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Silicon to Software™

MetaOptic Designer

A Fully Automated Tool for Metalens/Metasurface with Inverse Design Capability

EPIC Online Technology Meeting on
Metamaterials and Metalenses

9 January 2023, Dr. Maryvonne CHALONY
chalony@synopsys.com

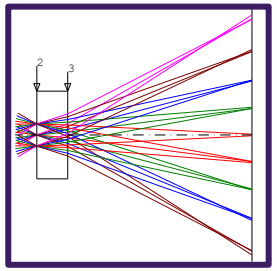
Existing Metalens Design Approach

- Semi-automatic multi-domain approach
  - Also involves tremendous manual work to lay out metalenses

Build Libraries → Layout Metalens → Simulation

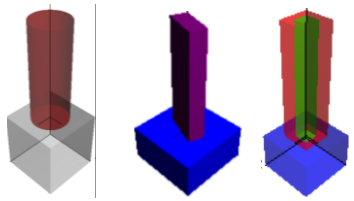
Ray-Tracing Optimizer
Generates desired phase profile(s) based on system performance specification

Lens phase profile library

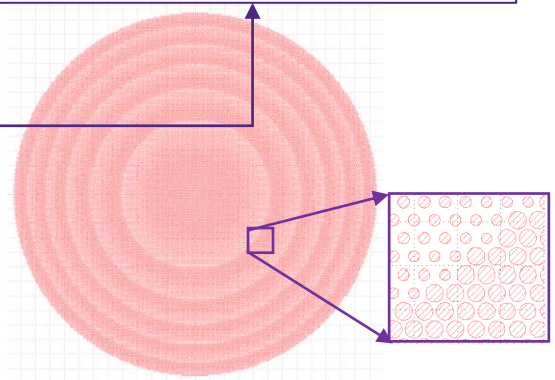


Rigorous EM simulator
For chosen meta-atom and design variables, RCWA or FDTD creates transfer function

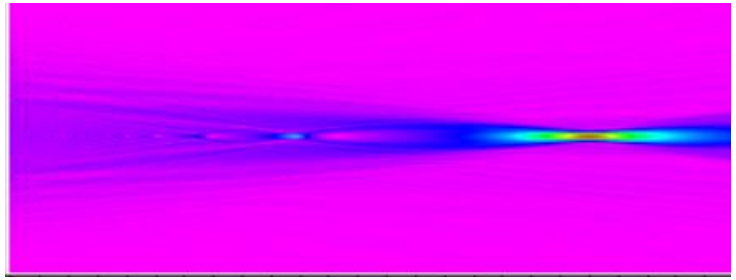
Meta-atom library



Layout:
Based on required phase, designer picks suitable meta-atoms to form the metalens



Verification:
Simulate the built metalens by suitable approach
- FDTD
- BPM
- FFT
- BSP
- Ray-Tracing



Novak, Matthew J., Bryan D. Stone, and Chenglin Xu. "Combined optimization, modeling and simulation techniques for non-traditional, next generation optics." *Computational Optics 2021*. Vol. 11875. SPIE, 2021.

A New Metalens Design Approach

MetaOptic Designer

Fully automated tool with inverse design capability

Enables designers at all levels of expertise to create novel metalens designs quickly and easily

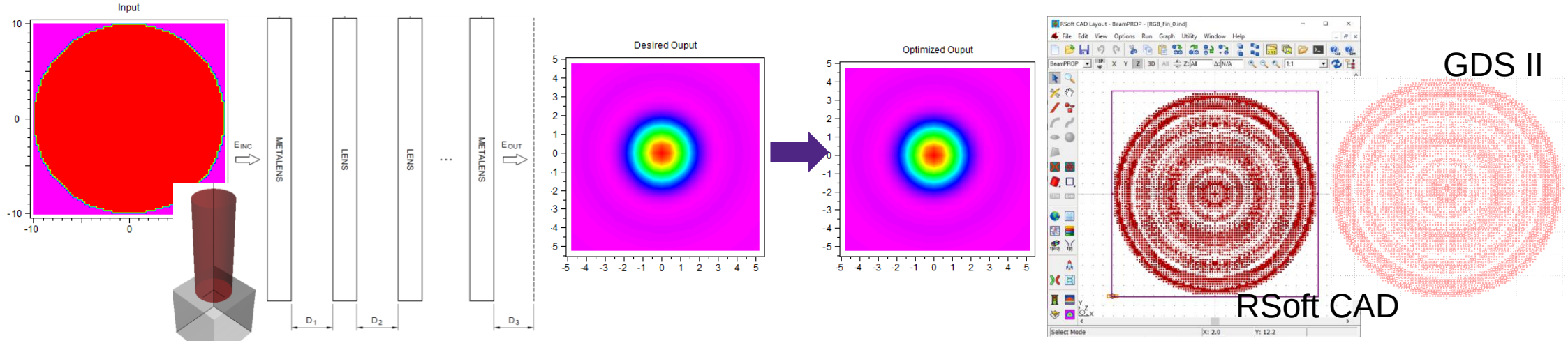
Shortens design cycles and reduces costs

MetaOptic Designer Overview

MetaOptic Designer automatically generates metalens/metasurface layouts, RSoft CAD files for simulation, and GDS files for fabrication.

Incidence + Meta-Atom + Optical System + Targets

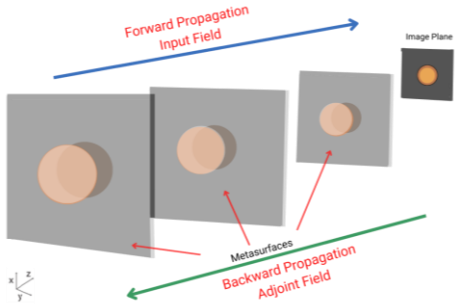
Optimized Results



Bos, J., Scarmozzino, R., Bahl, M., Heller, E., Xu, C., "A Design Automation and Simulation Flow for Lens Systems Containing Multiple Metasurfaces," META, July 2022, **Torremolinos Spain.**

Features:

- Inverse design
- Accurate -- validated by FDTD
- Efficient



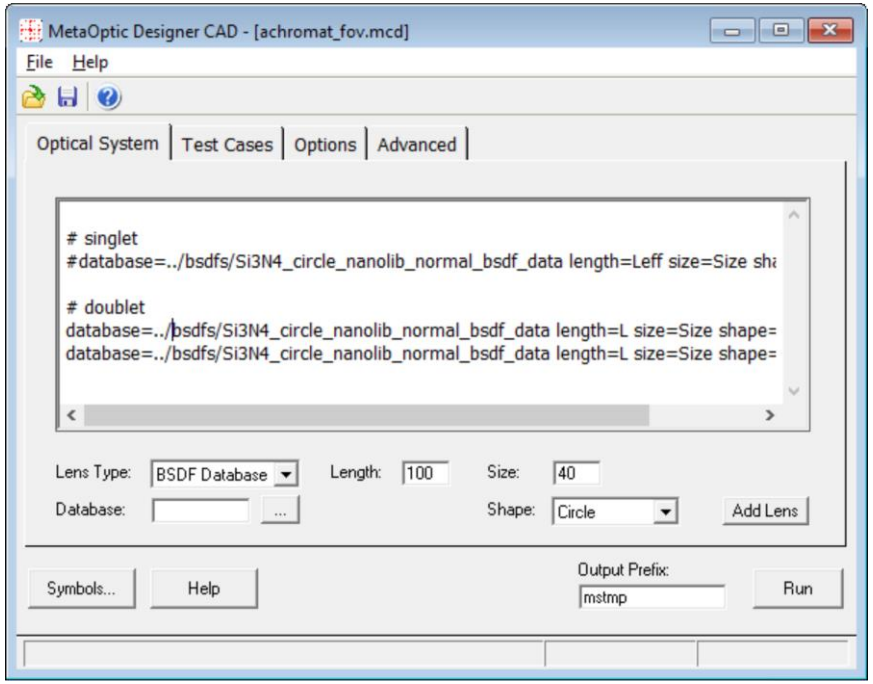
Benefits:

- Reduces the level of knowledge and expertise required of users
- Shortens design cycle and saves money
- Saves space by replacing bulky curved lenses with flat surfaces

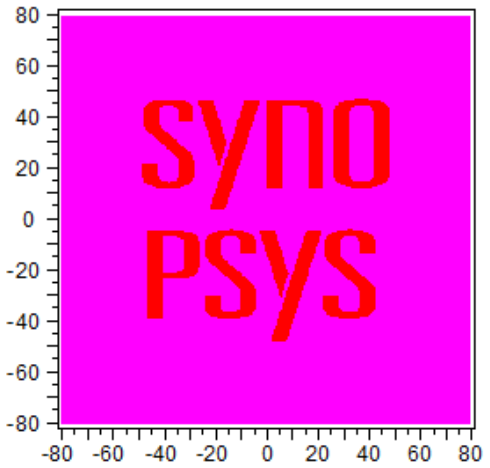
MetaOptic Designer Overview

Inputs and Outputs

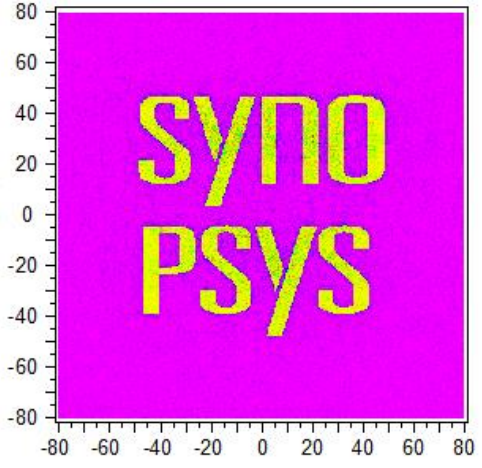
- User specifies the set of lenses in the optical system and the BSDF database (meta-atom library) for each.
- User specifies the desired target patterns and focus lengths.
- MetaOptic Designer determines the design parameters across each metasurface and exports GDS and optimization results.



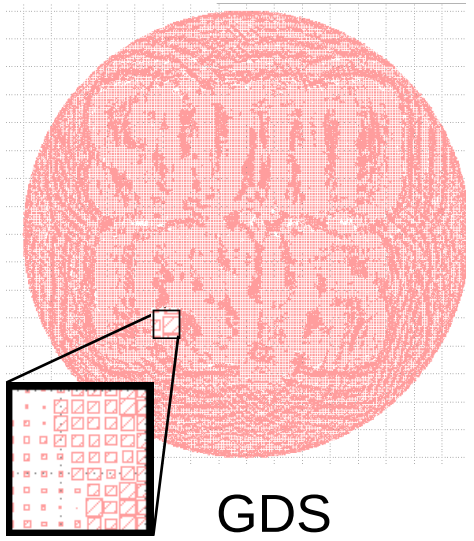
Target Pattern



Optimized Pattern



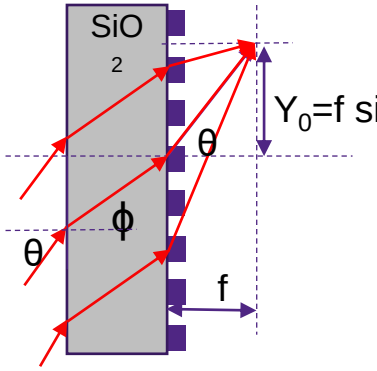
Optimized Layout

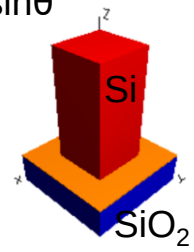


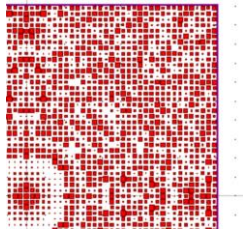
GDS

Design Examples

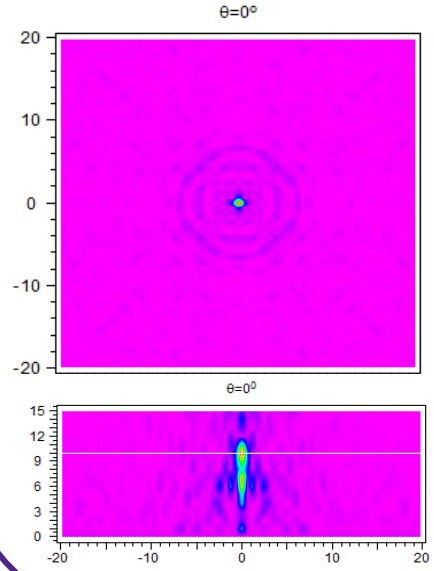
Fisheye metalens



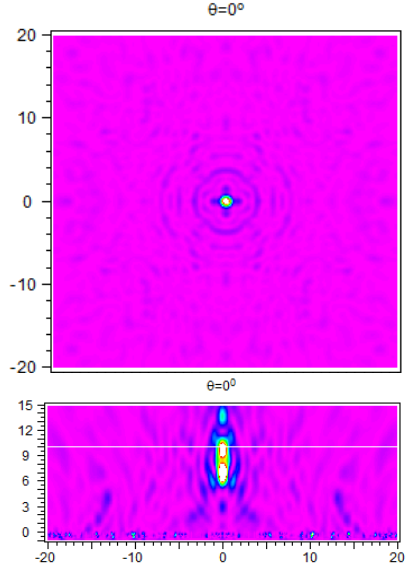




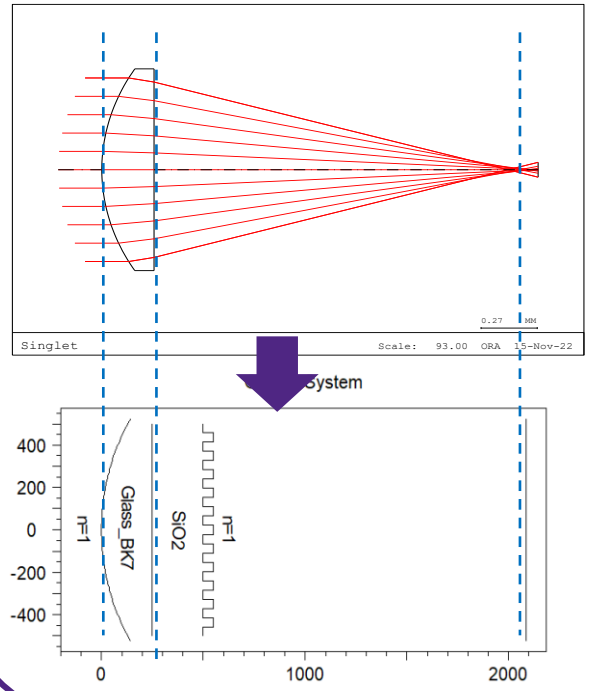
Optimized Results



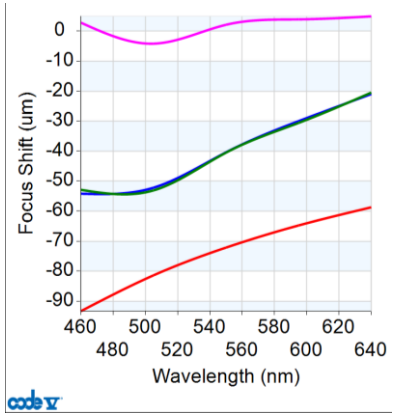
FDTD Validation



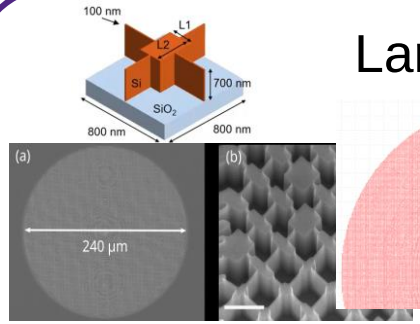
Refractive Lenses + Metalenses

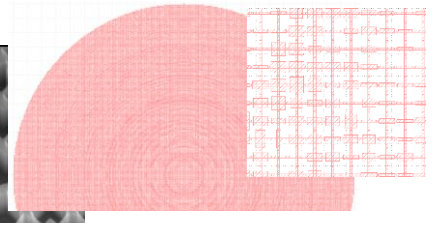


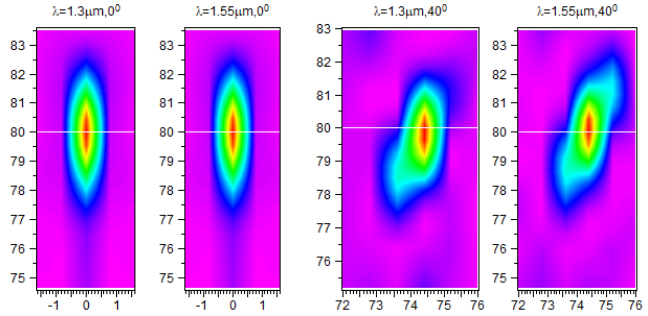
- wo Metacorrector, CODE V, Wavefront Best Focus
- wo Metacorrector, CODE V BSP, First intensity peak
- wo Metacorrector, MOD First intensity peak
- w Metacorrector, MOD, Max intensity



Large FOV and Achromatic Metalens

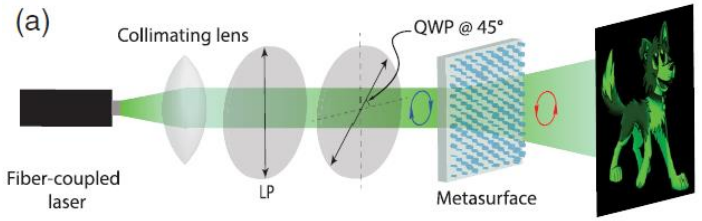


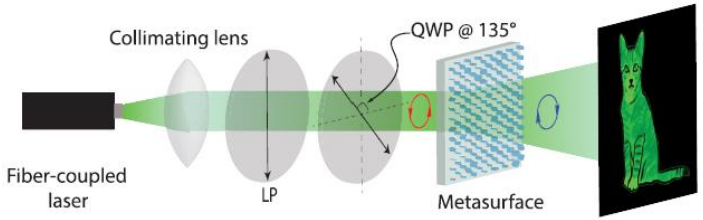




Liu, Y., Zhang, J., Le Roux, X., Cassan, E., Marris-Morini, D., Vivien, L., ... & Melati, D. (2022). Broadband behavior of quadratic metalenses with a wide field of view. *Optics Express*, *30*(22), 39860-39867.

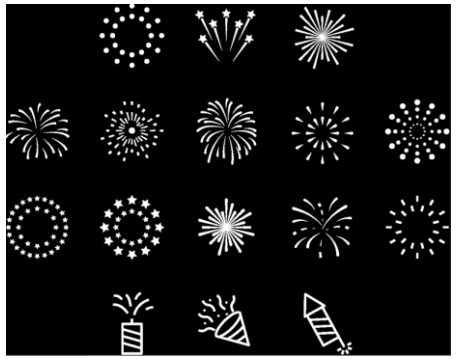
Polarization Selective Hologram



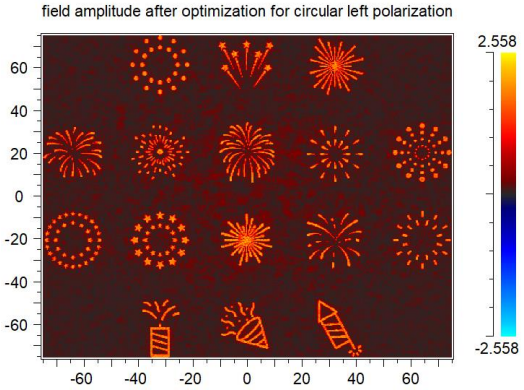


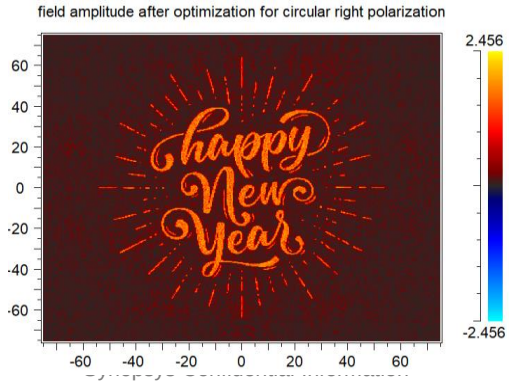
Mueller, J. B., Rubin, N. A., Devlin, R. C., Groever, B., and Capasso, F. (2017). *Physical review letters*, *118*(11), 113901.

Bitmap image used as target for the optimization

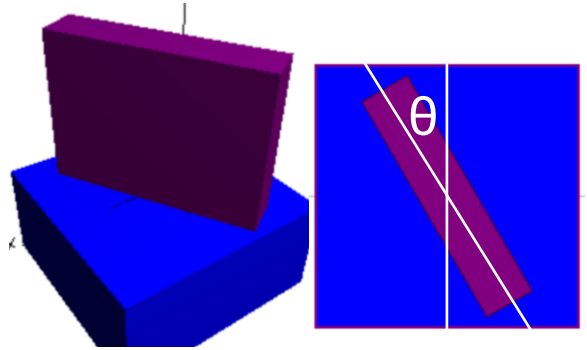


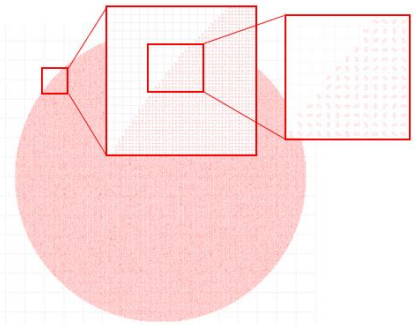
Amplitude of field after optimization





Meta-Atom





MetaOptic Designer Summary

Unique, fully automatic tool to design metalenses and metasurfaces using an inverse design algorithm

Dramatically simplifies and speeds design workflows

With minimum inputs required, designers at all levels of expertise can create novel metalens designs quickly and easily

Fast, rigorous FDTD validation ensures accurate optimization results

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Thank You