FABULOUS

FABrication of 3D metasurfaces to enable the next generation of high efficiency optical products

FABULOUS - Enabling the next generation of high efficiency optical products on 3D surfaces through Two Photon Polymerization

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EFFRA Manufacturing Partnership Days 2026,
Brussels, 17-18 November 2026

The Project

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Project goal:

Development of an Advanced Manufacturing Platform for Optical Metasurfaces

Design and implementation of a scalable fabrication system capable of:

- **Supporting high-throughput, high-resolution, and large-area production**
- **Enabling cost-effective manufacturing of 3D-structured optical metasurfaces**
- **Operating on non-planar surface topologies**
- **Delivering high efficiency, repeatability, and precision in industrial environments**

Partners

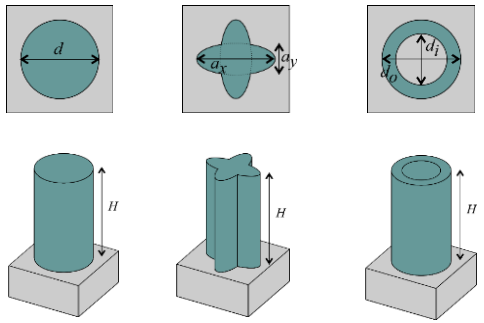
aimen TECHNOLOGY CENTRE
HEIDELBERG INSTRUMENTS
IMT Atlantique
Fraunhofer IISB
FORTH FOUNDATION FOR RESEARCH AND TECHNOLOGY - HELLAS
THALES Building a future we can all trust
PlanOpSim
MODUS Research and Innovation
FICOSA
IRES Innovation in Research & Engineering Solutions
STELLANTIS
nanoscribe

FABulous Methodology

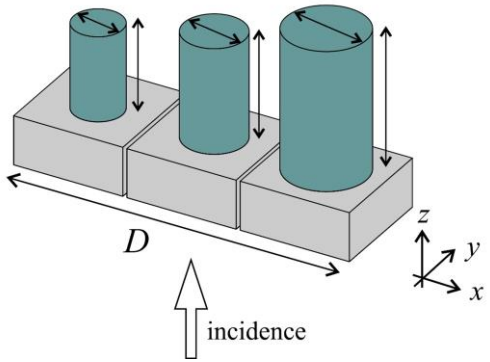
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Design

Meta-atom design

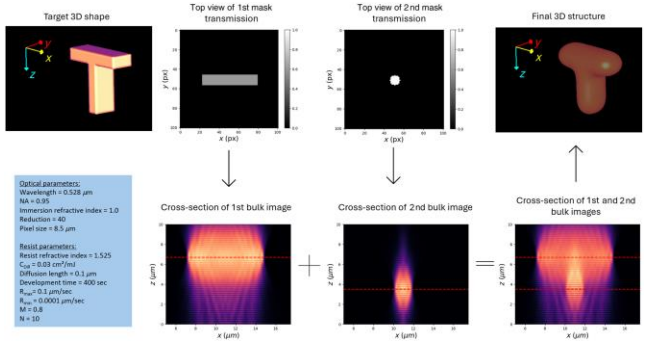


Meta-atom distributions

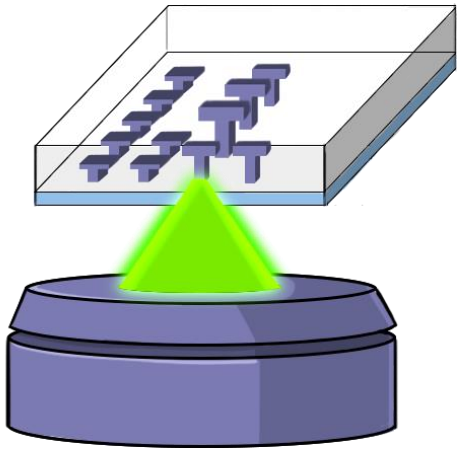


Parallel fabrication

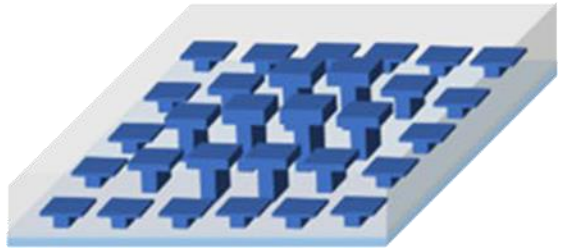
Fabrication co-optimization



Actual parallel fabrication



Printed metasurface



Validation in 3 use cases

FABulous use cases

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FABulous enables sustainable, high-efficiency manufacturing to support Europe's industrial decarbonization



Manufacturing high efficiency solar cells for high altitude platforms



Reducing the size and weight of automotive camera lenses

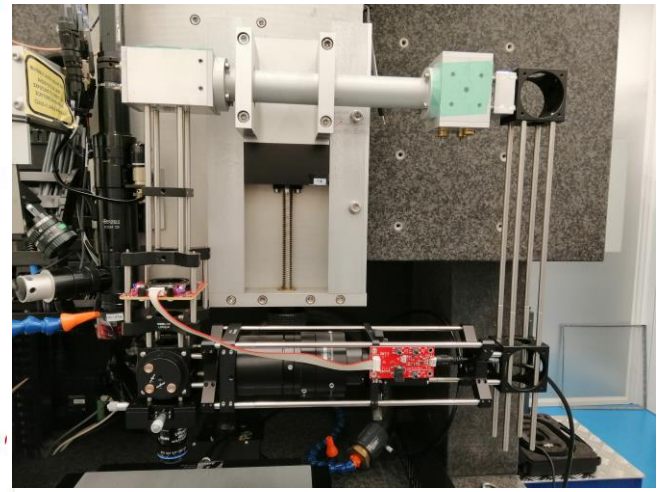


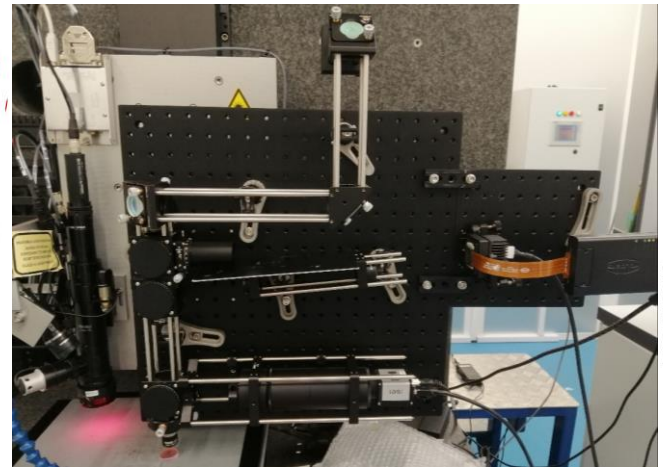
Manufacturing high efficiency light pipes used in automotive lighting systems

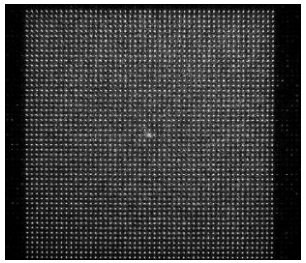
FABulous manufacturing

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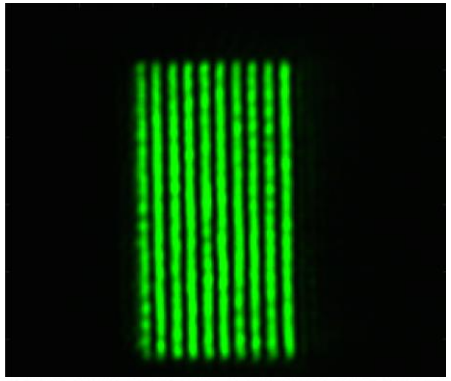
From experimental setups…

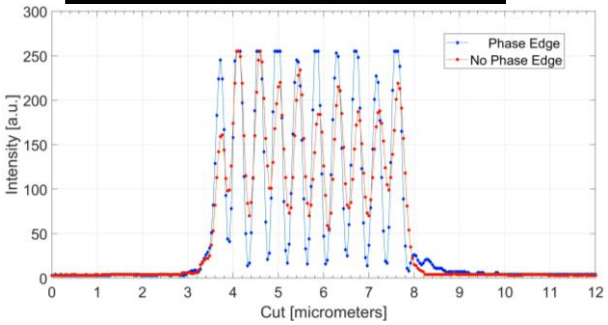






51×51 DOE





SLM Projection

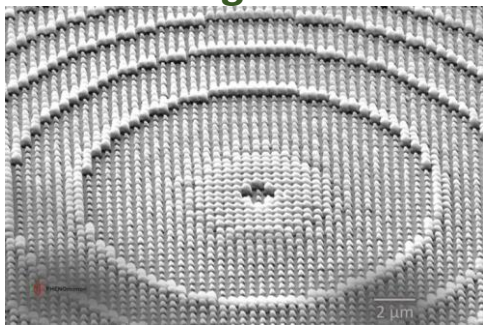
to industrial machines



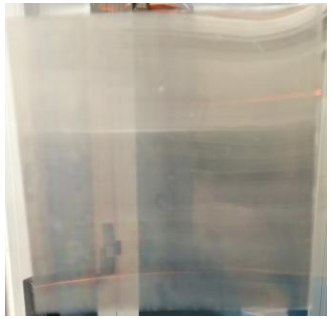
Area: 100x100 mm^2

Fabrication time: 19 min

Metalens fabrication with single beam



Lightguide fabrication with DOE



FABulous design

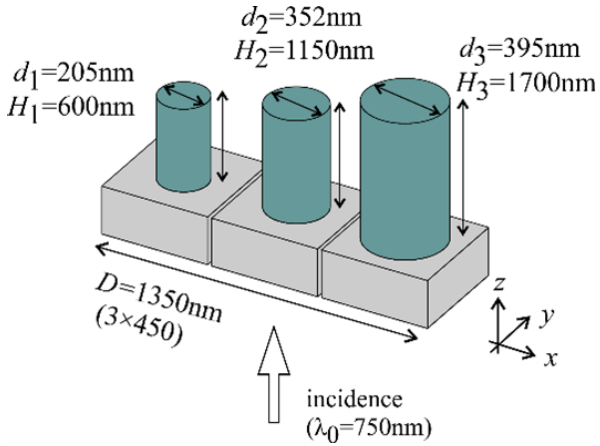

Metamaterials 2024
9-14 September 2024
Session: *Tunable and reconfigurable optical metastructures*

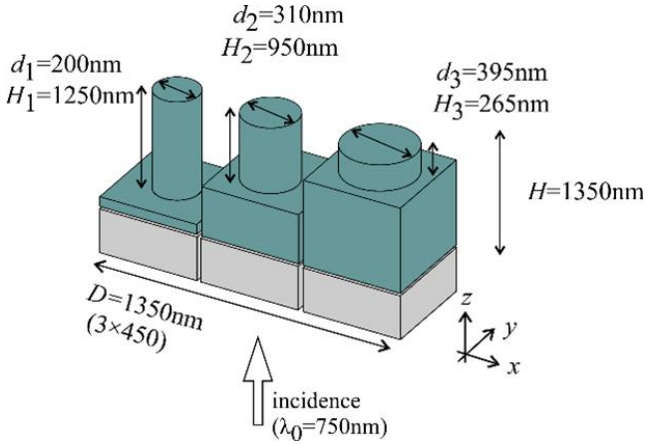
Polymeric Optical Metasurfaces by Two-Photon Lithography: Practical Designs for Beam Steering

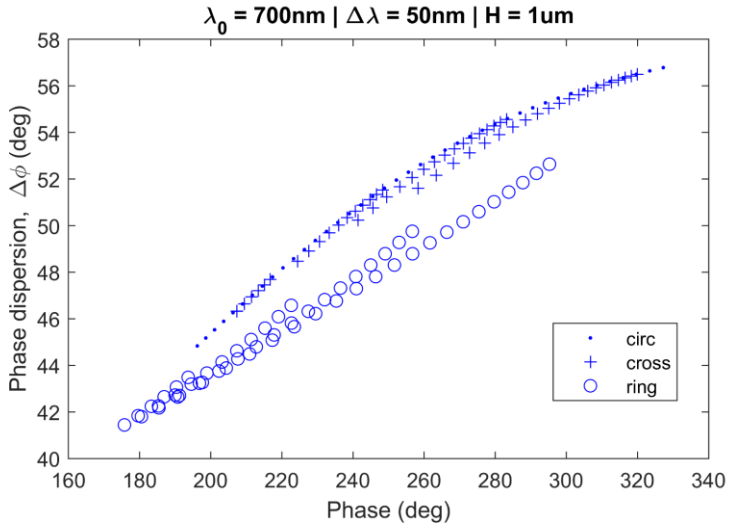
Odysseas Tsilipakos,[1,2] George Perrakis,[1] Maria Farsari[1], Maria Kafesaki,[1,3]
otsilipakos@iesl.forth.gr; otsilipakos@eie.gr

[1] Institute of Electronic Structure and Laser, Foundation for Research and Technology-Hellas, Greece
[2] Theoretical and Physical Chemistry Institute, National Hellenic Research Foundation, Greece
[3] Department of Materials Science and Technology, University of Crete, Greece

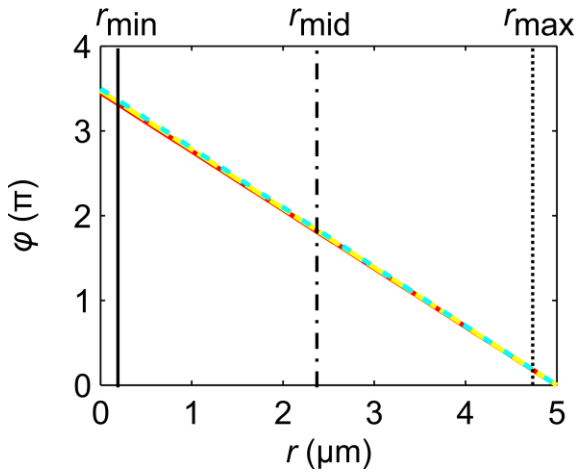
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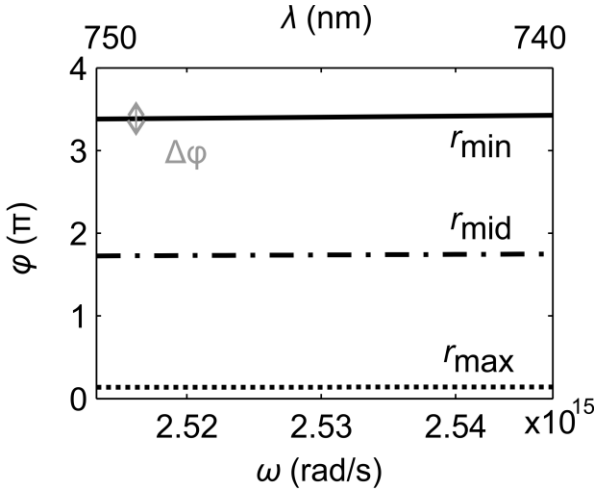






Bandwidth: 2 nm; Deflection angle: 0 → 30 deg; Extent: 30um

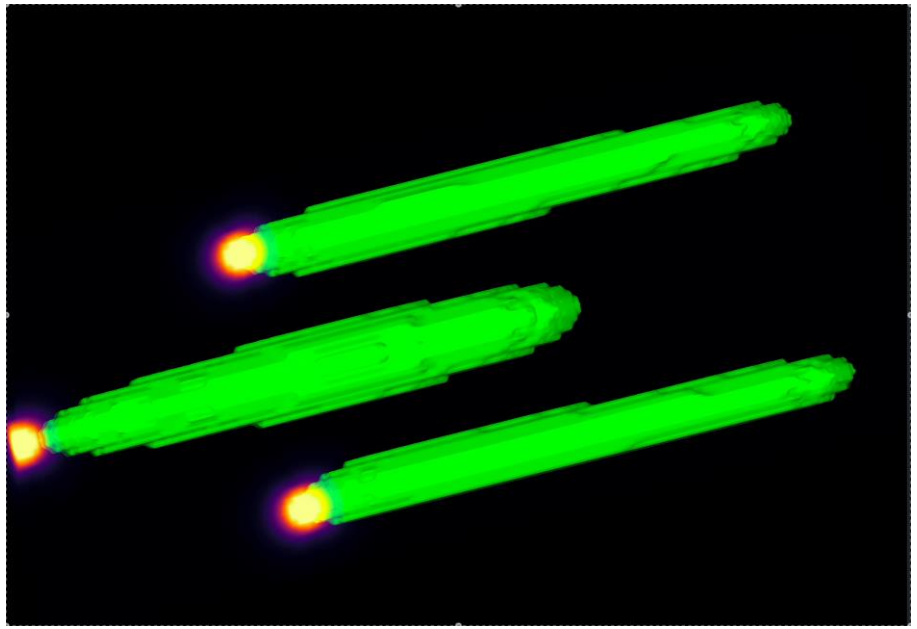




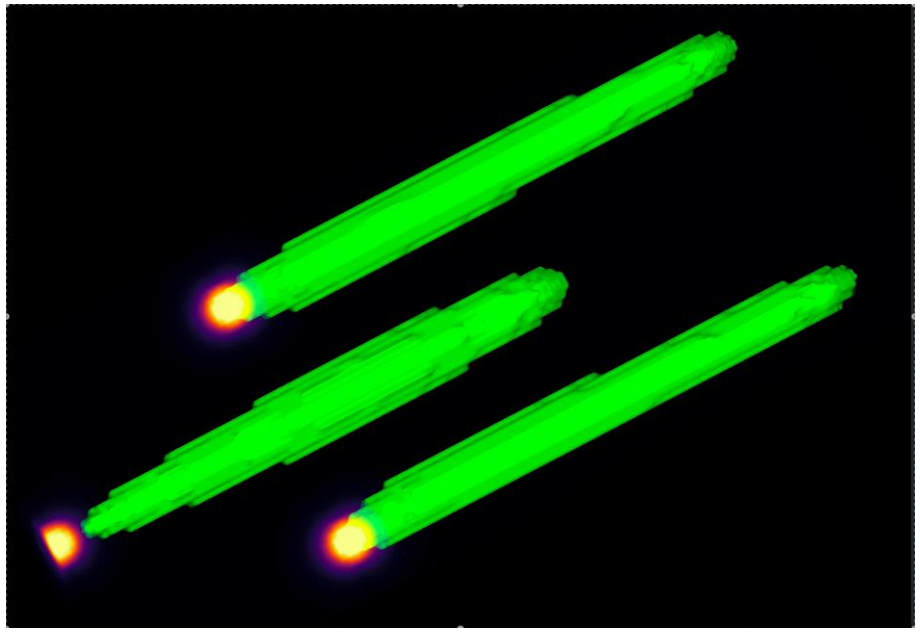
FABulous co-optimization

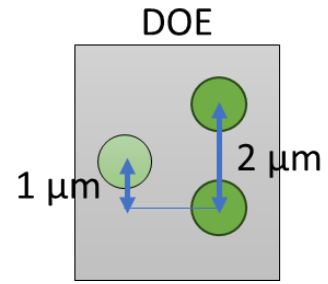
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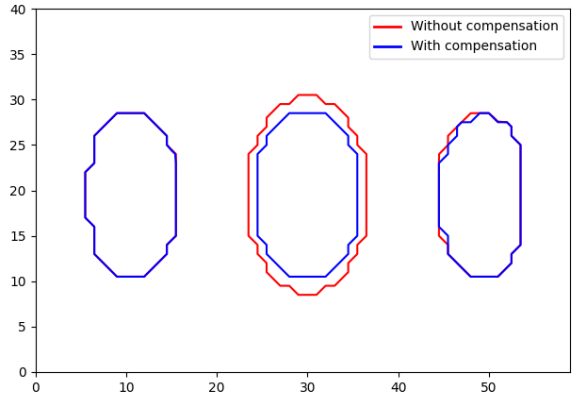
Without compensation

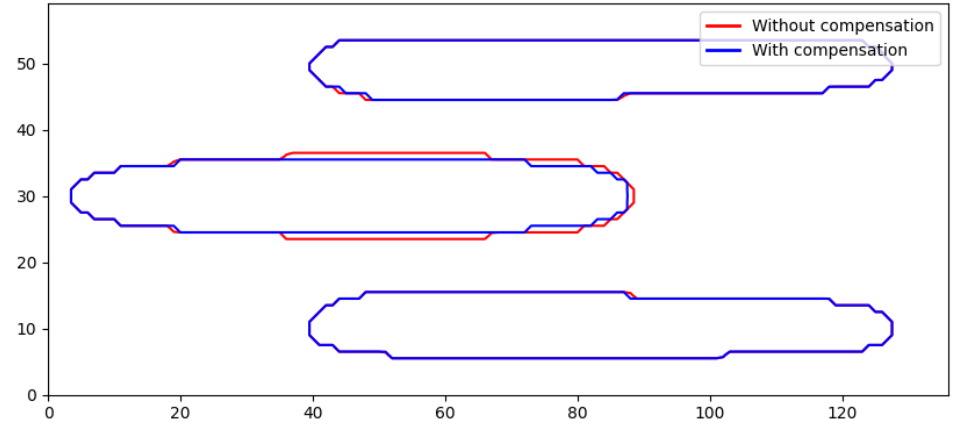


With compensation





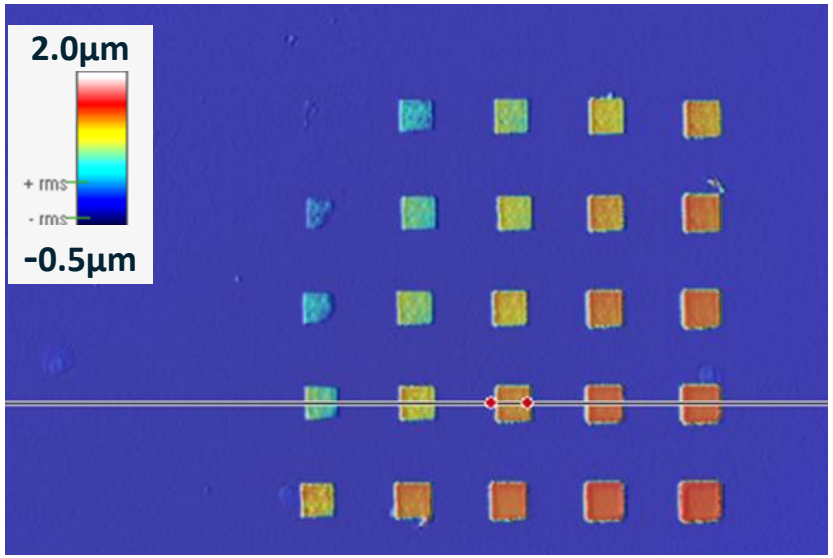


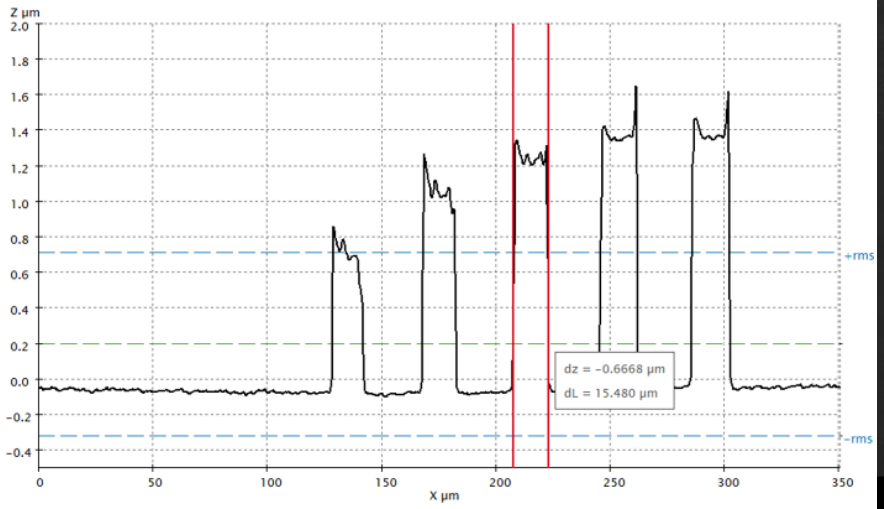


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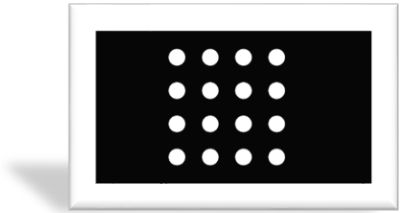
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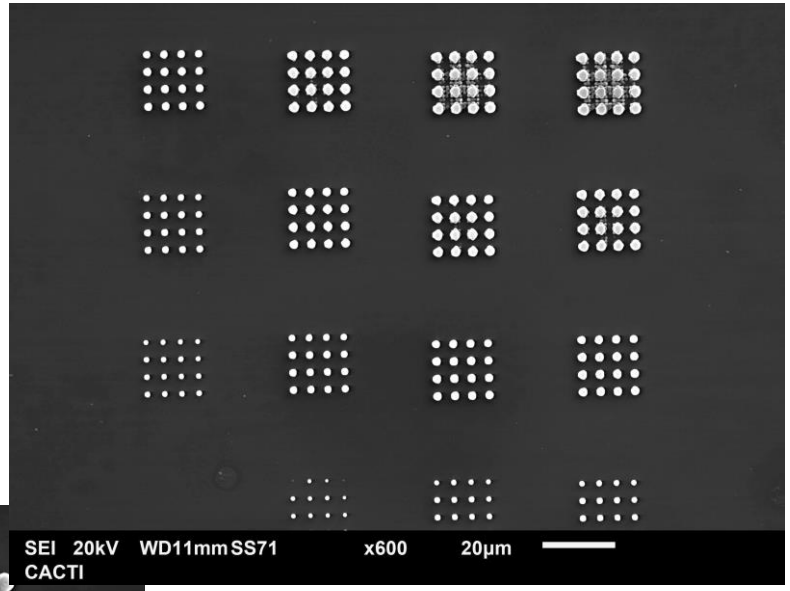
Height Regulation of Fabricated Structures

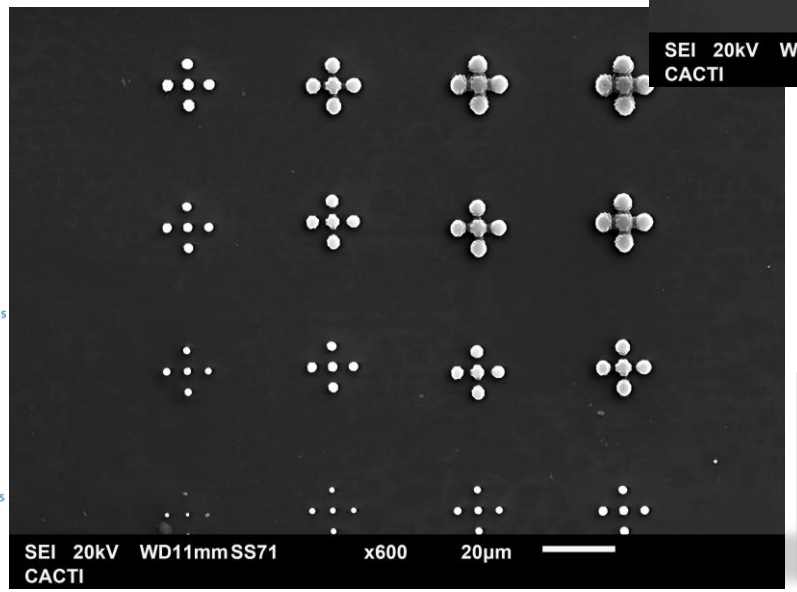


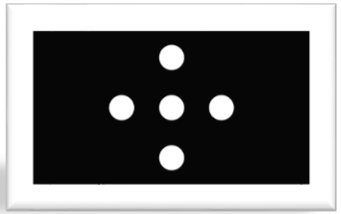


Dimensional Control: Size, Shape, and Inter-Element Spacing



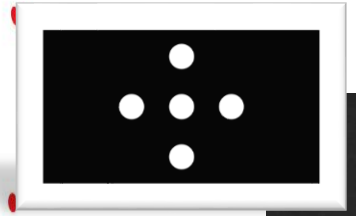




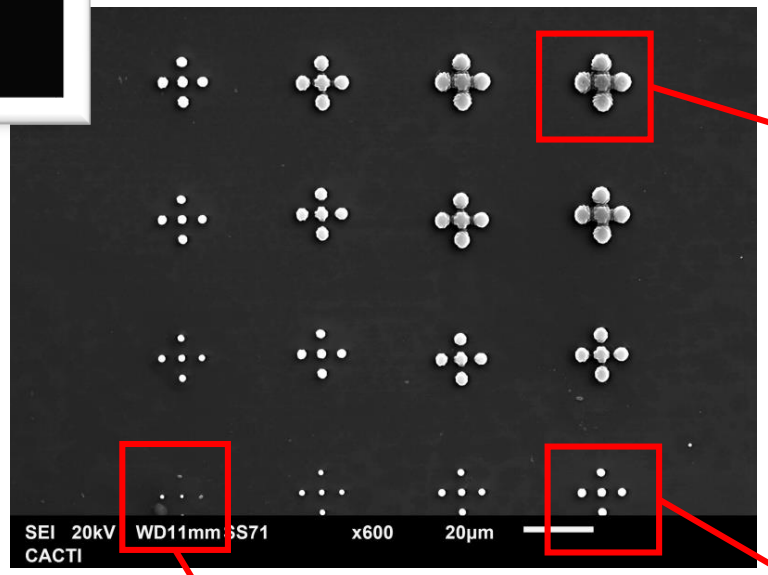


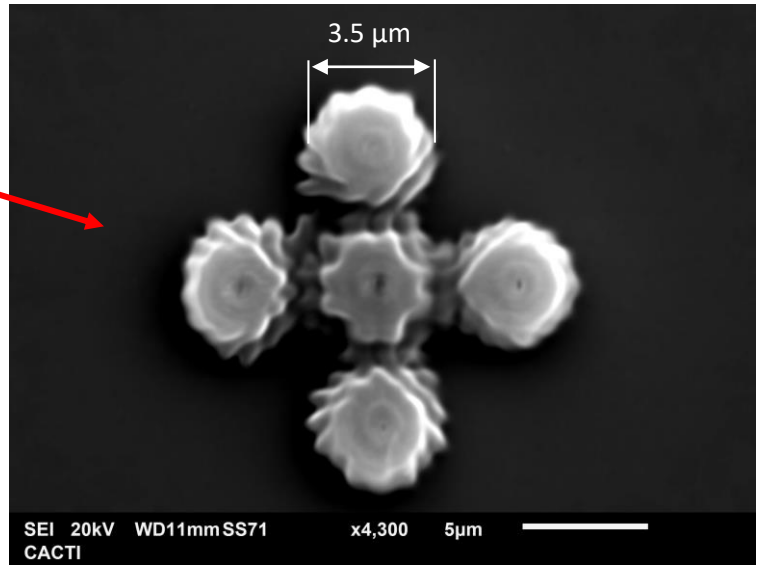
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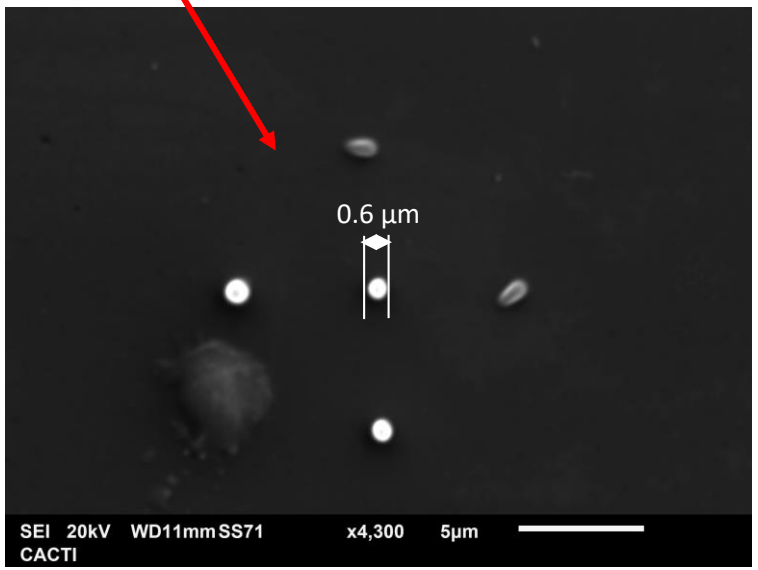
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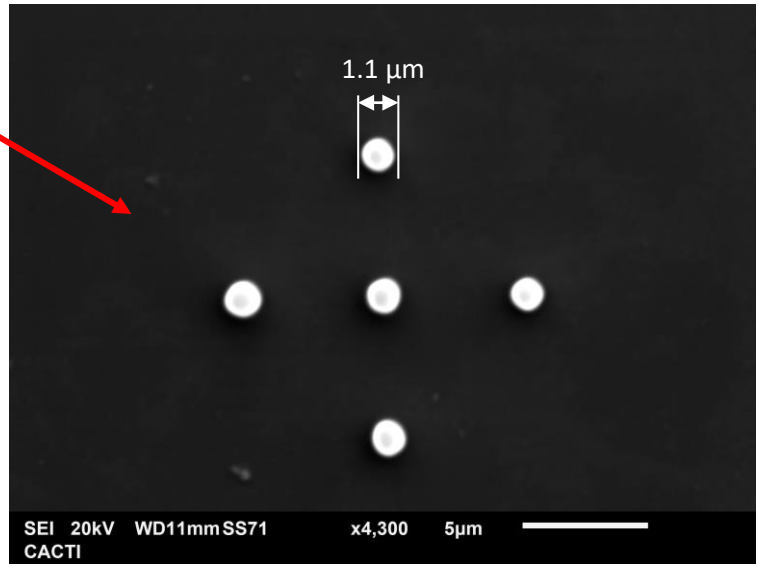


Size Control of Microstructures via Laser Power and Exposure Time Modulation



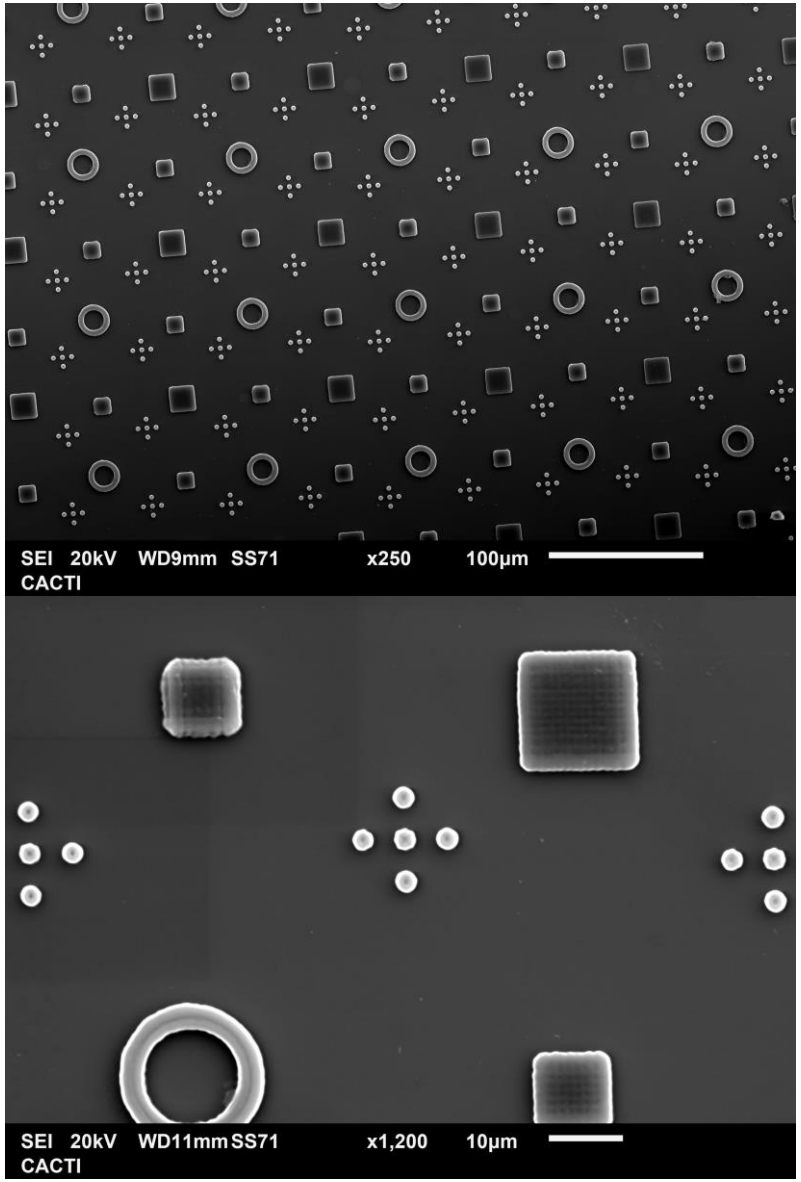




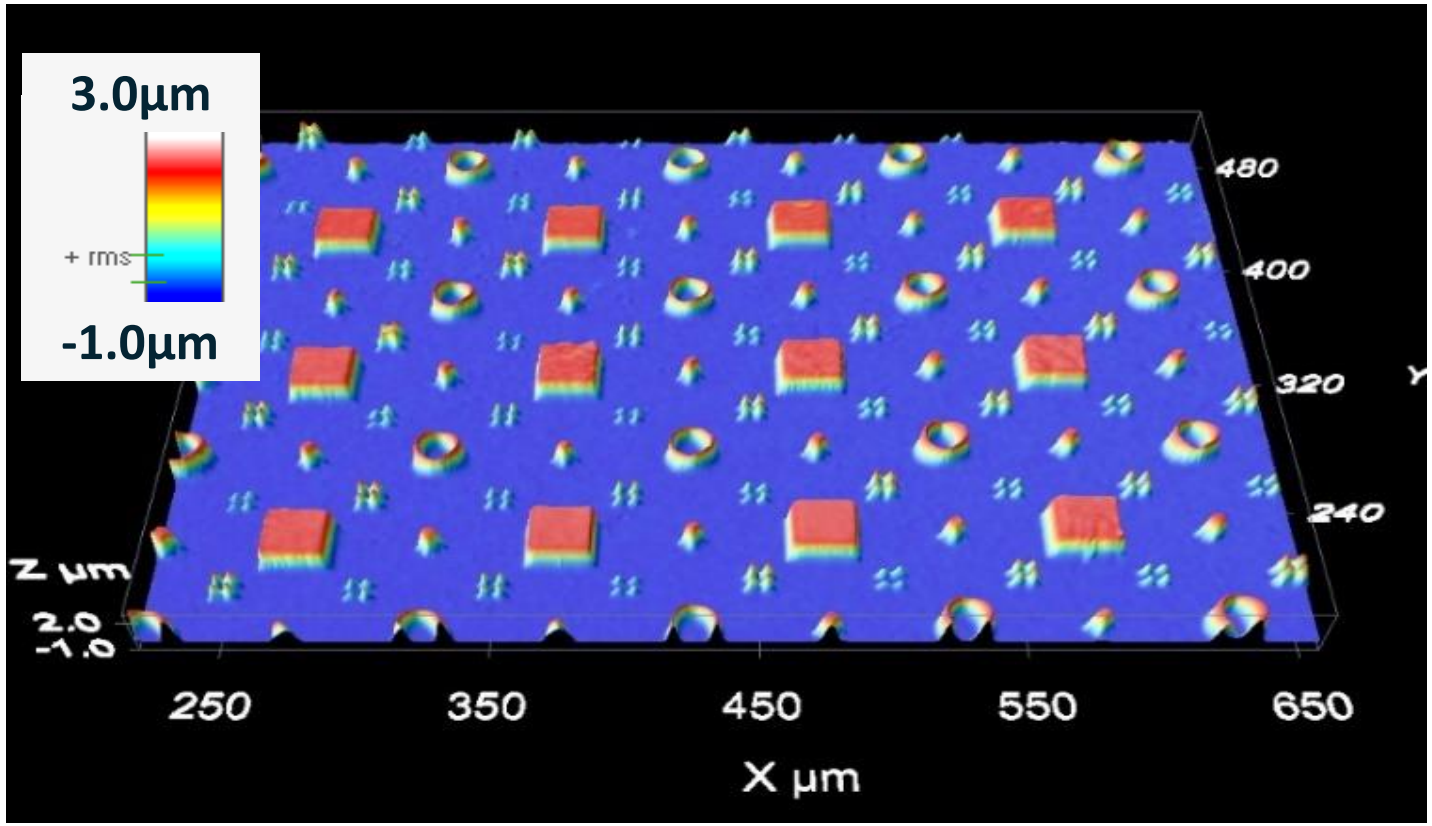


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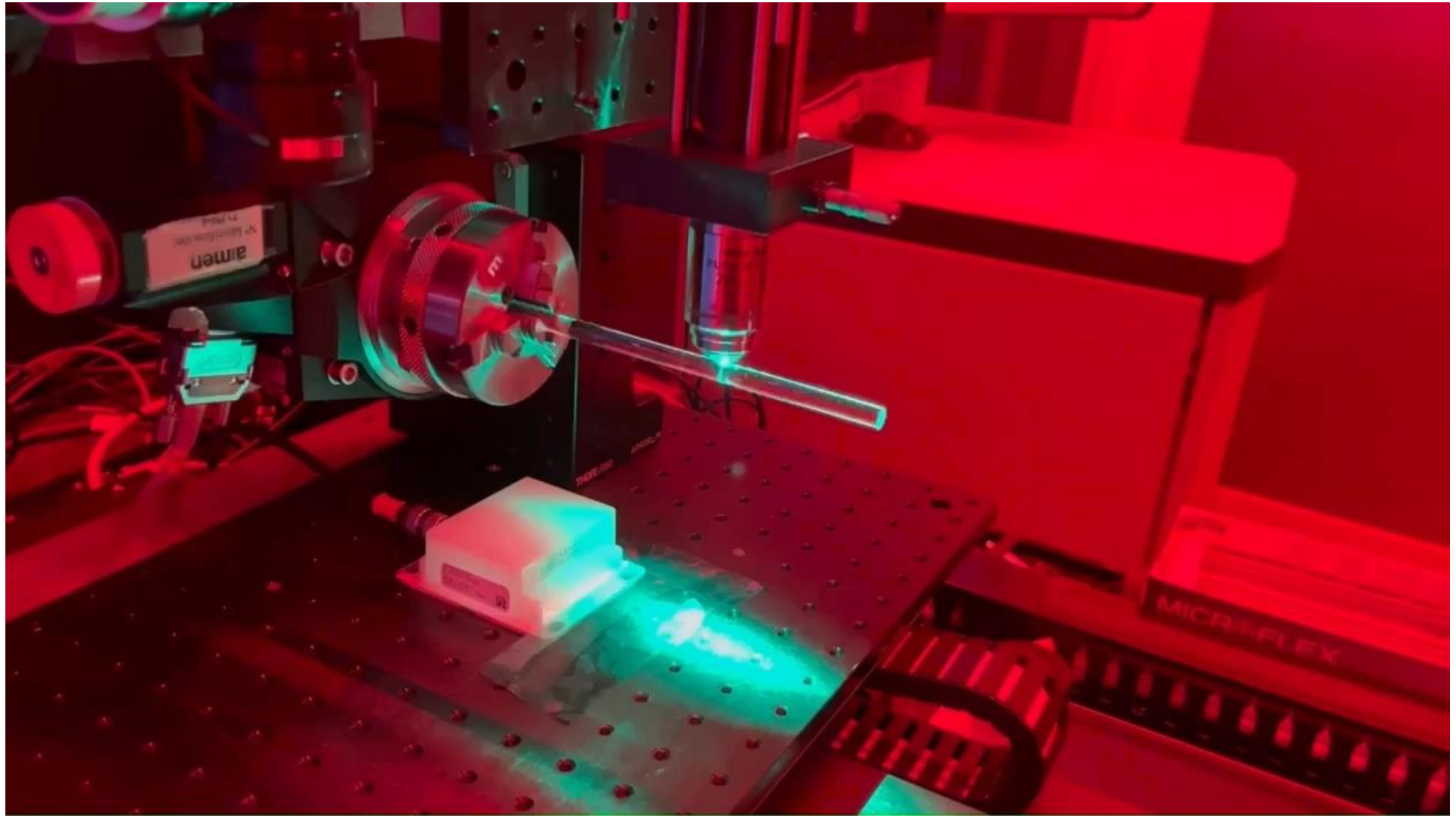


Optimizing Fabrication Meta-Atom Variants



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Summary

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- **A complete fabrication process for optical metasurfaces has been developed, including:**
  - Designing tools for customized optical surface functionalities;
  - Parallel fabrication strategies, based on:
    - Diffractive Optical Elements;
    - Spatial Light Modulators;
  - Fabrication co-optimization methods based on neural networks.
- **Increased throughput with:**
  - High resolution, below the micron size;
  - Excellent size control;
  - Impressive repeatability.
- **Industrially available, with applicability for highly demanding optical applications.**

Thanks for your attention

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