

Testing Spiral Zone Plates in the EUV

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Motivation

- It has been demonstrated that light can be structured into tube-like optical vortices carrying Orbital Angular Momentum (OAM). [1]
- XUV laser seeding experiment at LOA: these Zone Plates were designed to provide new degrees of freedom to an XUV laser, shaping it into a vortex beam carrying OAM.
- EUV Imaging: While OAM beams are used for phase contrast in the visible regime, this approach has not yet been demonstrated in the EUV, where the diffraction limit ($\sim \lambda$) allows nanoscale spatial resolution.

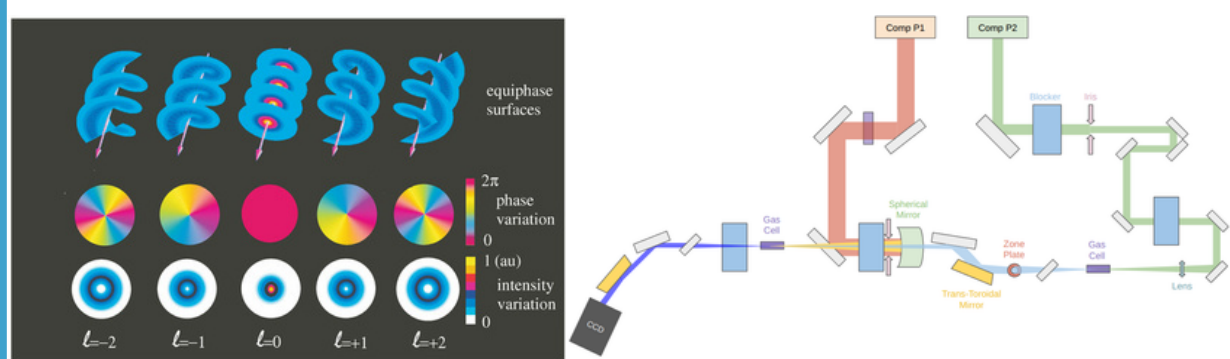


Fig.1 - a. Tubular light shaping for different topological charges, l . **b.** OAM seeding experiment setup at LOA.

Fresnel Zone Plates

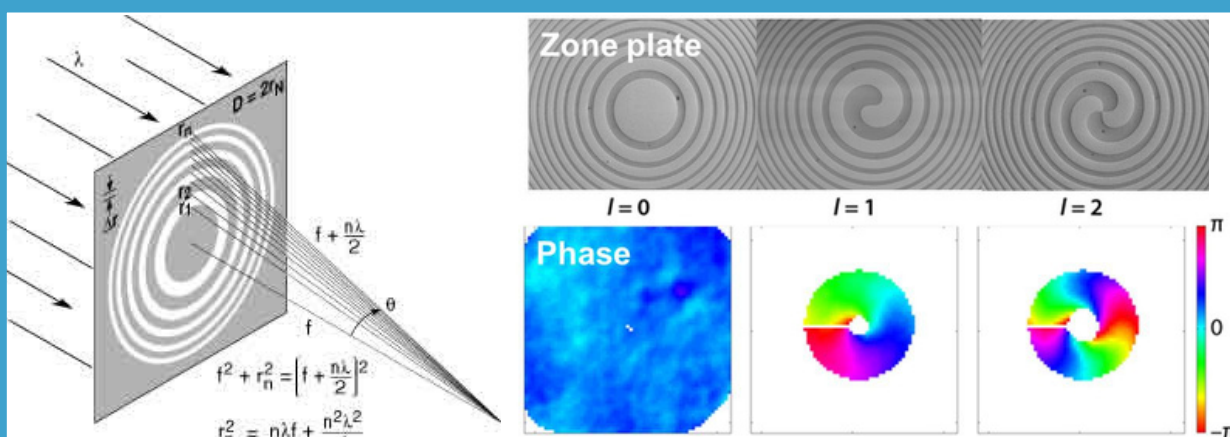


Fig.1 - a. A Fresnel zone plate lens [2]. **b.** Top row: Spiral zone plates with topological charge $l = 0$, $l = 1$ and $l = 2$. Bottom row: Resulting phase at the wavefront. (Adapted from [3])

Amplitude Zone Plates

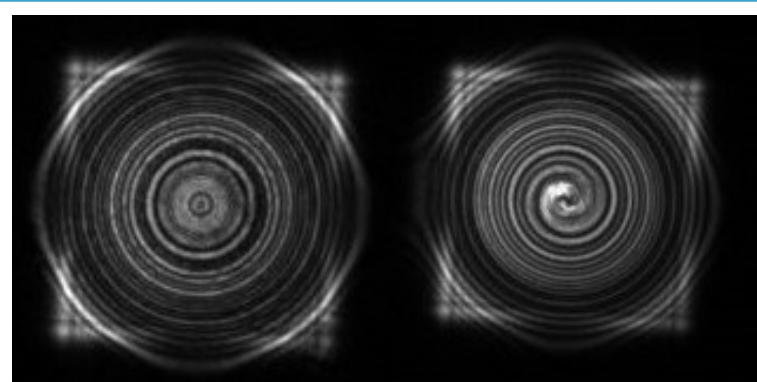


Fig. 2 - Beam profile measured at a wavelength of 32 nm after passing through the Si_3N_4 lenses.

Zone Plate	Transmission	Calculated thickness
1	0.285%	139 nm to 142 nm
2	0.304%	137 nm to 141 nm

Phase Zone Plates

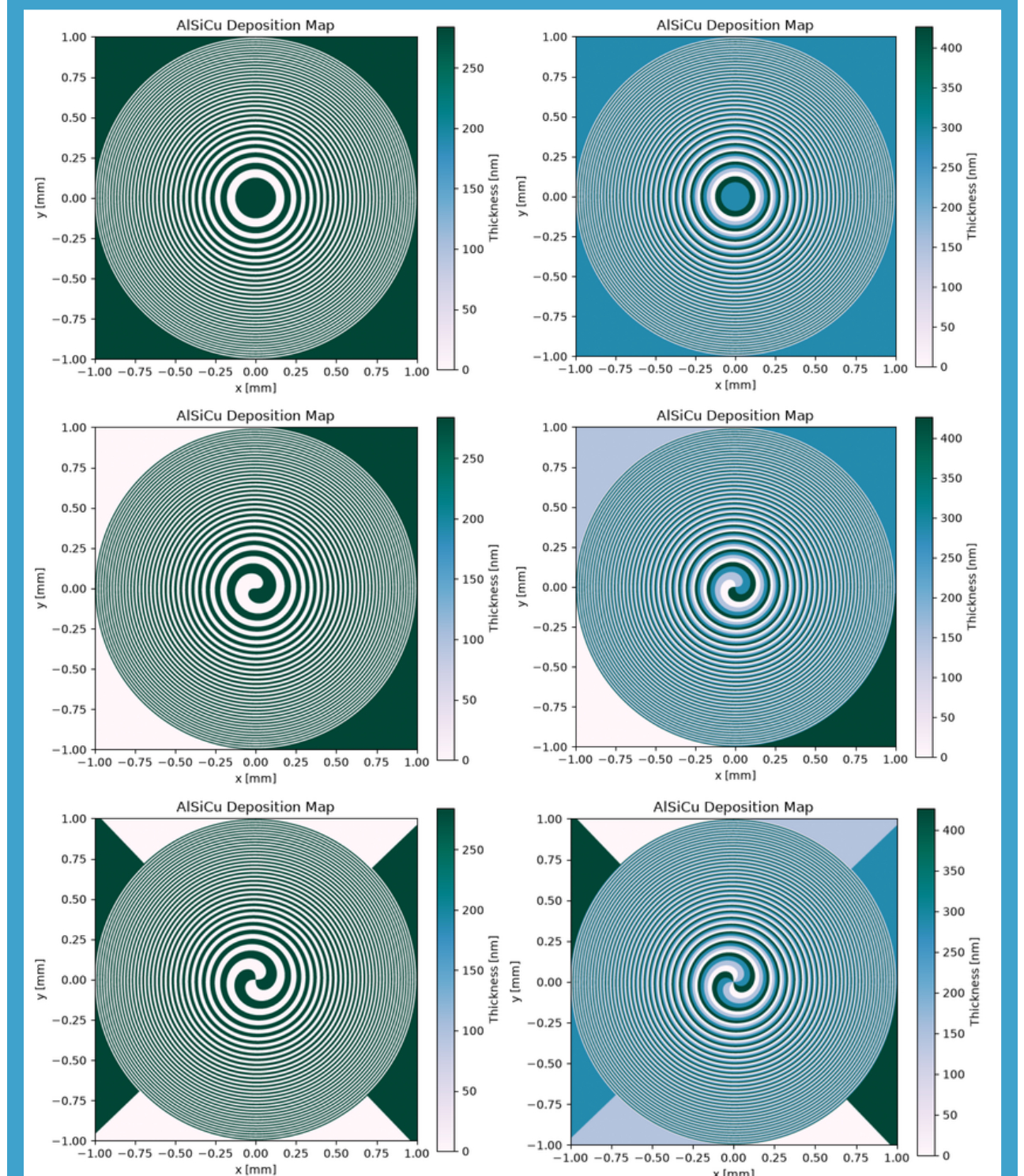


Fig. 3 - AlSiCu deposition maps for different geometries.

Steps	Thickness	Efficiency	Transmission	$\Delta\phi$ (rad)
2	285 nm	29.80%	47.70%	π
4	427 nm	50.80%	35.40%	$3\pi/2$

Conclusion



Fig. 4 - Microscopic view of the final 2-step zone plates.

- There was a residual layer of Si_3N_4 in the membrane blocking light transmission.
- Next Step: improve the manufacturing process to correctly remove this layer.
- Only a few groups have fabricated phase zone plates with EUV capability.

References:

- [1] P. Estrela et al., Extreme ultraviolet vortex light tubes by chromatic wavefront shaping of high harmonics (2024).
- [2] D. Attwood, A. Sakdinawat, X-Rays and EUV Radiation: Principles and Applications, 2nd ed., Cambridge Univ. Press (2016).
- [3] P. R. Ribič et al., Phys. Rev. X 7, 031036 (2017)