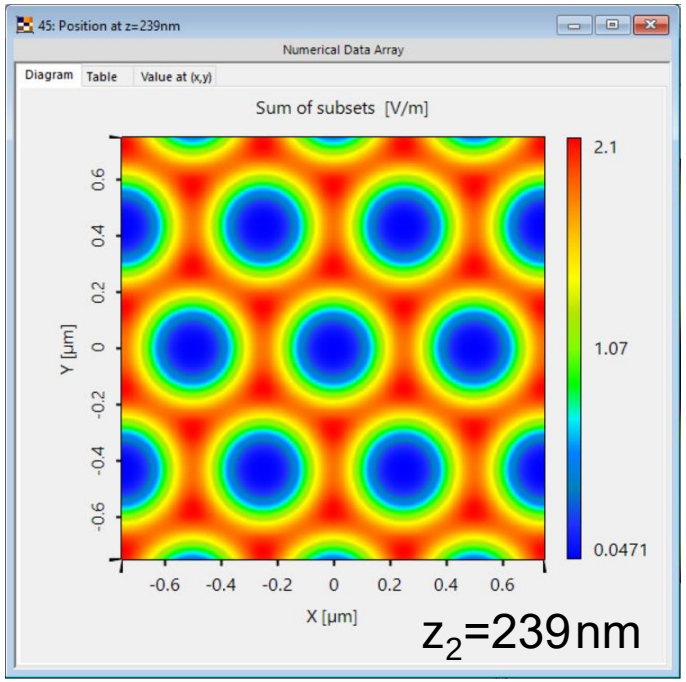
The total intensity is obtained by an incoherent average of the results from the linear x- and y-polarization states.

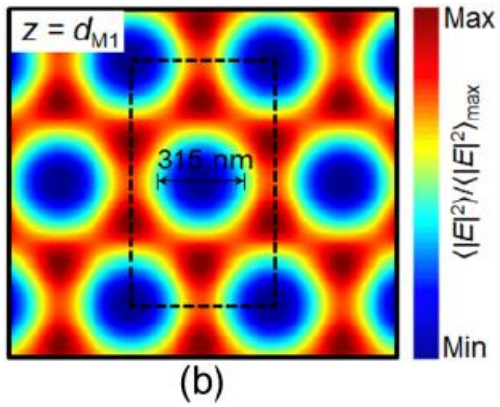
Talbot Pattern at Different Positions



simulation result in VirtualLab Fusion



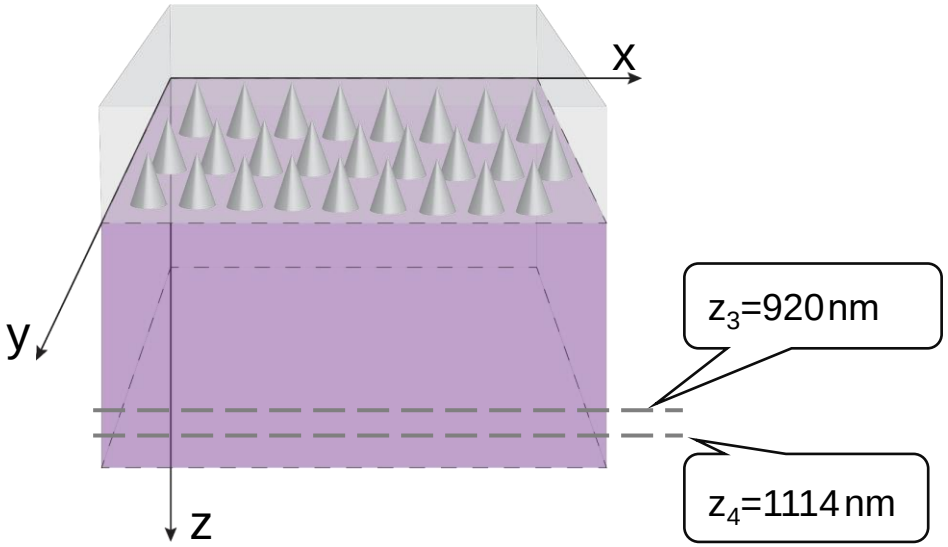




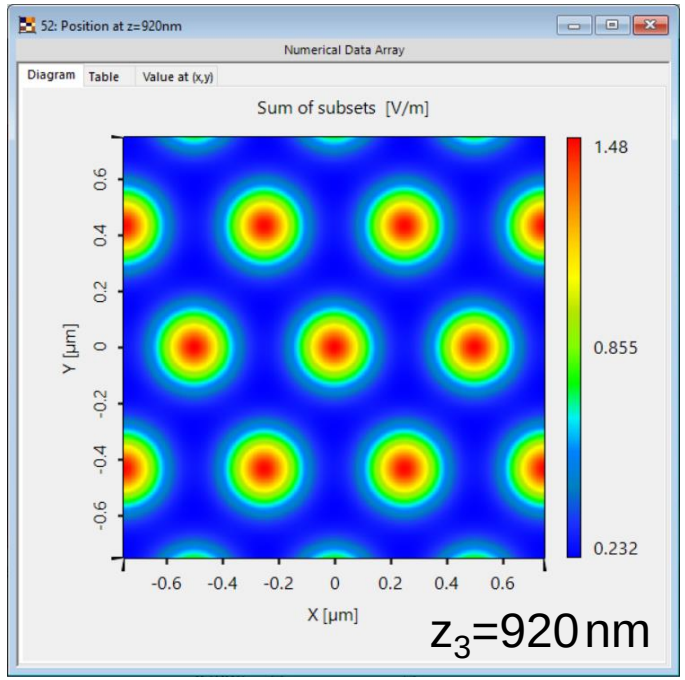
simulation result from reference:

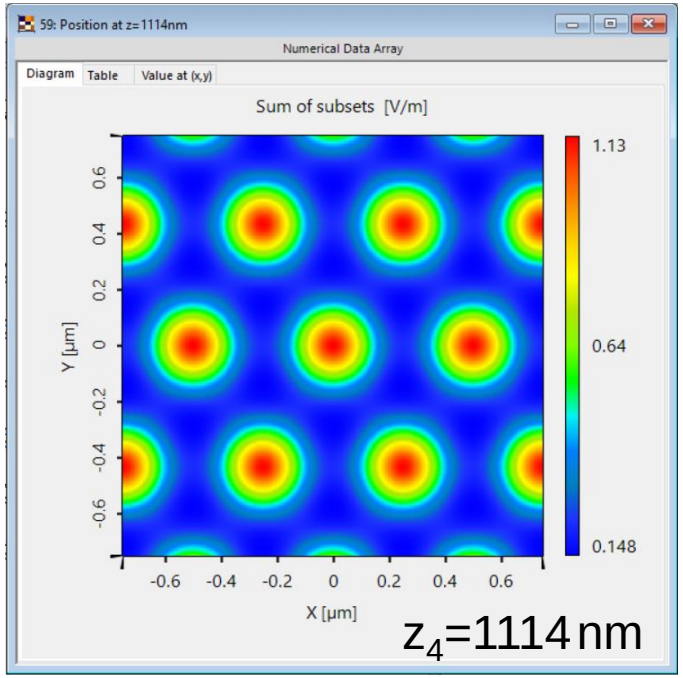
I.-H. Lee, *et al.*, Opt. Express 23, 25866-25873 (2015). [Fig. 2 (b) d_{M1}=120nm]

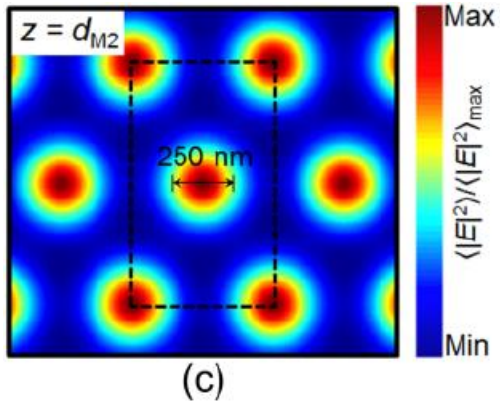
Talbot Pattern at Different Positions



simulation result in VirtualLab Fusion



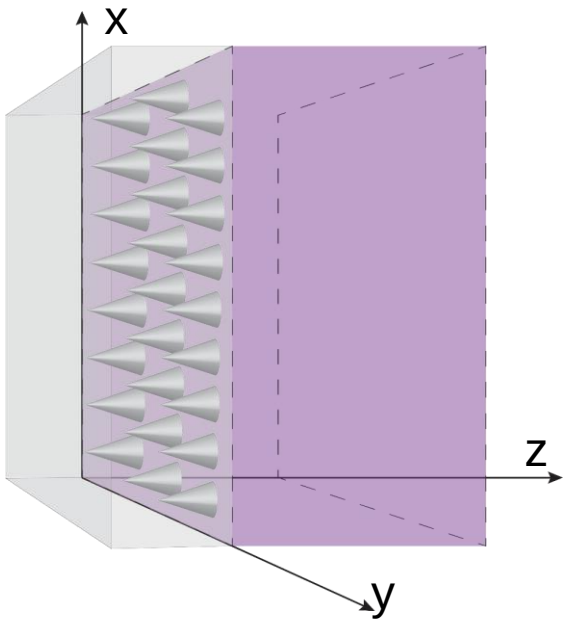




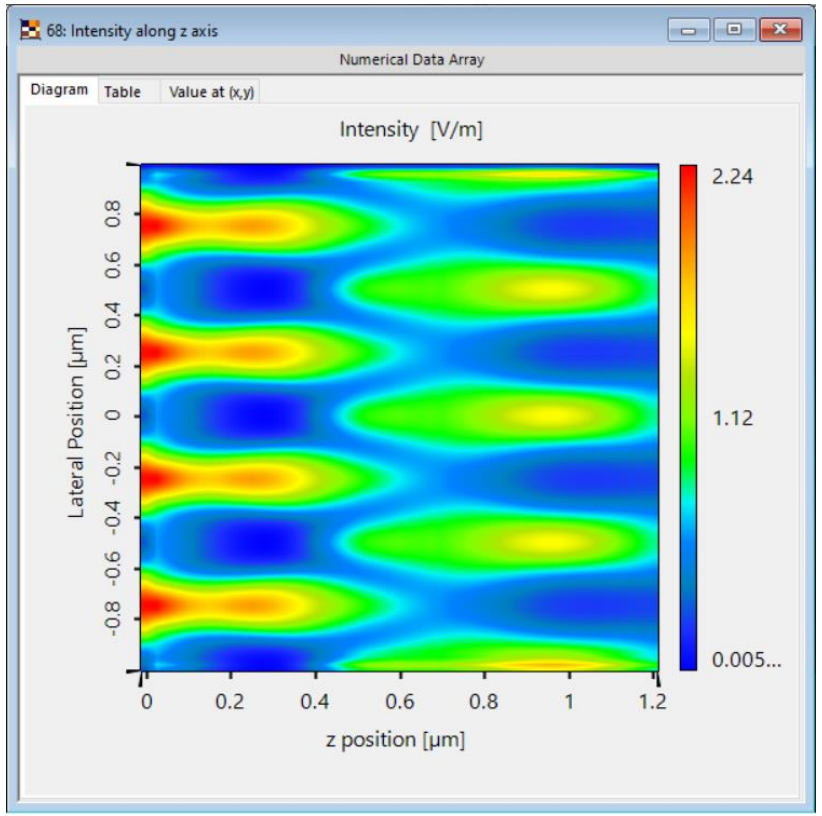
simulation result from reference:

I.-H. Lee, *et al.*, Opt. Express 23, 25866-25873 (2015). [Fig. 2 (c) d_{M2}=920nm]

Intensity along Z-Axis

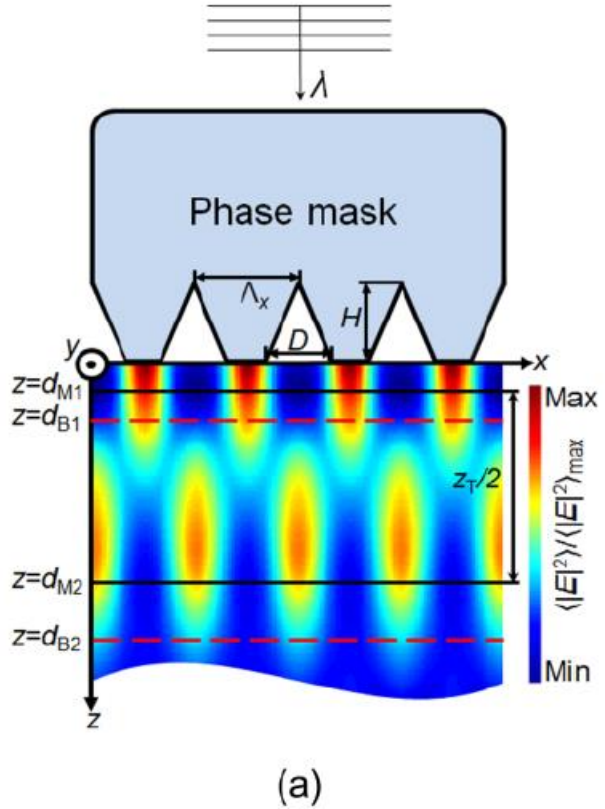


simulation result in VirtualLab Fusion

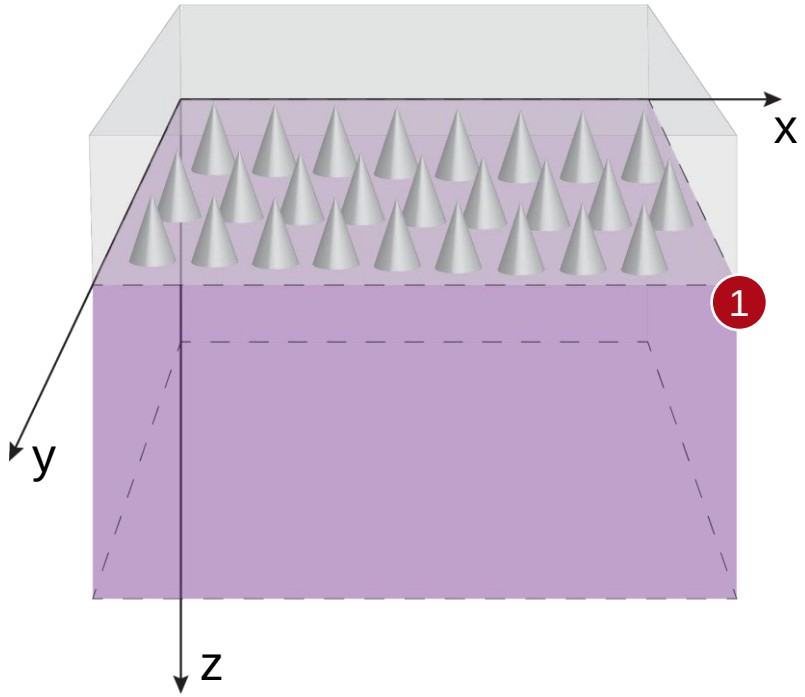


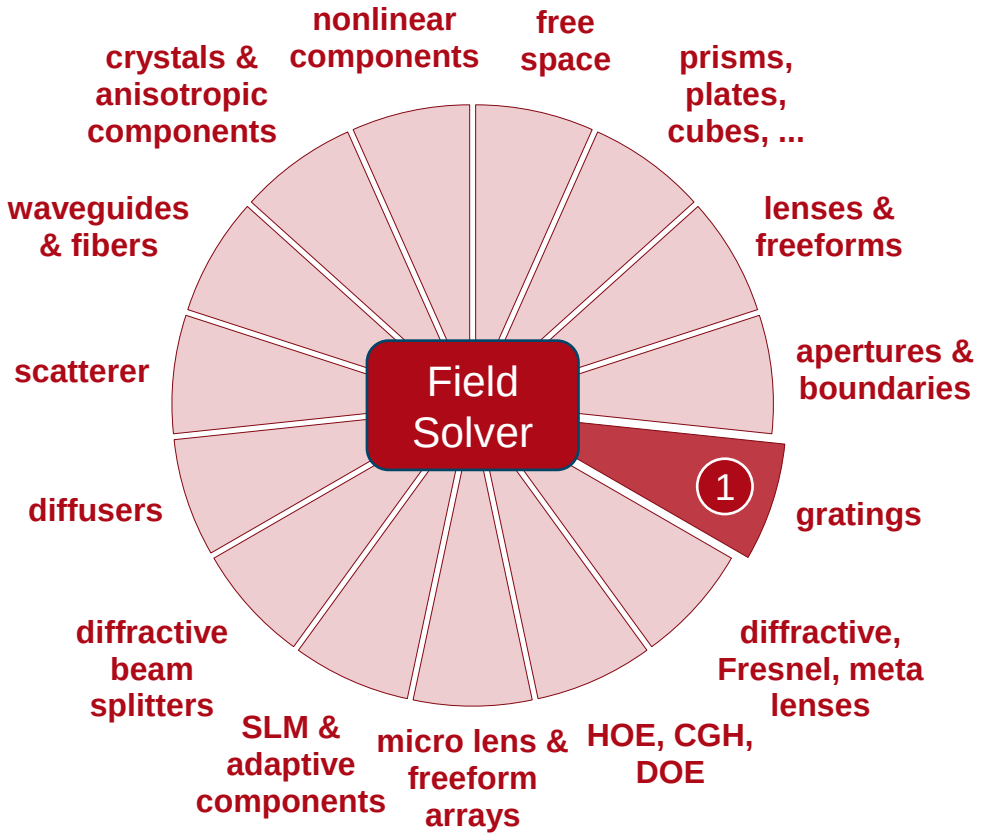
simulation result from reference:

I.-H. Lee, *et al*., Opt. Express 23, 25866-25873 (2015). [Fig. 2 (a)]



VirtualLab Fusion Technologies





Document Information

title	Talbot Images of A Conical Phase Mask
document code	GRT.0023
document version	1.1
software edition	VirtualLab Fusion Advanced
software version	2021.1 (Build 1.180)
category	Application Use Case
further reading	- Ultra-Sparse Dielectric Nano-Wire Grid Polarizers - Grating Order Analyzer - Modeling of the Talbot Effect - Configuration of Grating Structures by Using Interfaces - Configuration of Grating Structures by using Special Media