



# PHOT 451: Microscale optical system design

## LECTURE 01

*Michaël Barbier, Fall semester (2025-2026)*

# COURSE INFORMATION

## Instructor

Dr. Michaël Barbier

e-mail: [michaelbarbier@iyte.edu.tr](mailto:michaelbarbier@iyte.edu.tr)

Office: door on the right of Z5

Hours: Friday 9:00-17:00 (via  
appointment)

## Teaching Assistant(s)

Eray Ceyhan

e-mail: [erayceyhan@iyte.edu.tr](mailto:erayceyhan@iyte.edu.tr)

Office: Z9B

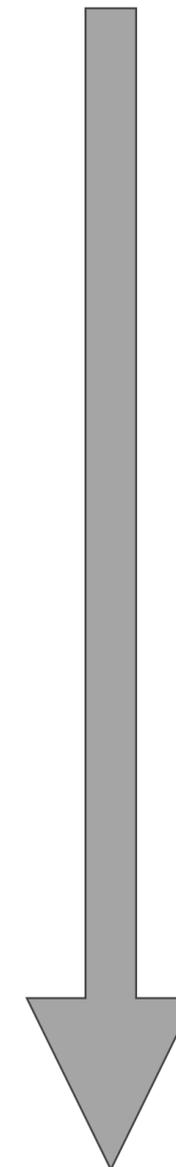
Hours: TBA

## Course Schedule

Monday      8:45 – 12:30      Building F, D1

# CONTENTS OF THE COURSE

- Review:
  - Microscale lenses, gratings, binary vs. blazed
  - Math: Complex numbers, Matrices, Fourier transforms
  - Wave propagation: Free space, wave guides, fibers
  - Approximations & Aberrations
- Optics:
  - Refractive: lenses (Reflective optics)
  - Diffractive optics
- Microlens arrays
- Wave guides, Coupled wave guides
- Photonic crystals



# COURSE MATERIALS

## Course book

**J. Jahns, S. Helfert, Introduction to Micro- and Nanooptics, Wiley (2012)**

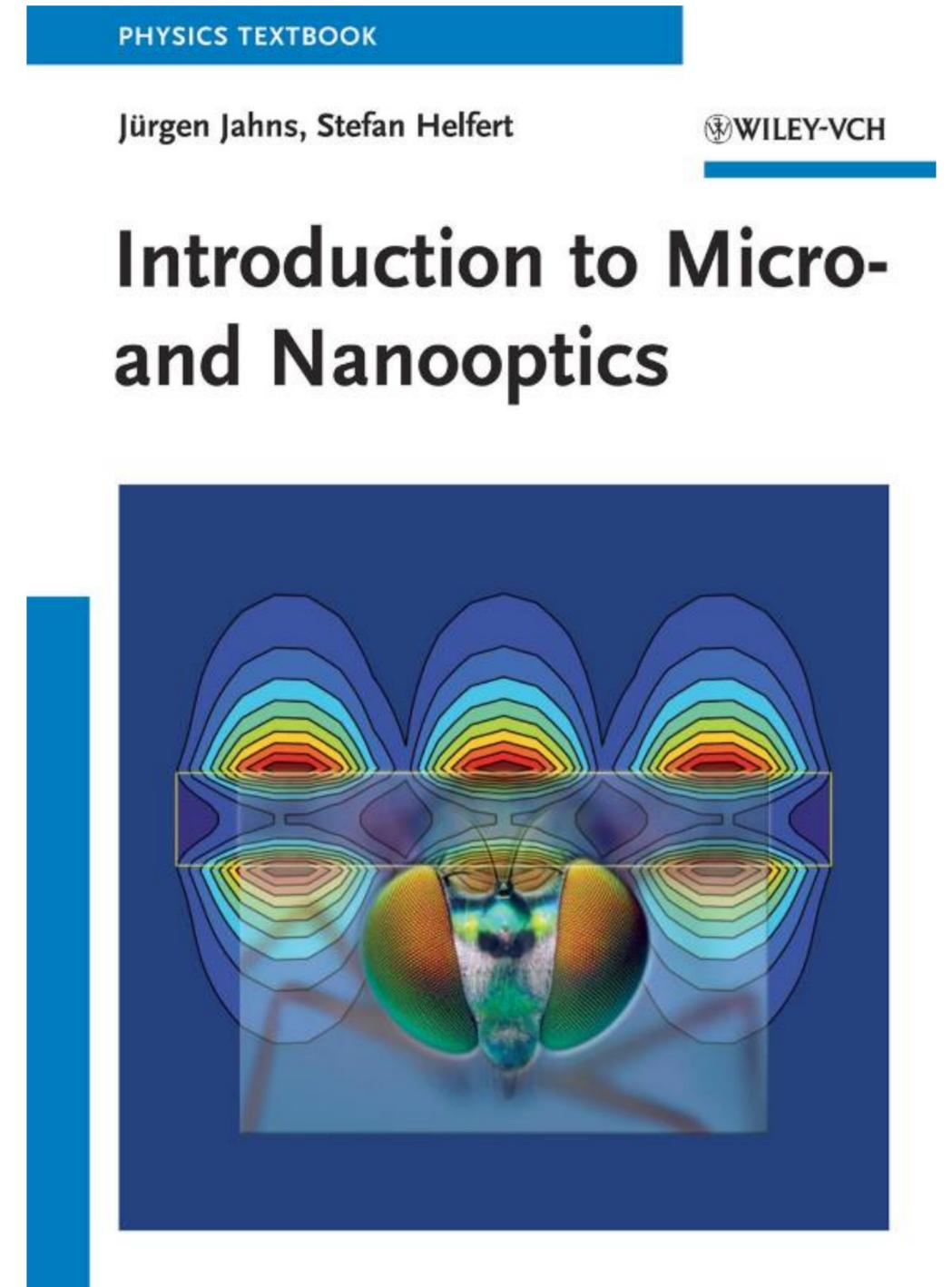
S. Sinzinger, J. Jahns, Microoptics, 2<sup>nd</sup> edition (2003)

## Supplementary materials

S. Bhattacharya, **Introduction to Ray, Wave, and Beam Optics with Applications**, IOP (2024)

R. Siew, **Modern Classical Optical System Design**, IOP (2024)

B.C. Kress, P. Meyrueis, **Applied Digital Optics**, Wiley (2009)



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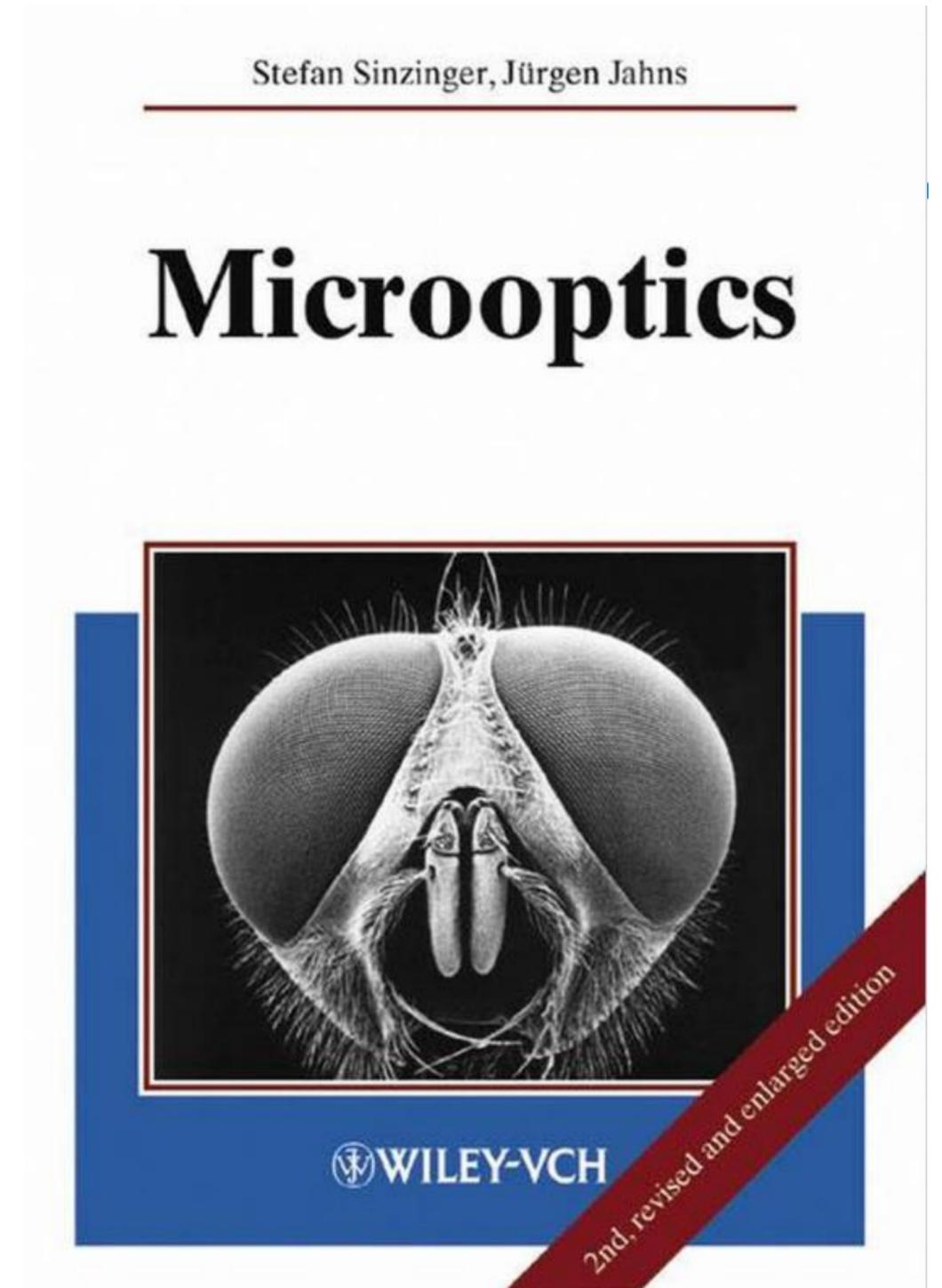
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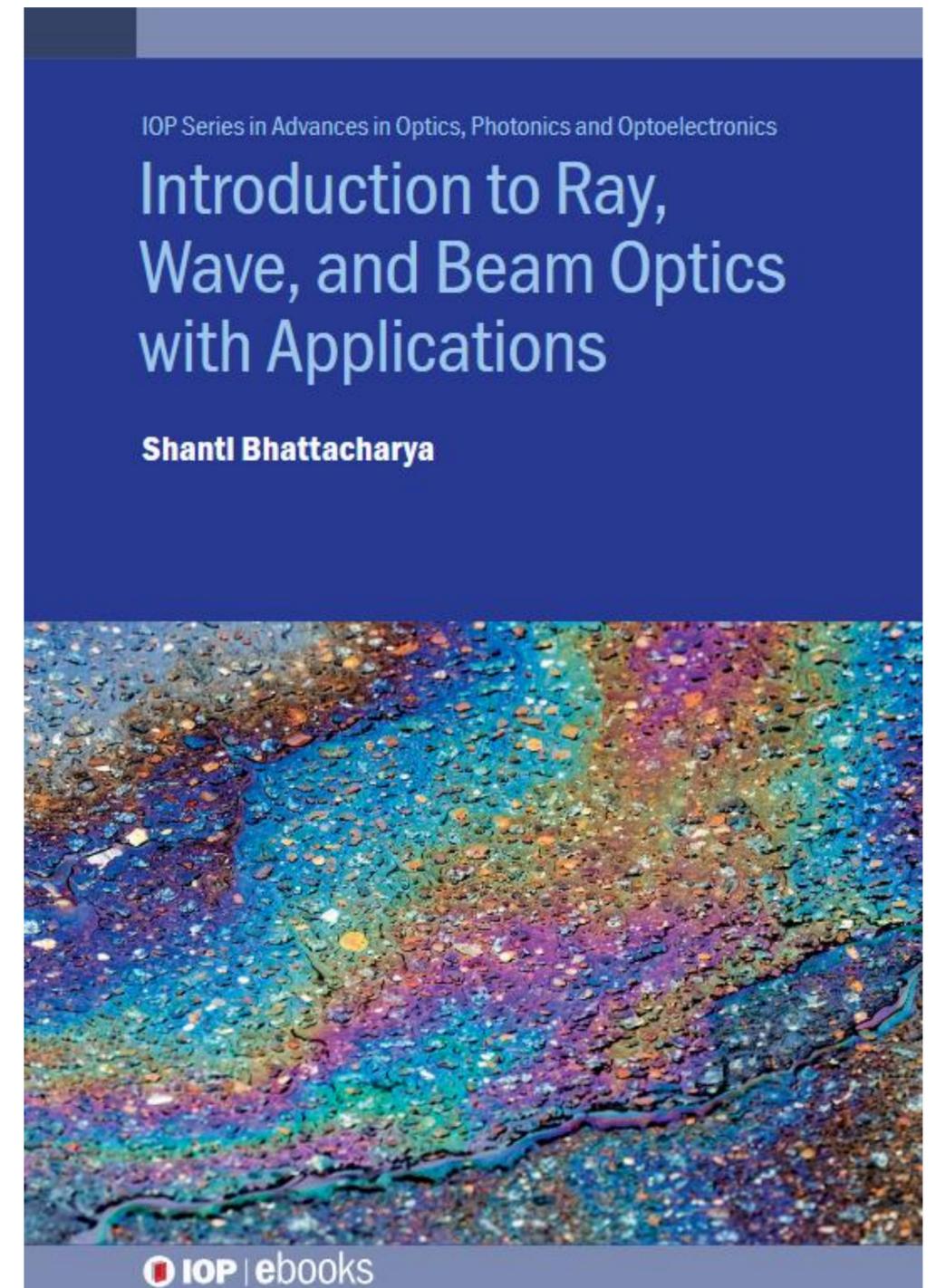
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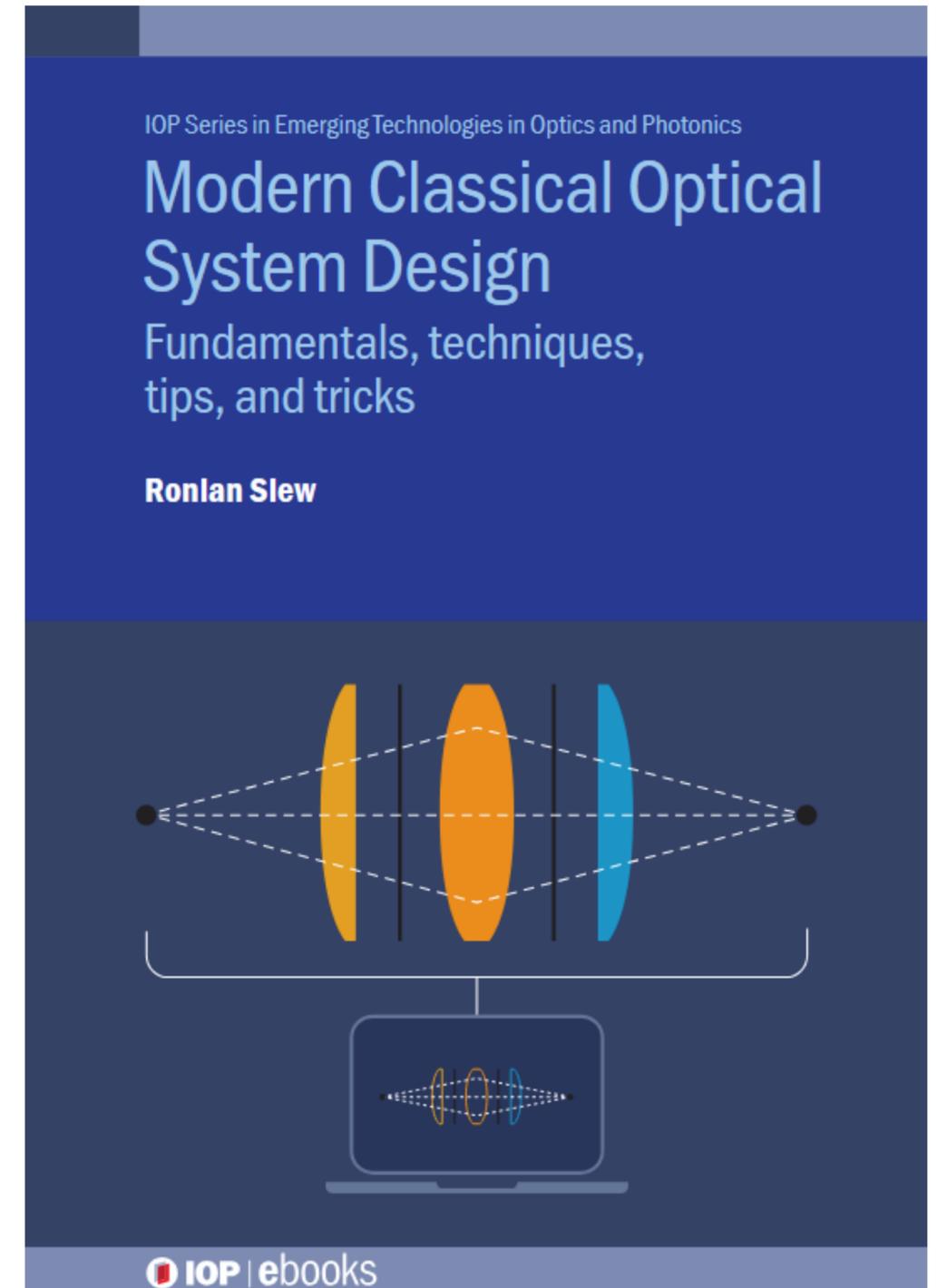
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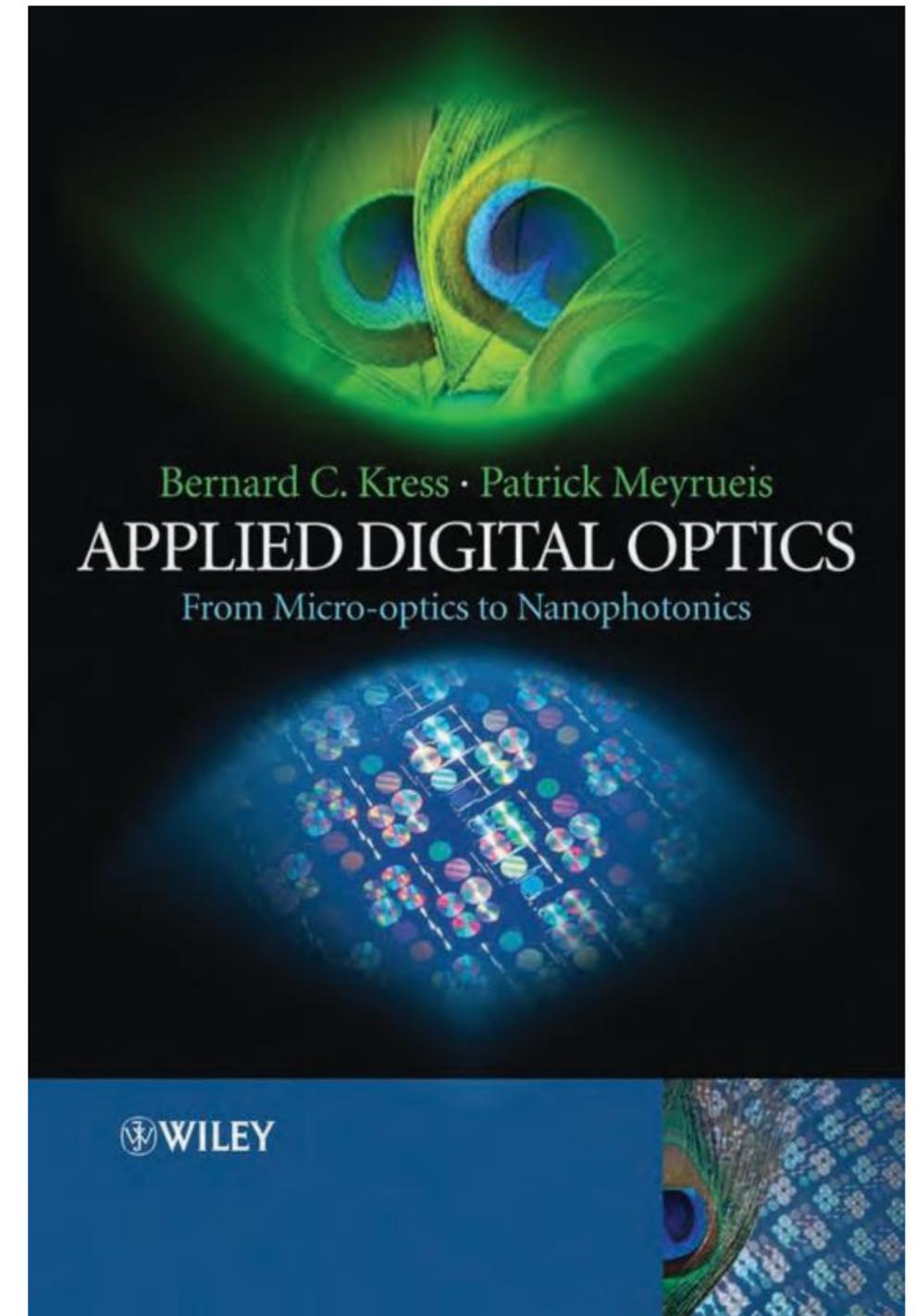
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# COURSE MATERIALS

## Supplementary material

[Youtube channel on design of optical systems](#) using Zemax

[Python API for Lumerical](#)

[ZOS-API for Zemax](#) (connect via MATLAB, Python, C#, and C++)

# OVERVIEW OF THE COURSE

week	Topic
Week 1	Introduction to micro-scale optical components
Week 2	Light propagation in free space
Week 3	Geometric optics and raycasting
Week 4	Diffraction limit & Abberations
Week 5	<b>Quiz</b> + Beam propagation
Week 6	Refractive optical elements Microlenses
Week 7	Blazed Fresnel lenses
Week 8	Digital lenses
Week 9	Diffractive optical elements
Week 10	<b>Quiz</b> + Wave guides and beam propagation
Week 11	Wave mixing
Week 12	Gratings, periodic structures
Week 13	photonic crystals
Week 14	Whole optical system optimization

# COURSE SYLLABUS AND CLASS WORKFLOW

## **2 quizzes**

- Each 15% of your grade, 1 hour duration
  - Quiz 1: Monday 27.10.2025
  - Quiz 2: Monday 01.12.2025

## **1 project with presentation**

- 30% of your grade

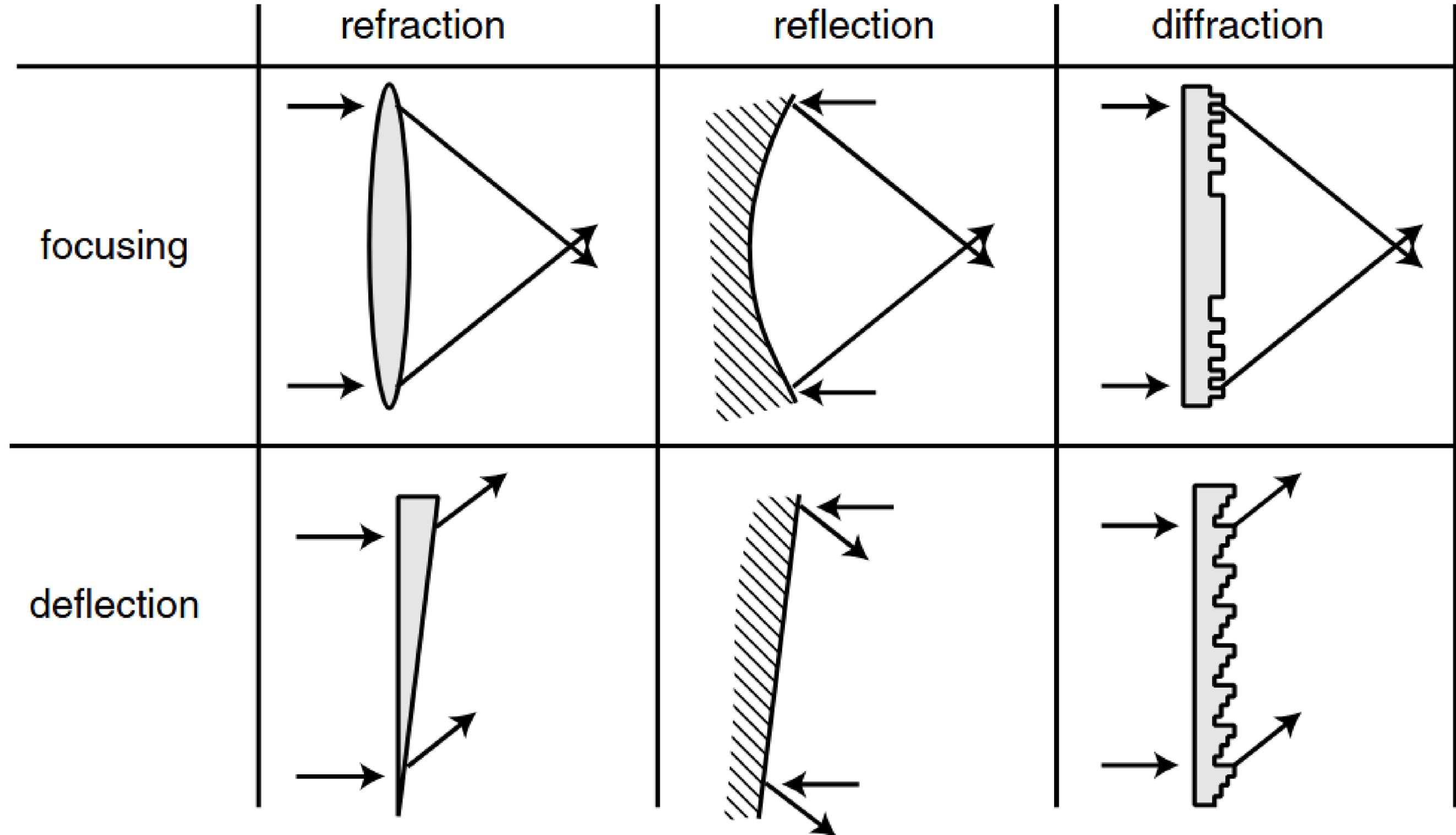
## **Final Exam**

- 40% of your grade
- Topics from the whole year
- Duration: 3 hours



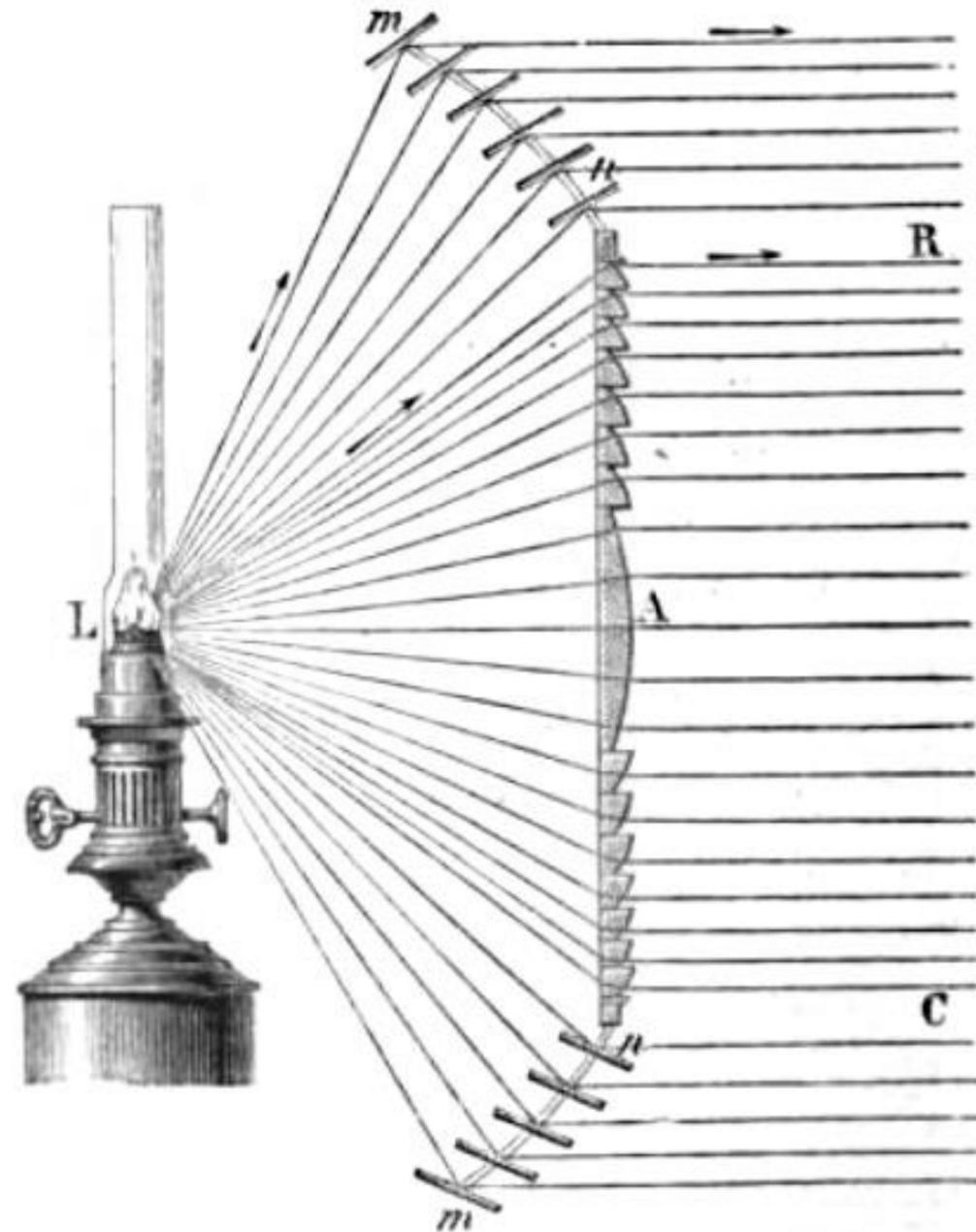
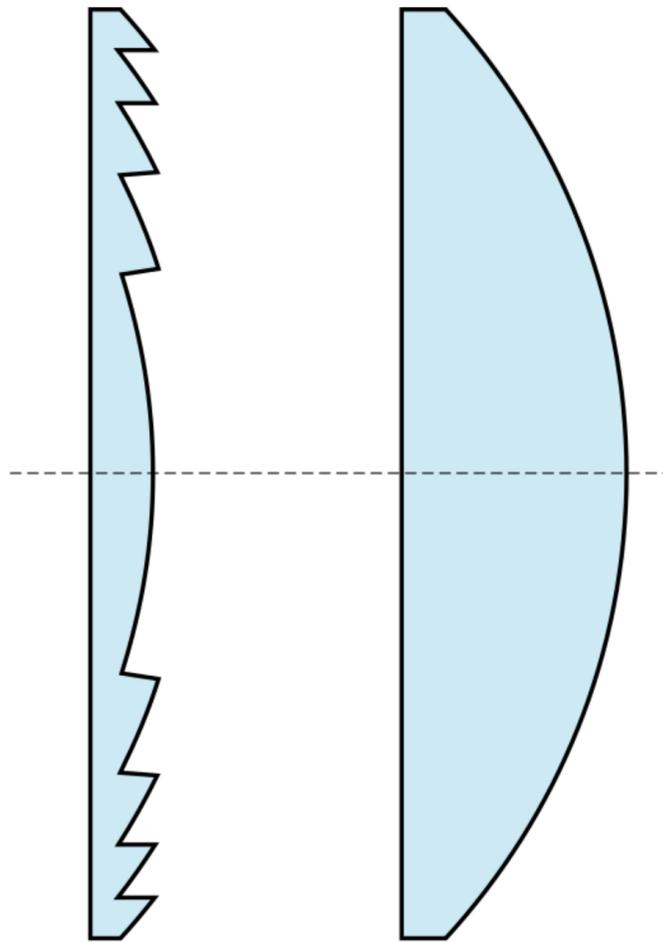
# Towards Micro-optical Elements

# OPTICAL ELEMENTS



# OPTICAL ELEMENTS

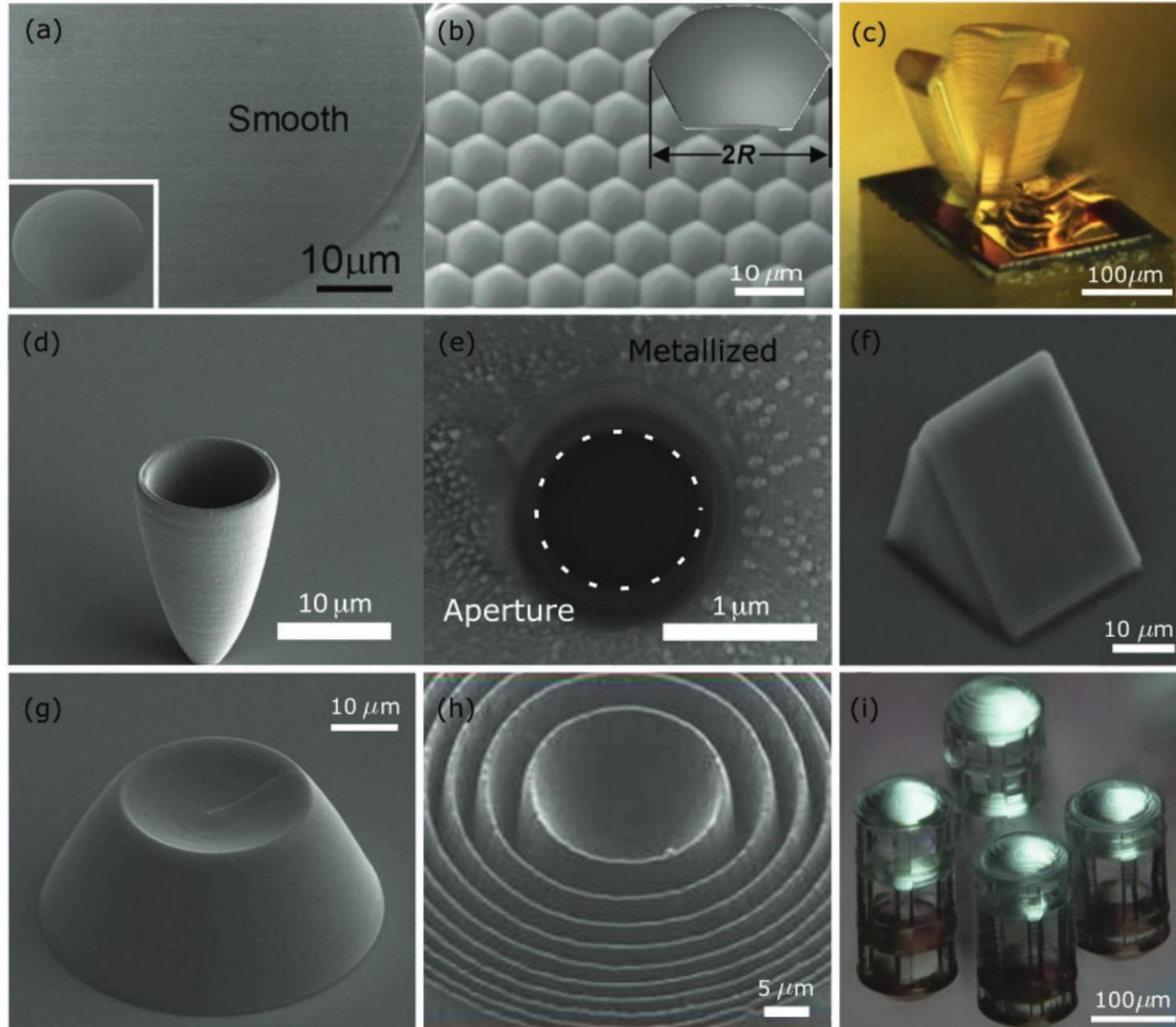
- Fresnel Lens



1821 Augustin-Jean Fresnel

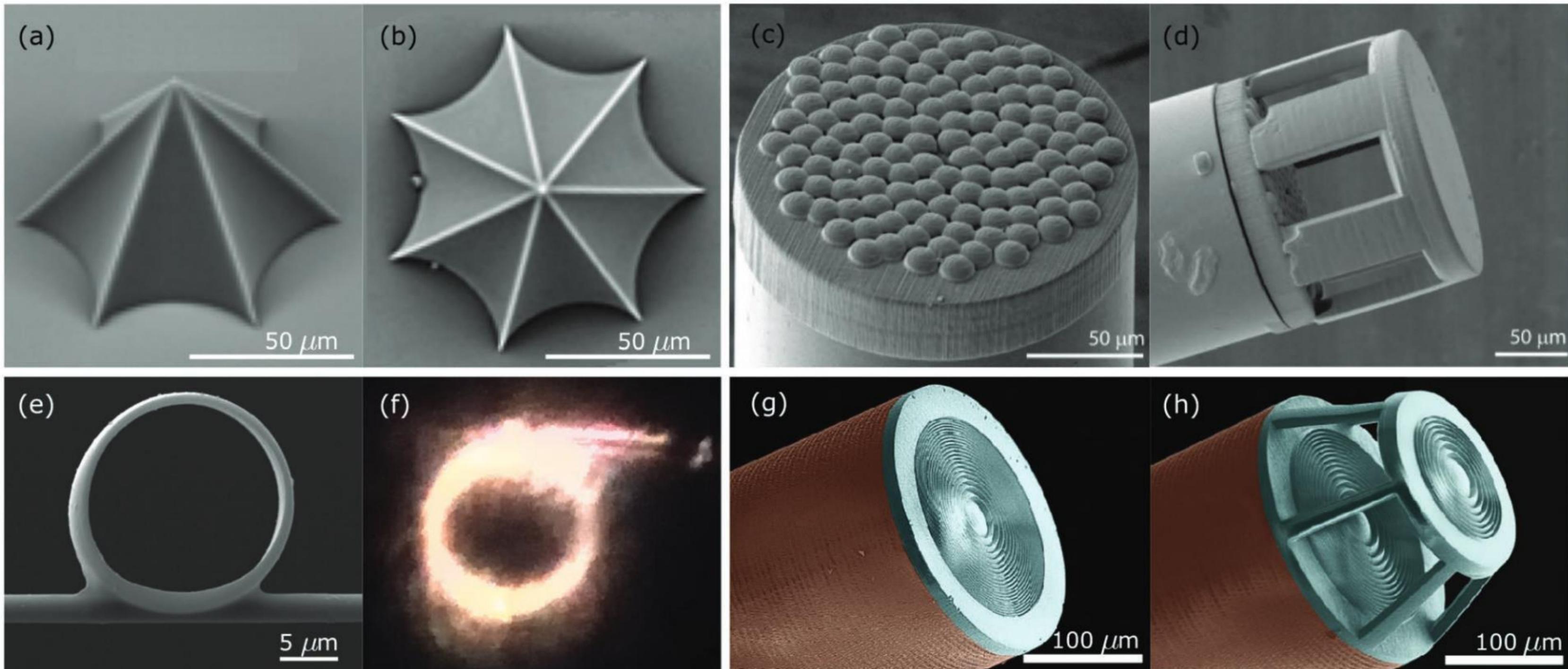
Images adapted From Wikipedia

# MICRO-OPTICAL ELEMENTS



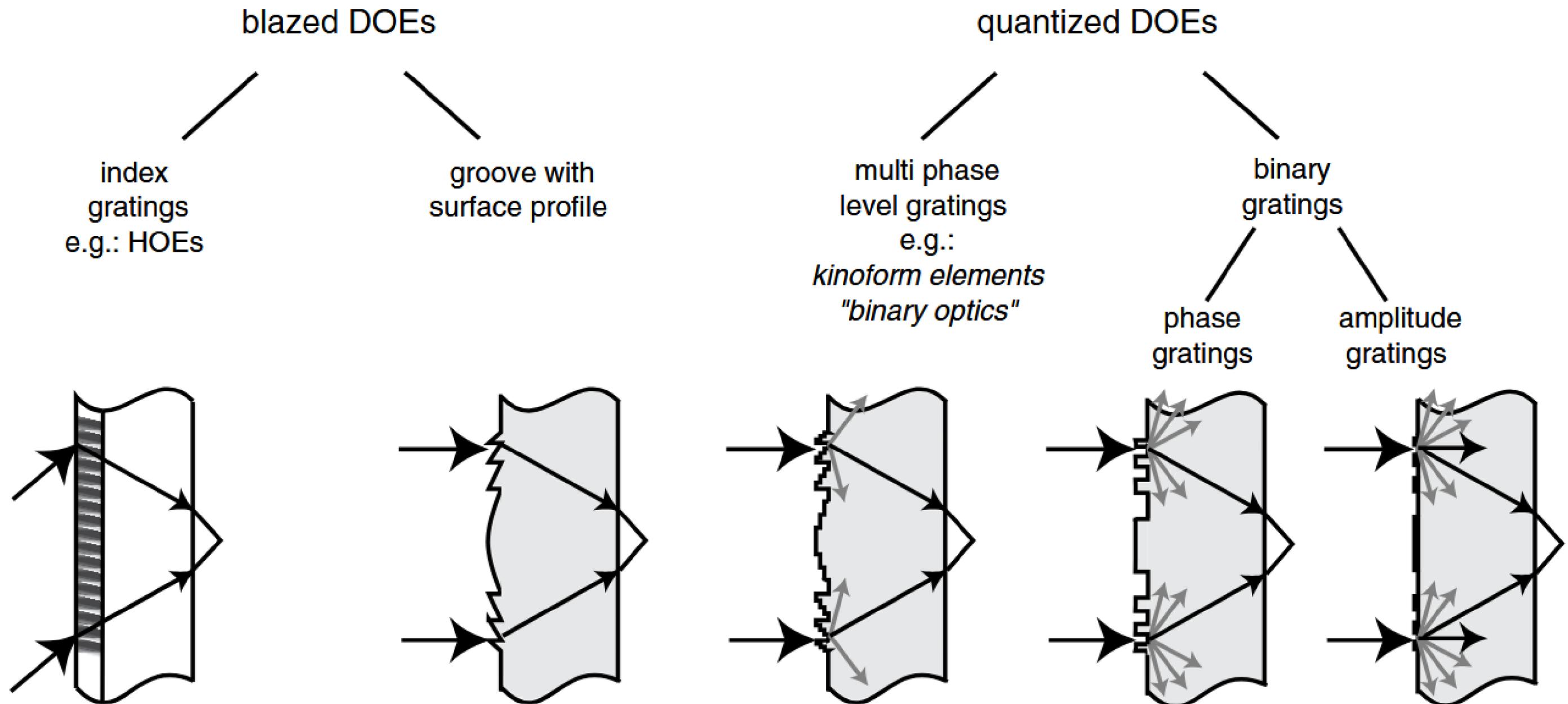
Micro-Optics 3D Printed via Multi-Photon Laser Lithography , Diana Gonzalez-Hernandez et al. Adv. Optical Mater. 2023, 11, 2201701

# MICRO-OPTICAL ELEMENTS

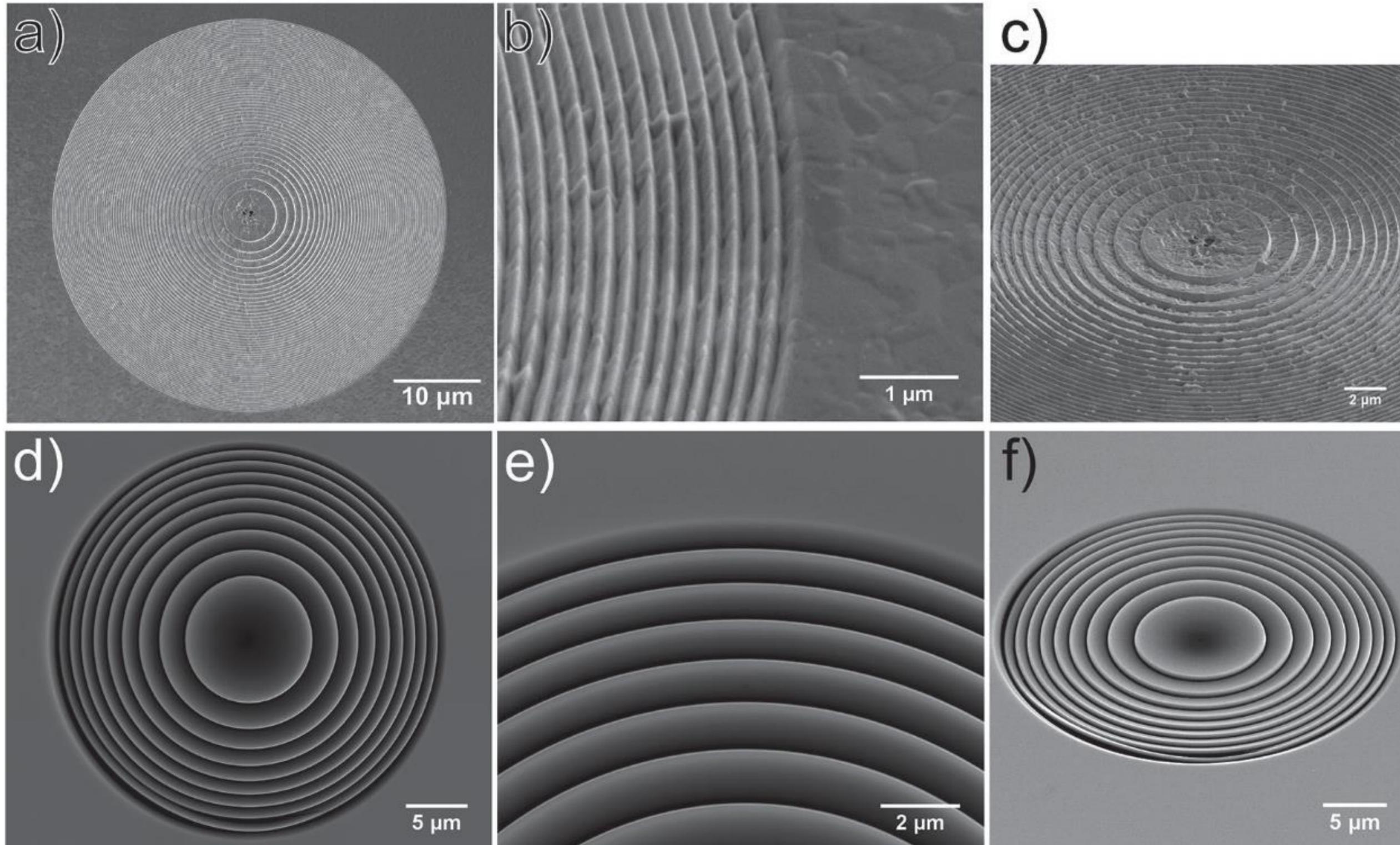


# BLAZED, QUANTIZED & BINARY

- Diffractive Optical elements

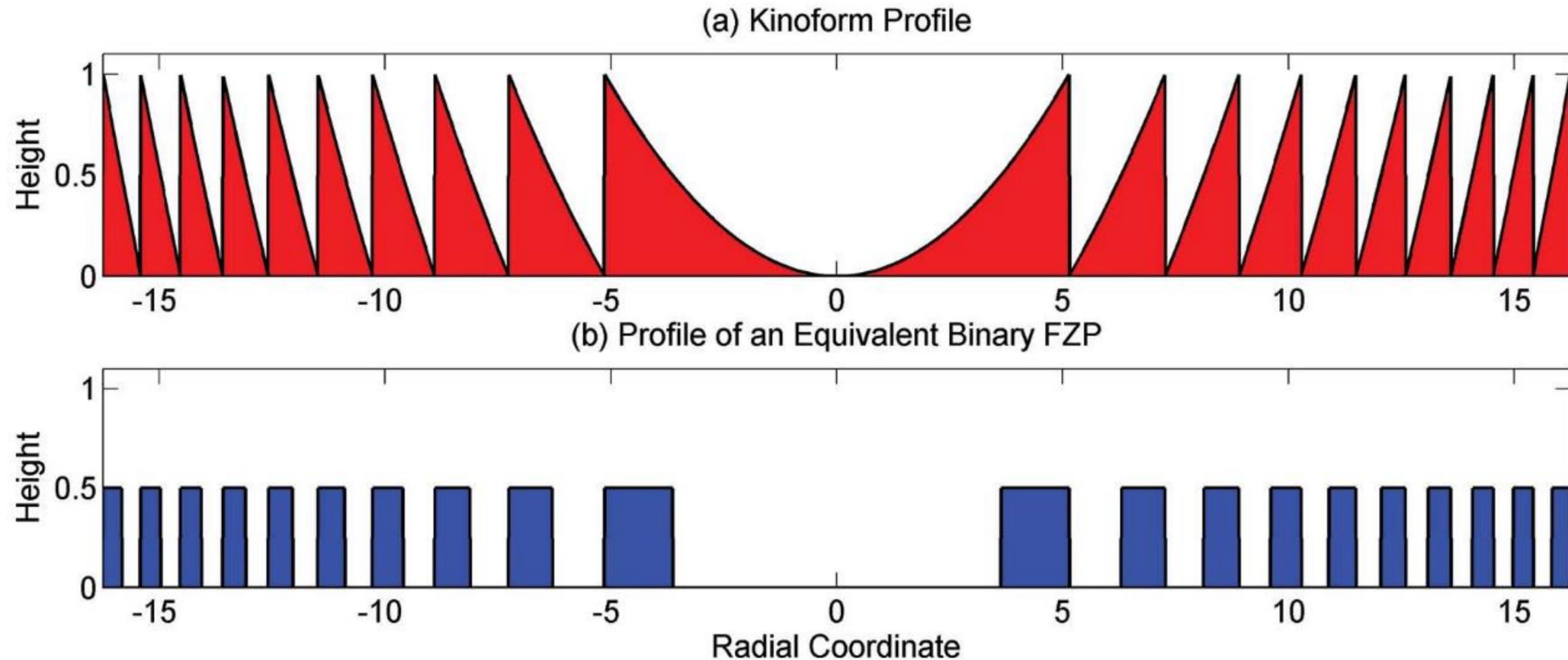


# BLAZED VS. BINARY

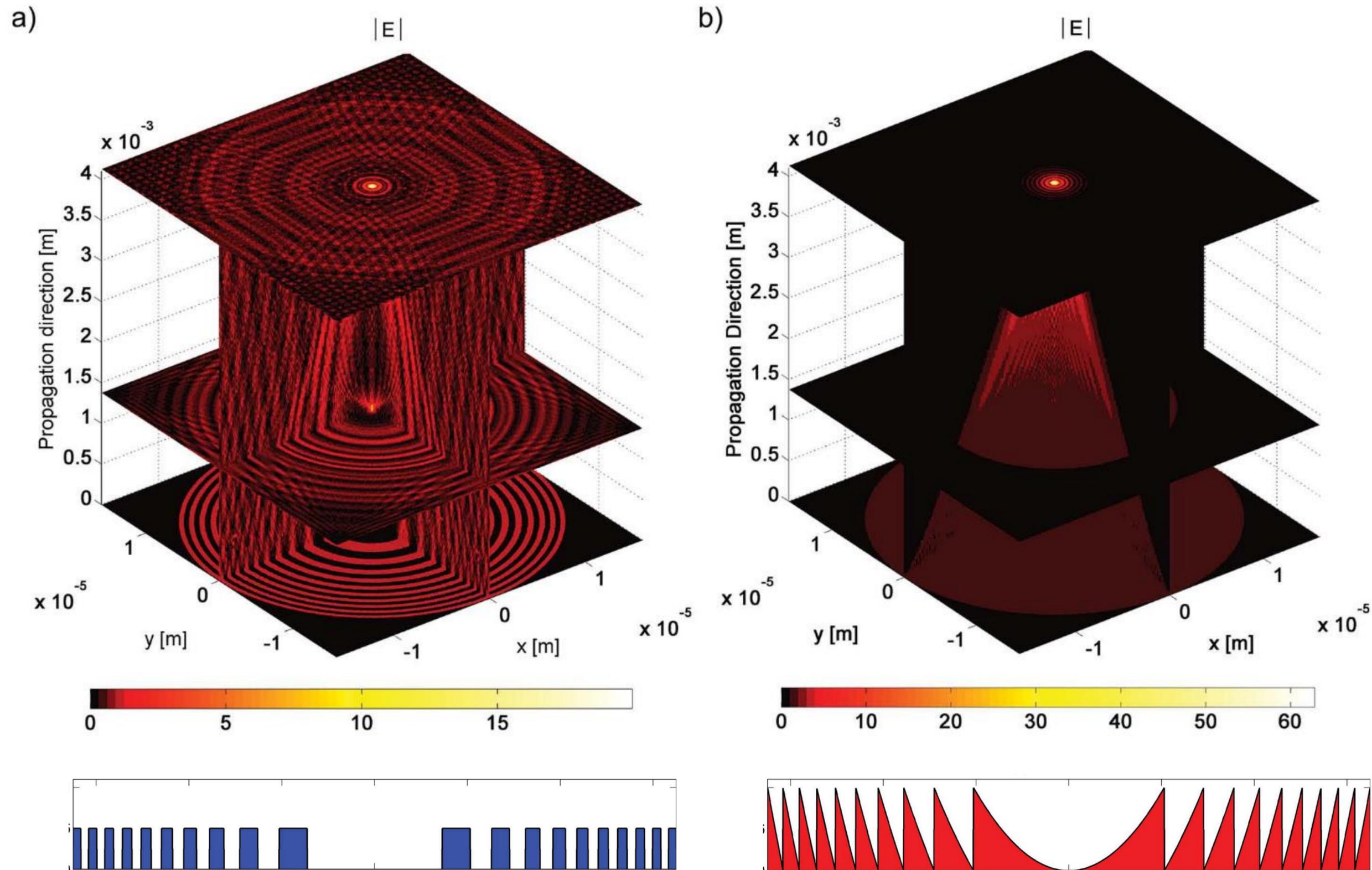


# BLAZED VS. BINARY

- Blazed harder to manufacture but better performance



# BLAZED VS. BINARY



# FROM MACRO TO MICRO

- Scaling down optical elements
- Smaller elements → larger artifacts
- Wavelength vs. object size:
  - Geometric ray optics ← Simulate by Raycasting (e.g. Zemax)
  - Scalar wave equation ← Uncoupled electric & magnetic field
  - Paraxial approximation
  - Beam optics ← Beam propagation, ABCD matrices
  - Electromagnetic waves ← Electromagnetic waves, simulate by FDTD (e.g. Lumerical)