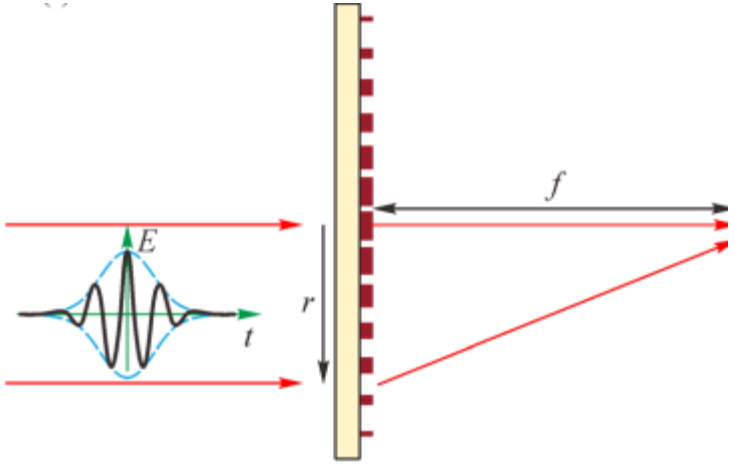
University of St Andrews

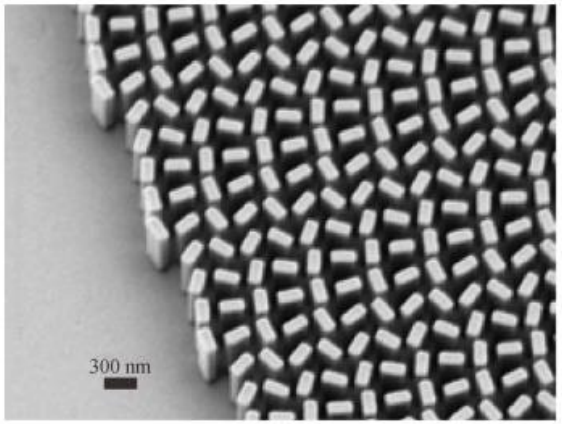
Metamaterials for optical communication and imaging, opportunities and challenges

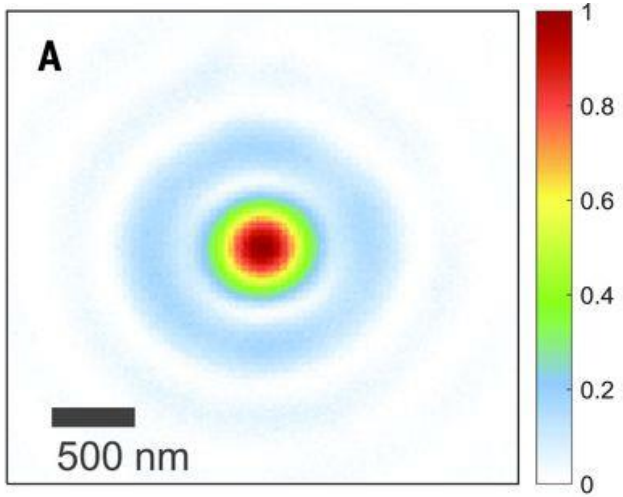
Sebastian A. Schulz
University of St Andrews
sas35@st-andrews.ac.uk
http://nanophotonics.wp.st-andrews.ac.uk/

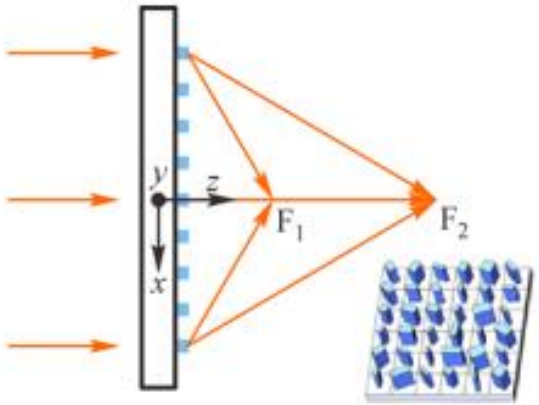
Imaging - lenses

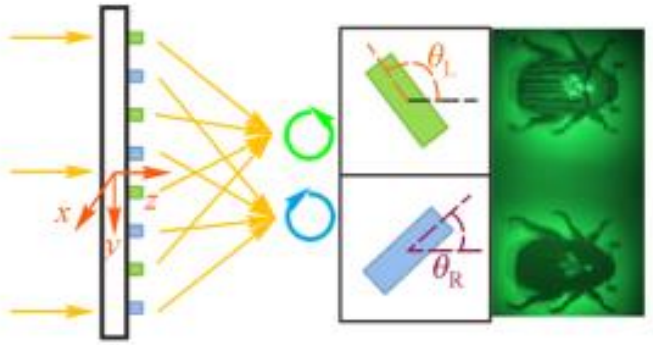
- Use nanoantennas/fins/resonators to encode desired phase profile

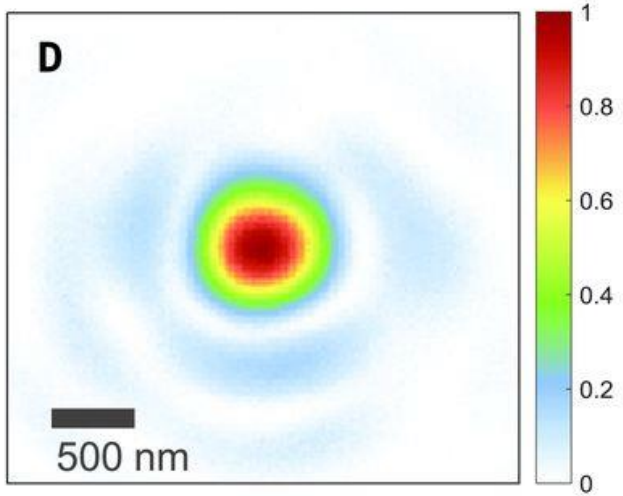










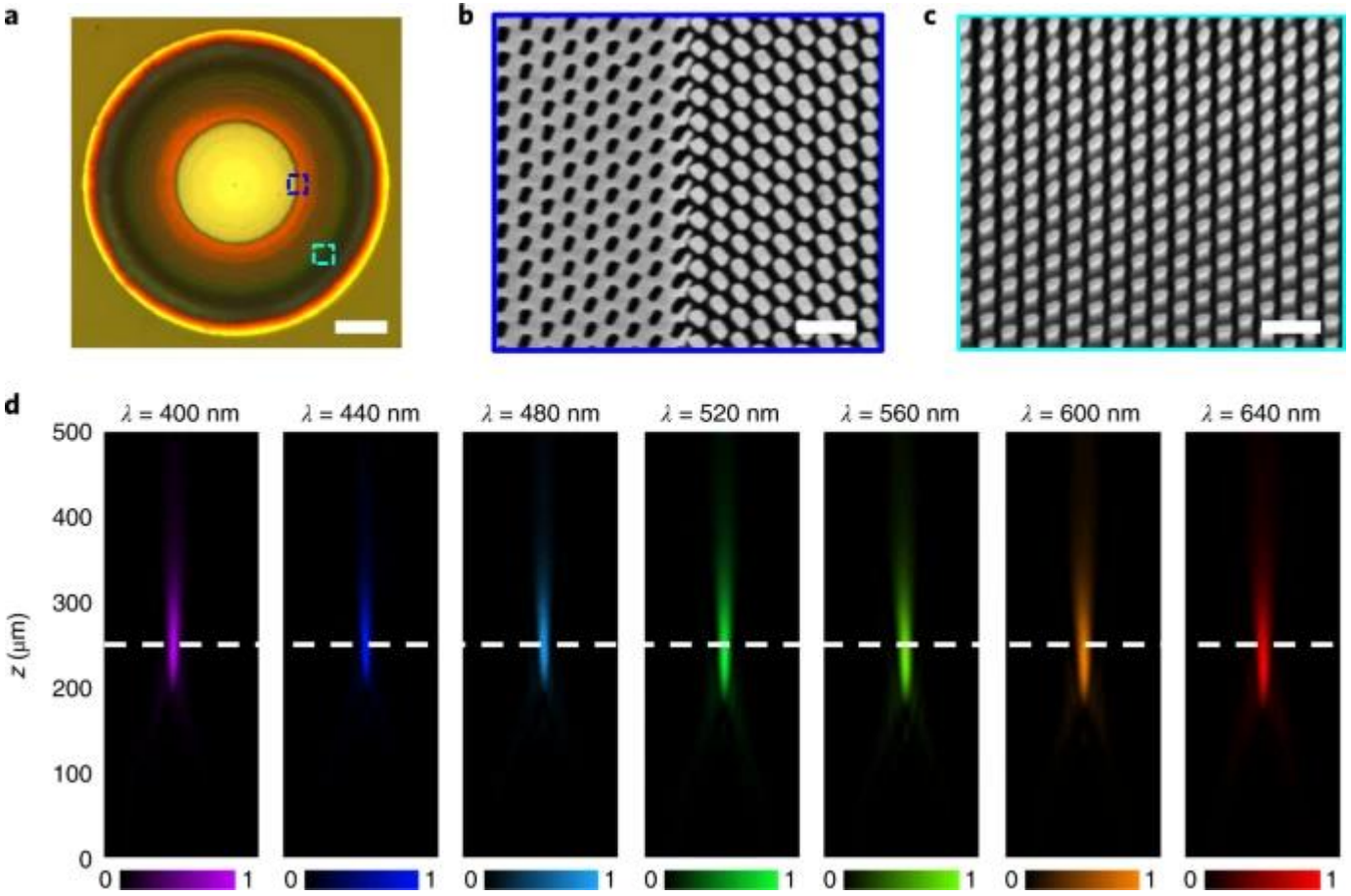


Recommended review: Front. Optoelectron. 2021, 14(2): 170–186

Imaging - lenses

- Can optimize for different performance

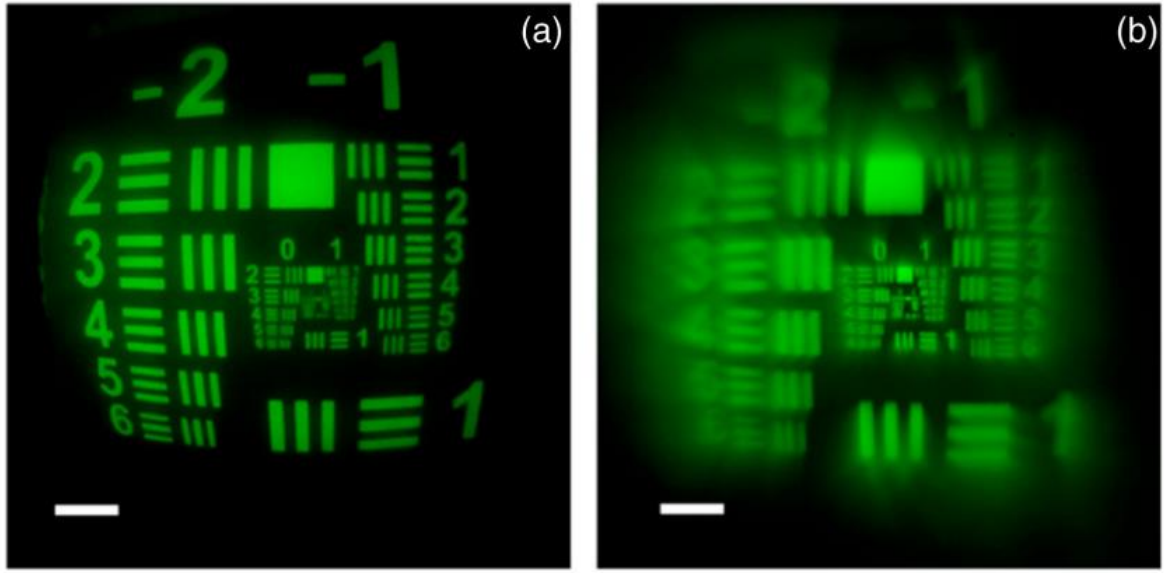
Achromatic lens



Nature Nanotechnology 13, 220 (2018)

Wide field of view

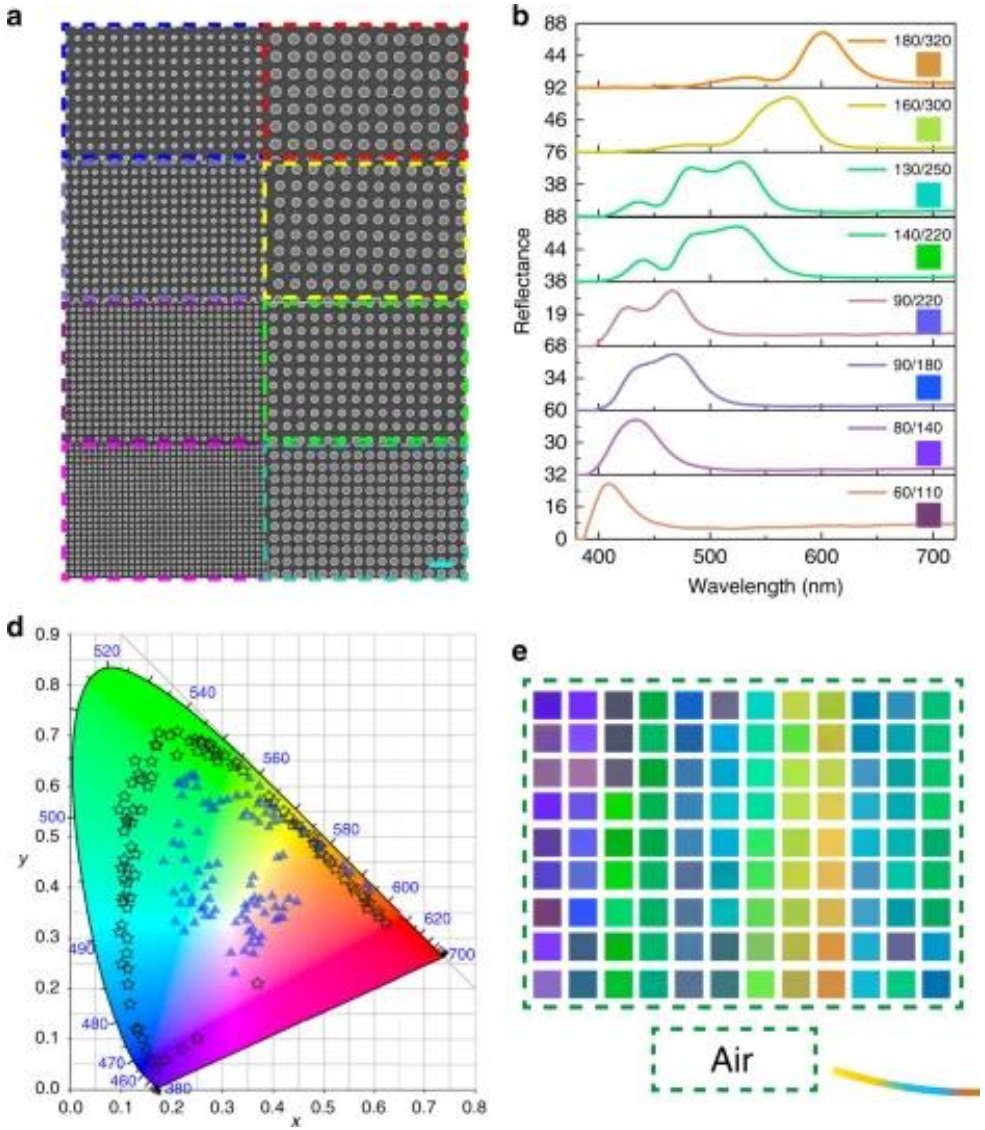
Quadratic phase hyperbolic phase



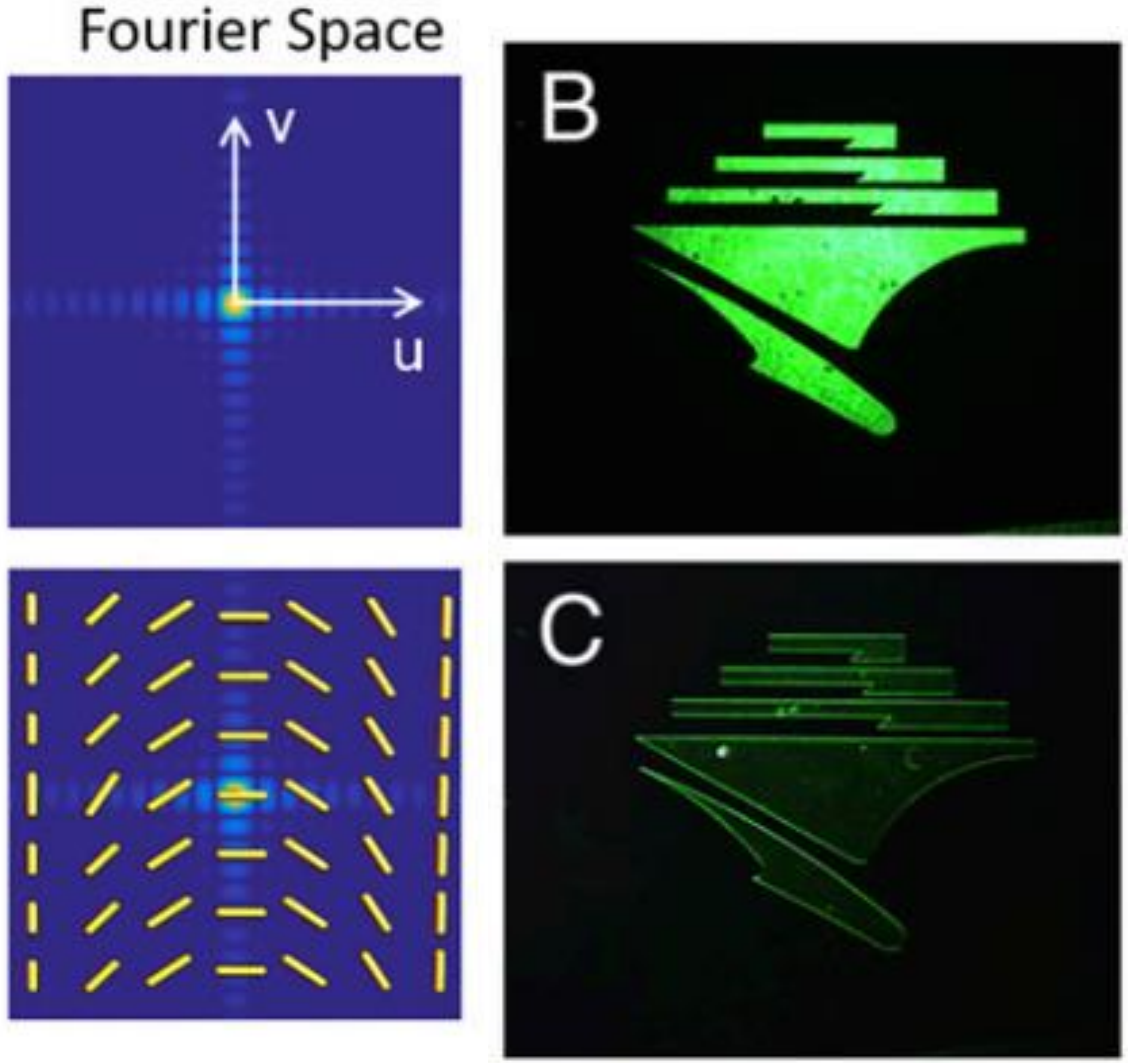
Advanced photonics 5, 033001 (2023)

Beyond lenses

Filters, e.g. colour -> hyperspectral imaging or spatial frequencies (image manipulation)

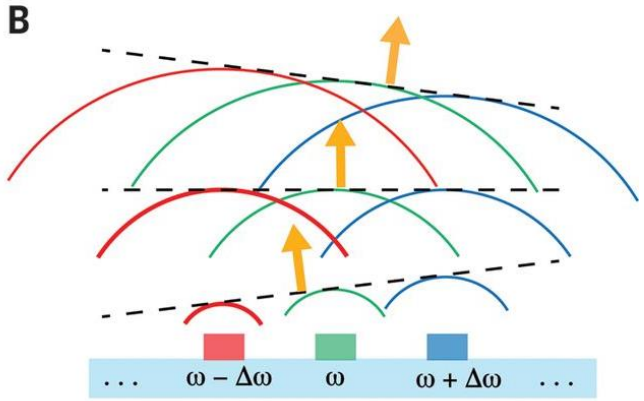


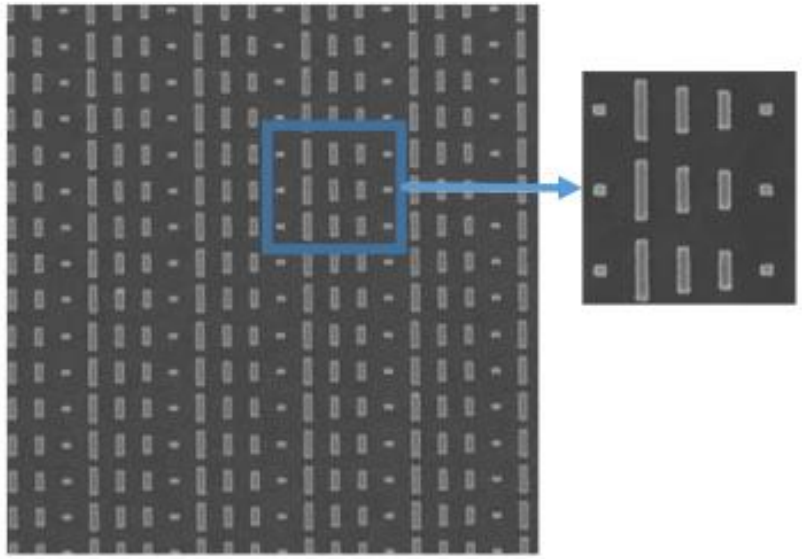
Nature Communications 11, 1864 (2020)

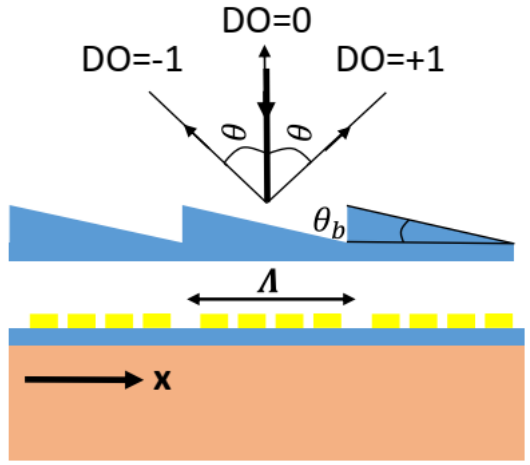


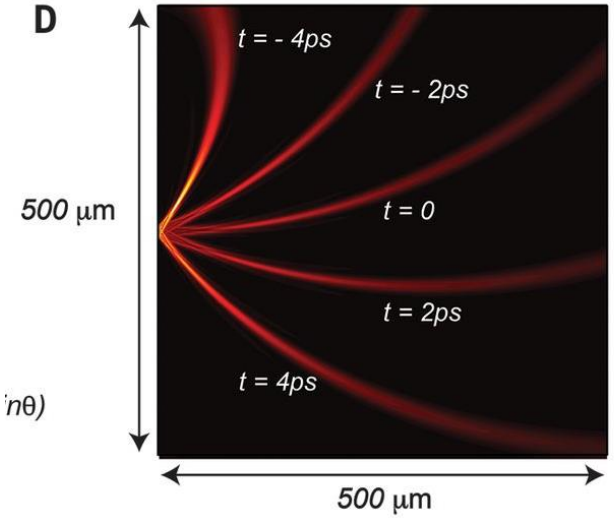
PNAS 116, 11137 (2019)

Communications: Beam steering

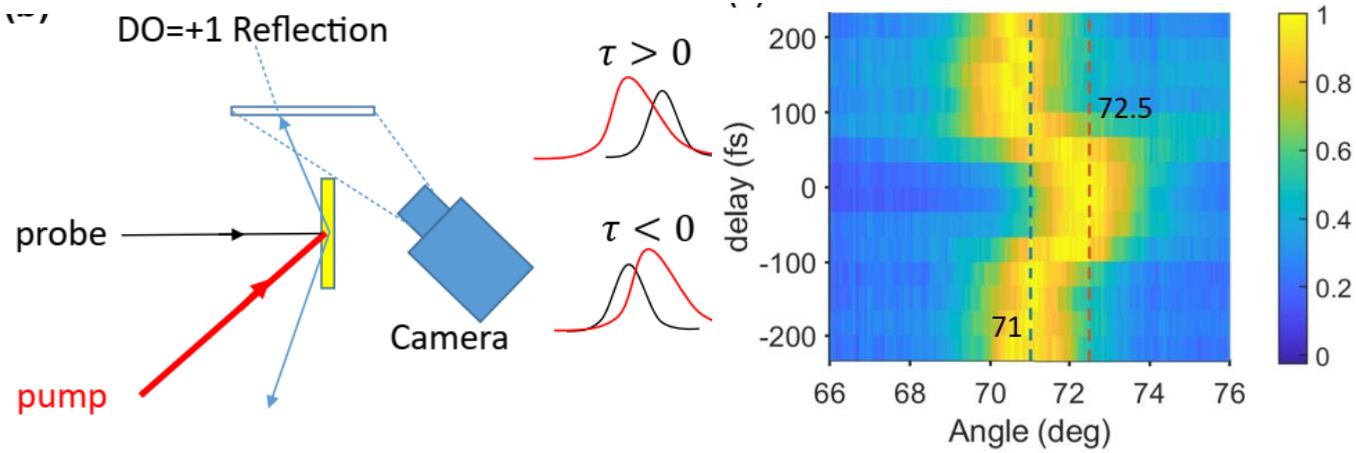






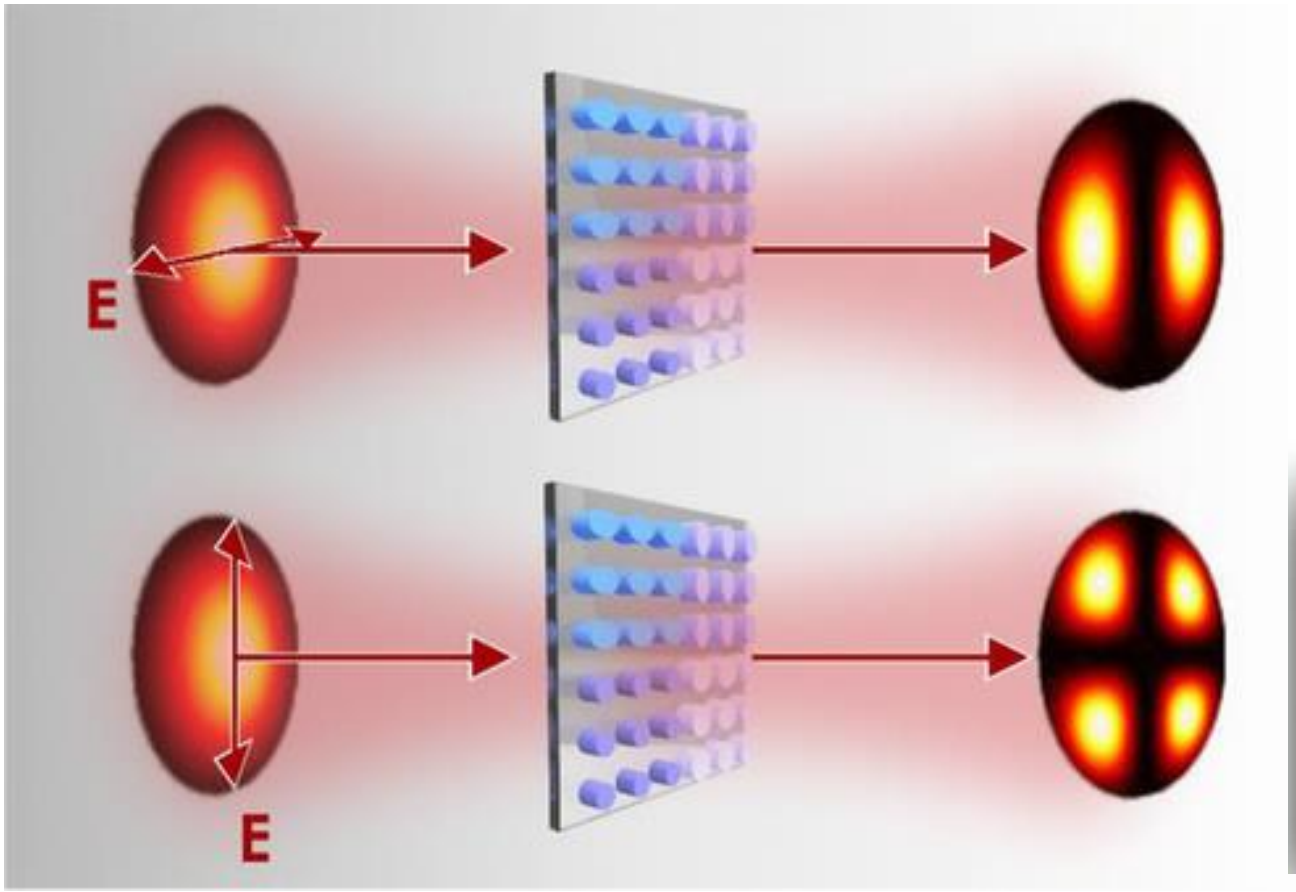


Science 365, 374 (2019)

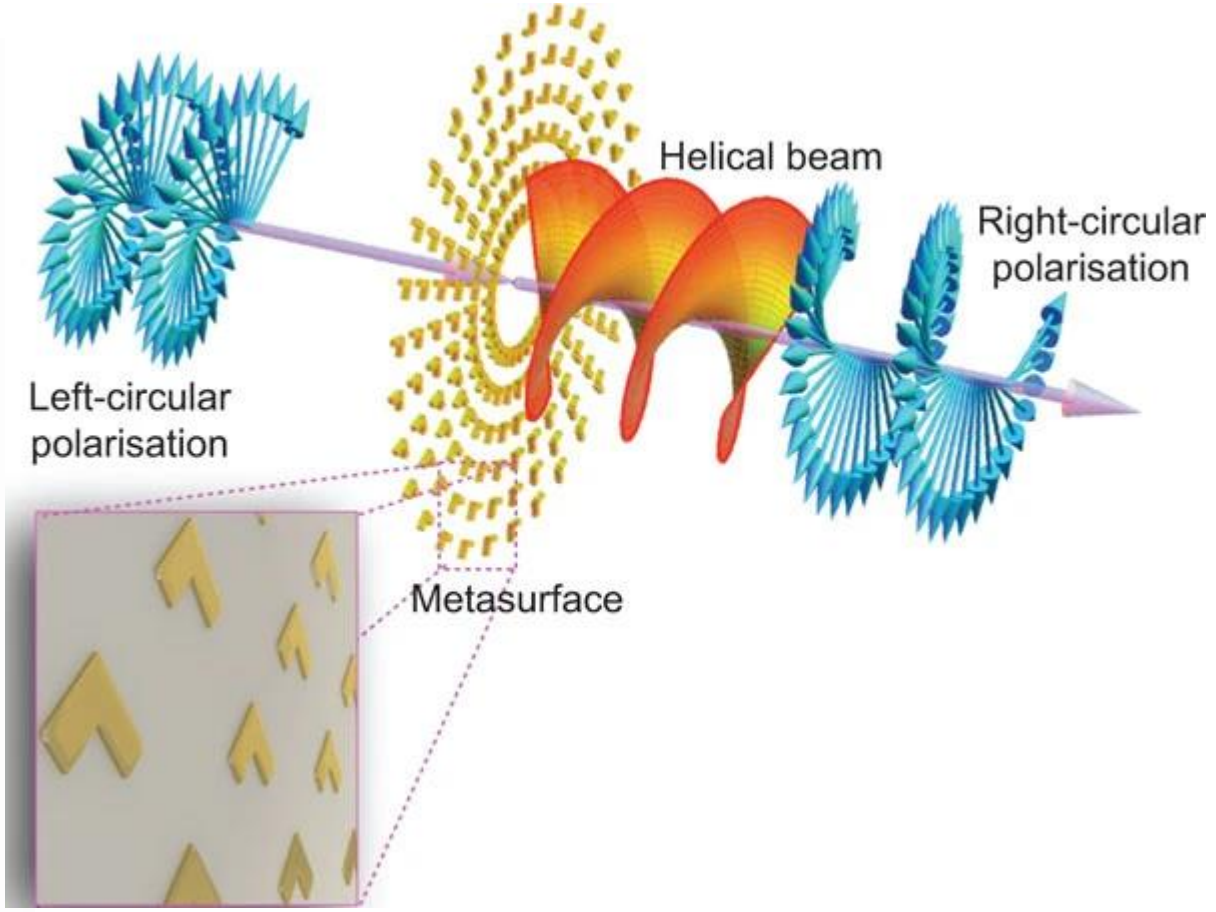


Nanophotonics 12, 1733 (2023)

Communications: Beam forming

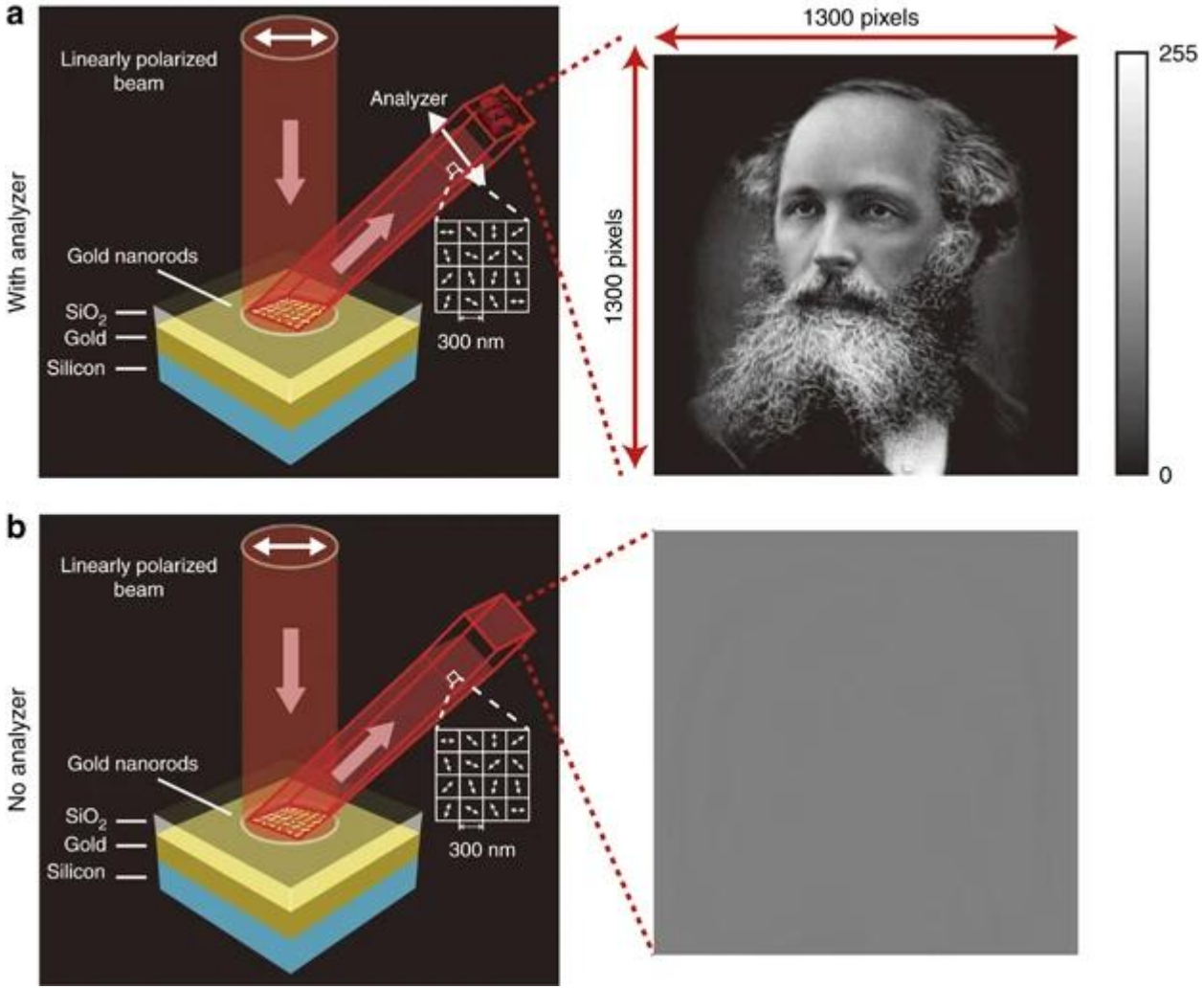


Laser Photonics Review 12, 1800031 (2018)

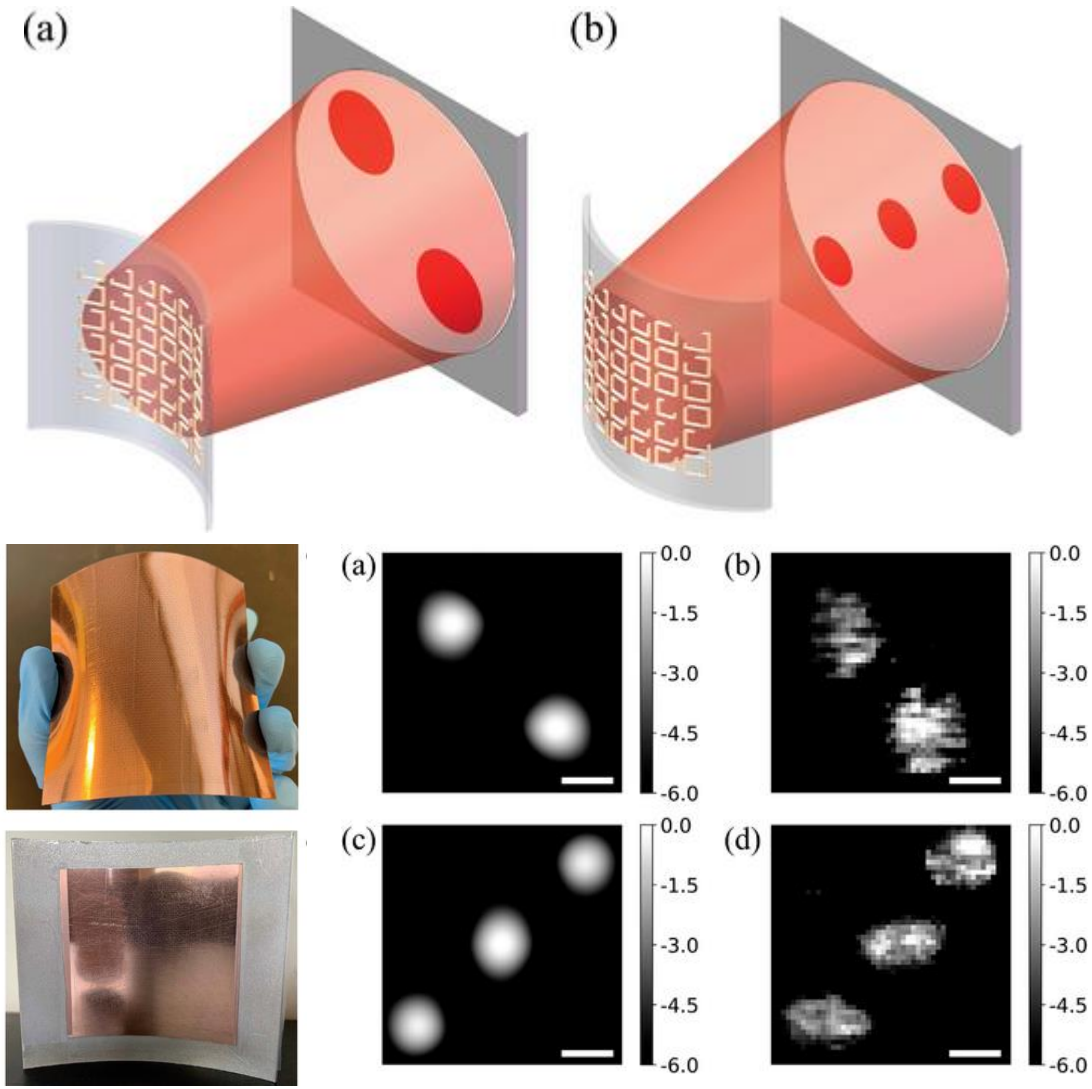


Light: Science and Applications 3, e167 (2014)

Communications: advanced holography



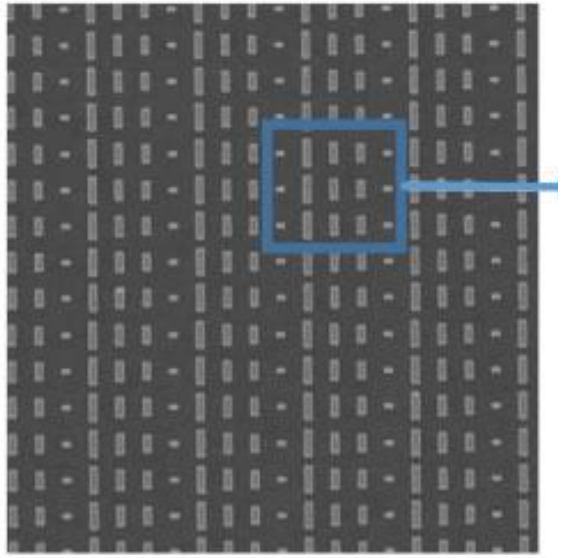
Light: Science & Applications 7, 17192 (2018)

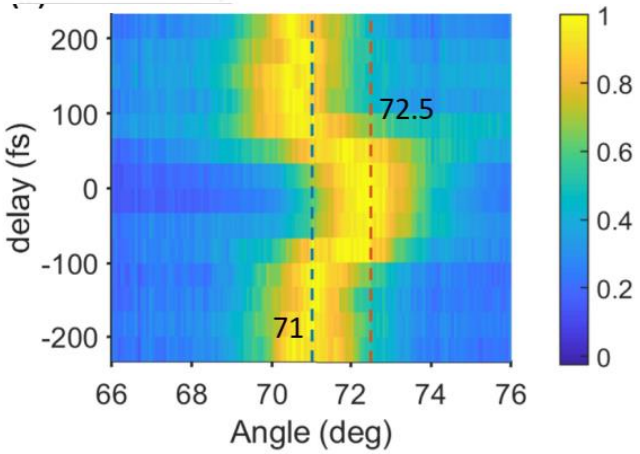


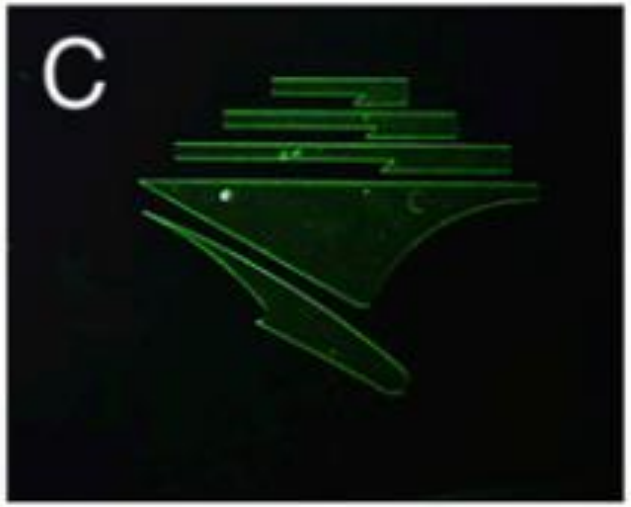
Advanced Materials Technology 8, 2202006 (2023)

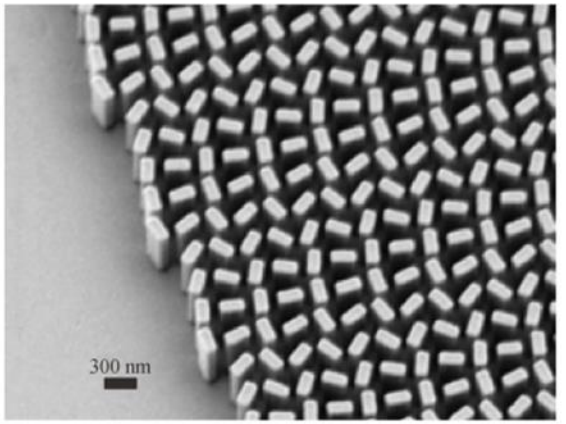
Opportunities

- Savings
  - space, weight, money
- Reduced energy usage
  - Computation for free
- Eliminate mechanical components
- Decouple form from function



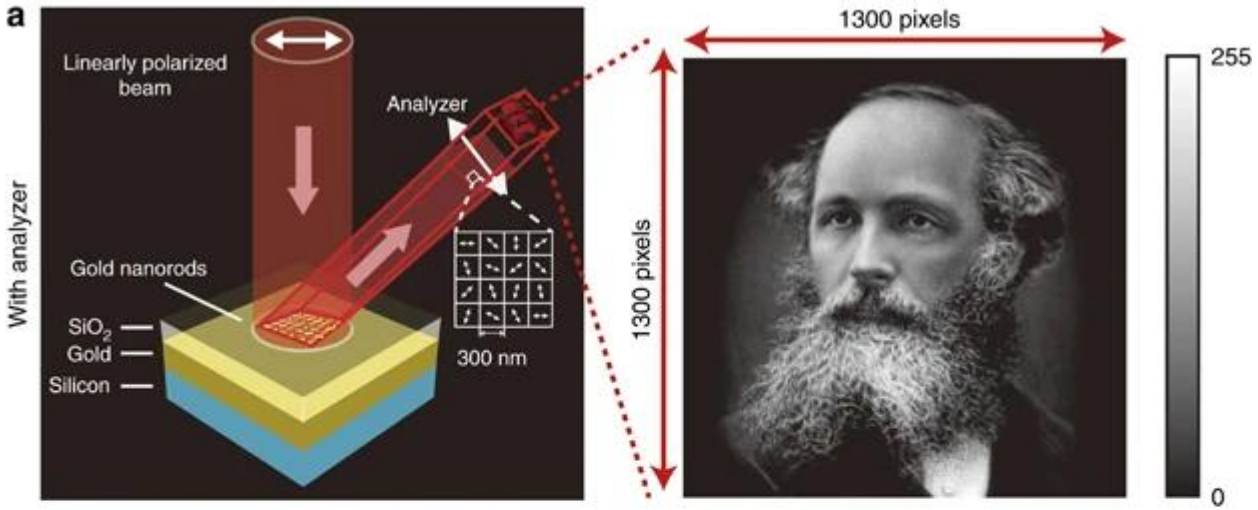


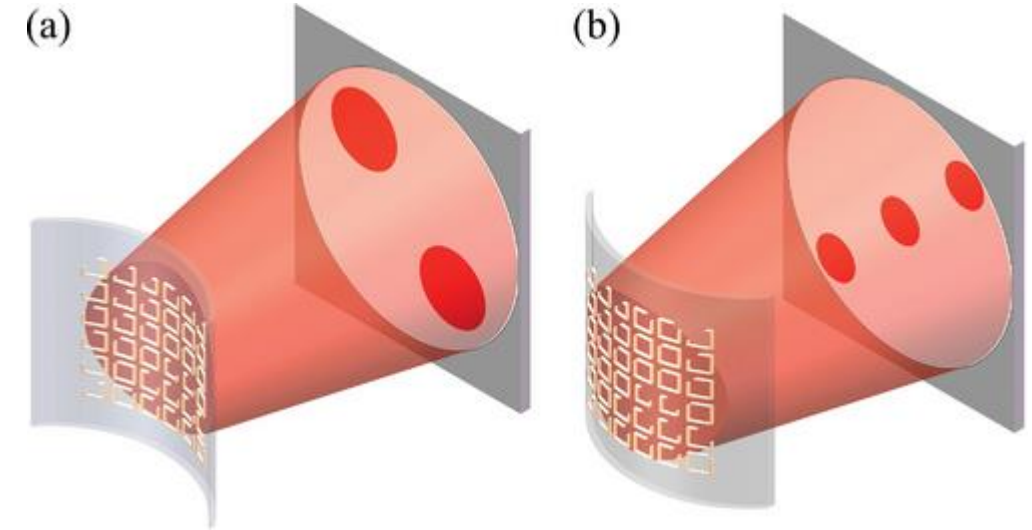


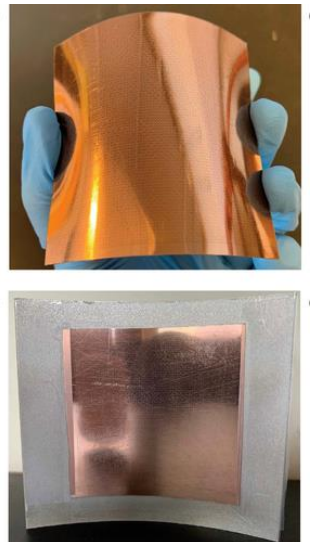


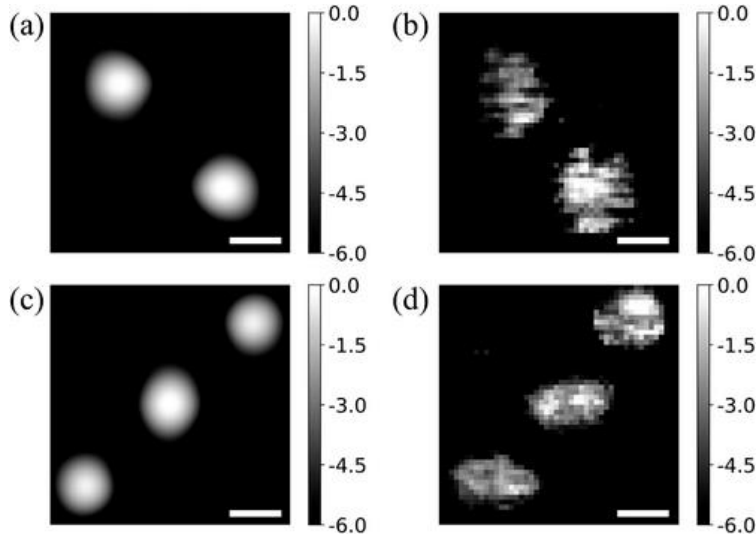
Challenges

- Tunable functionality lacks behind static



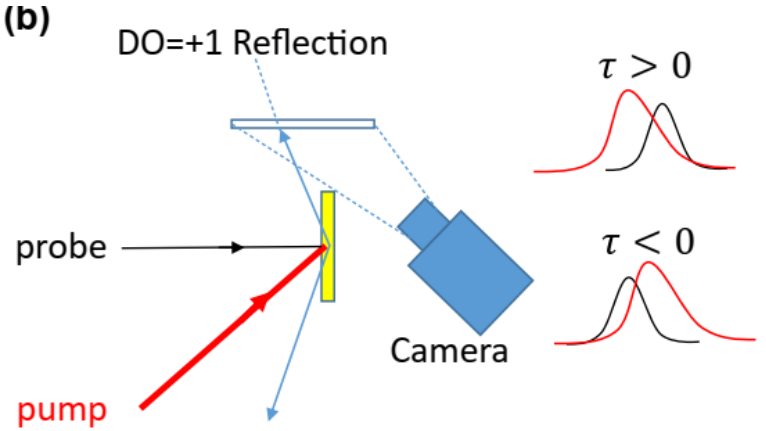


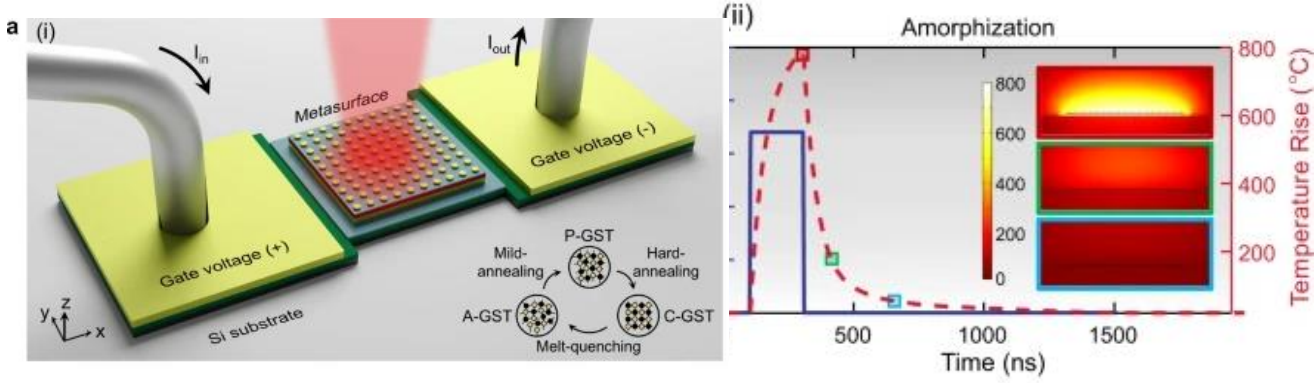


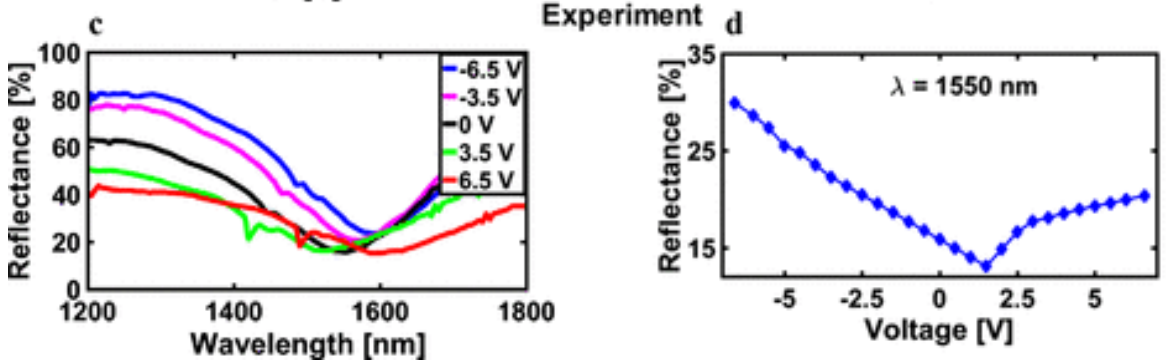


Tuning mechanisms

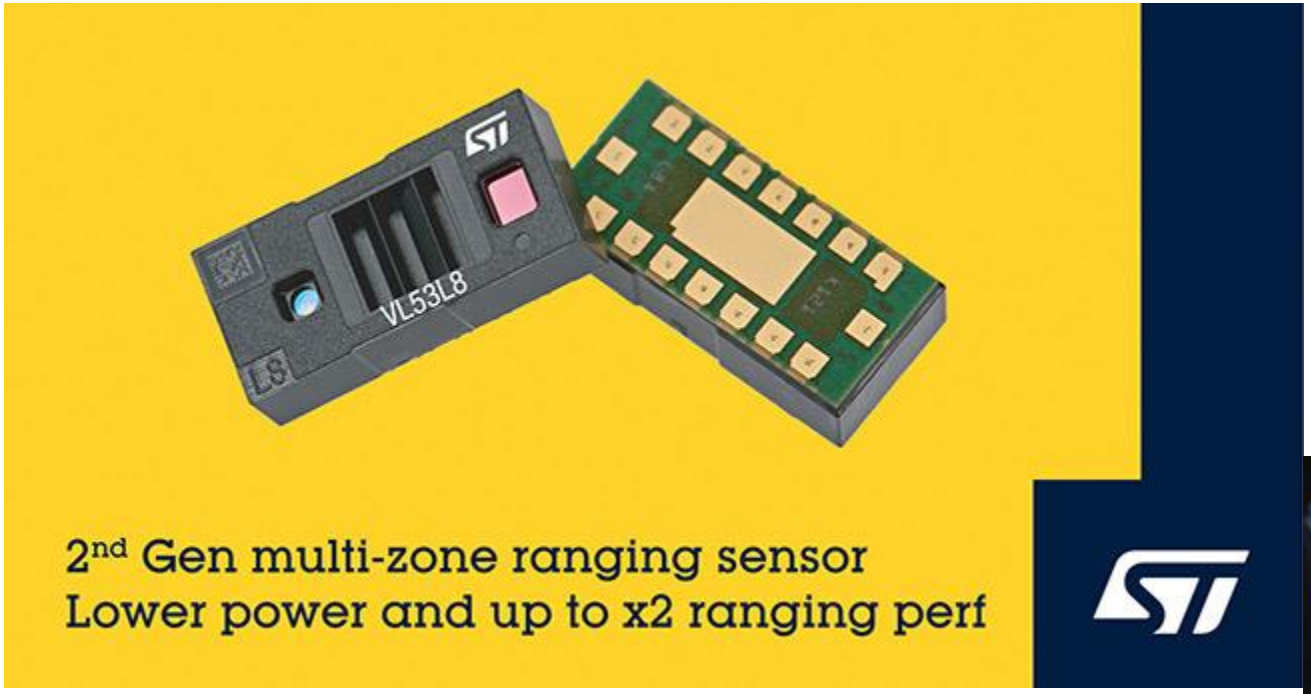
- Optical tuning:
  - High power lasers
  - Phase change materials
    - High temperatures (and number of repeat cycles)
- Electric tuning
  - Strong phase response
  - But low transmission/reflection

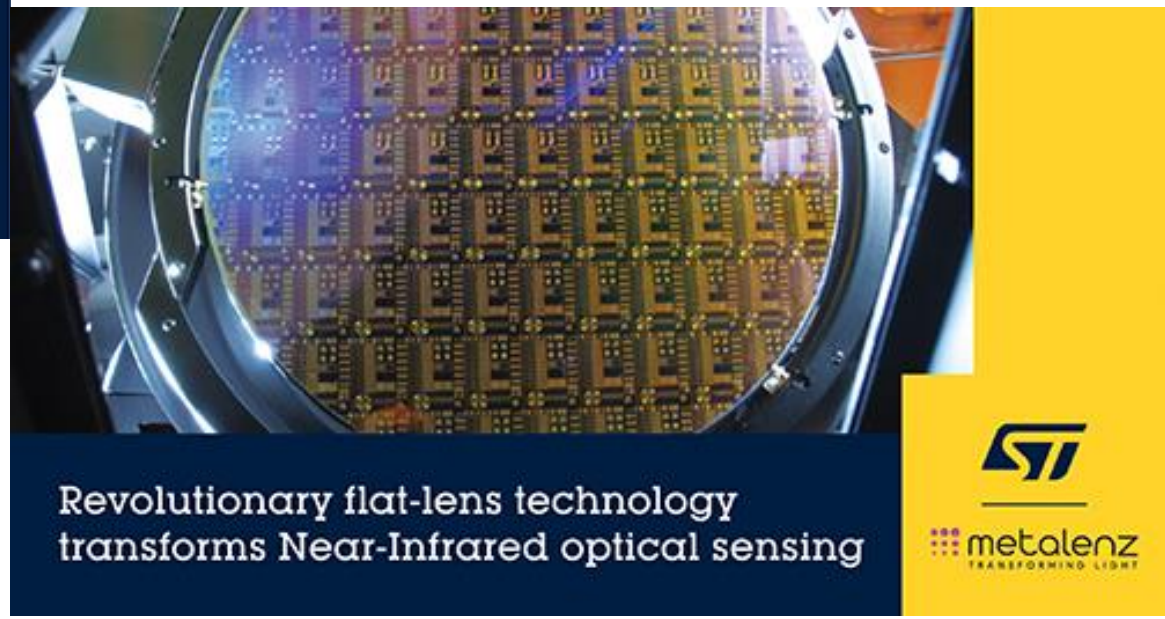






First commercial metasurfaces product





Discussion points

- Huge variety of applications -> huge potential
- Ability to decouple form and function is ideal

- Passive metasurfaces ready to be rolled out?

- Tunable ones not yet?

- How does space operation (and certification) complicate things?