



Empowering Innovation with Novel Designs and New Materials

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About imec

200 mm / 8-inch CMOS PILOT LINE
Operated 24/7
Sensor Technologies

300 mm / 12-inch CMOS PILOT LINE
Operated 24/7
Sub-10 nm CMOS

- World-leading R&D in **nanoelectronics & digital technology**
- **8** sites worldwide
- **>5500** international R&D top talents, ~95 nationalities
- Unique **€ 3B** leading-edge **semiconductor fabs**
- Delivering **industry relevant technology** solutions serving semiconductor, ICT, IoT, healthcare and energy markets
- Collaborating with **600+** industrial partners
- Created **118 spin-off** companies and incubated **200+** start ups

World-class infrastructure

Hyperspectral imaging lab & demo room

Integrated imagers lab

Smart sensor lab

ExaScience lab

RF & high-power lab

Photonics labs

200mm cleanroom

- Silicon pilot line for prototyping and low-volume manufacturing
- iSiPP200 and iSiPP50G photonics prototyping platform
- 200mm GaN-on-Si platform
- Quantum computing lab
- Materials & interface lab
- 5,200m²

Measurement & testing lab
GaN lab

NERF labs

Material and device
characterization labs

300mm cleanroom

- (High-NA) EUV, Attolab, advanced patterning
- State-of-the-art etch, implant, cleaning, metrology, deposition, ... equipment from leading-edge OEMs
- Ballroom type of cleanroom (7,200m², Class 1,000)
- 24/7 operational

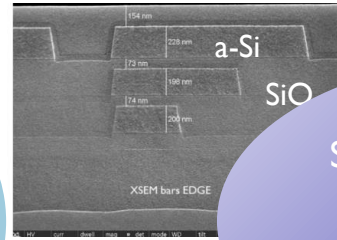
Bio labs

- Cell & tissue culture labs
- Optical labs
- Wet chemistry labs
- Clinical labs
- Pre-PCR lab
- Neuropixels lab

NIL, DUV, i-DUV, EUV,
IL, EBL,



Imaging and
sensing



SiN_x , NbO_x , TiO_x , a-Si,
NIL resins
TCO: ITO, IGZO, ..
PCM: GST, SbS_x , ..

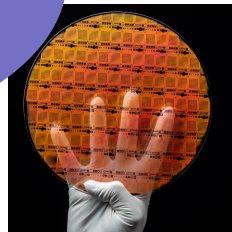
Advanced Patterning

Specialty Substrates

Optical Material Toolbox

Multilevel Technology

Silicon, (high RI) glass,
CMOS, flat panel



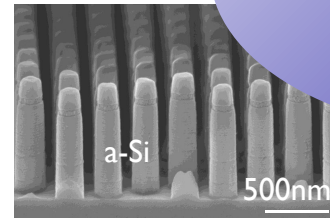
AR/XR

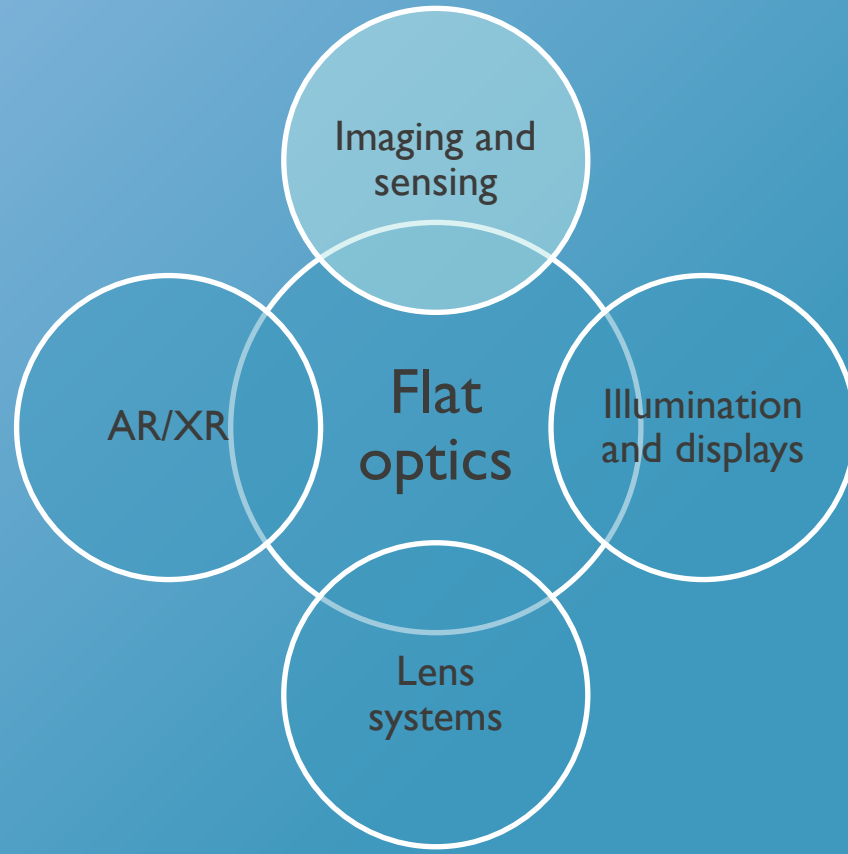
Flat
optics

Illumination
and displays

Lens
systems

High AR etching &
refilling,
multilevel & double-
sided processing





Imaging and
sensing

AR/XR

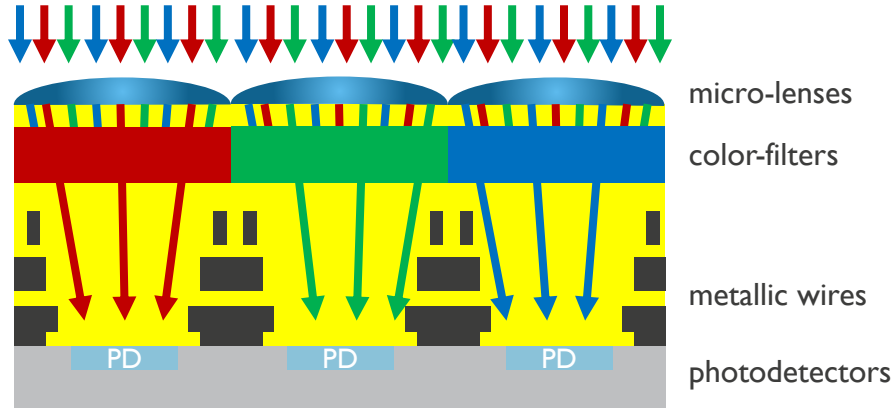
Flat
optics

Illumination
and displays

Lens
systems

Conventional frontside illuminated pixel architecture

Conventional approach Color filter

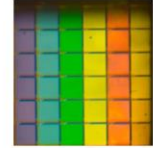


Plasmonic color filters

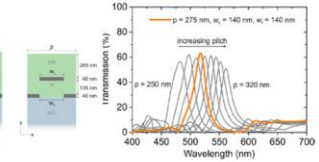
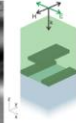
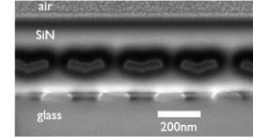
Plasmonic devices on transparent substrates in 200nm technology for on-chip color filters and polarizers.

- Color filters by design for multispectral sensing.
- Integrated polarizers for boosting efficiency of light sources.

Color picture of color filters in transmission



XSEM of plasmonic color filter

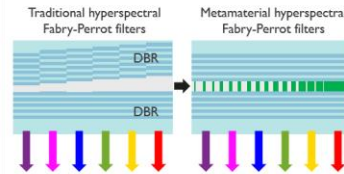


imec

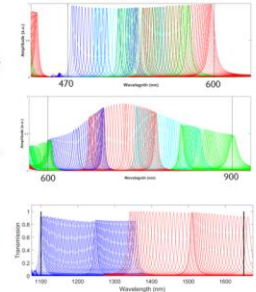
De Proft A, et al. "Highly Selective Color Filters Based on Hybrid Plasmonic-Dielectric Nanostructures." ACS Photonics 9, no. 4 (2022): 1349-1357.

confidential

Fabry Perrot color filters by design



Color filter by design simulations

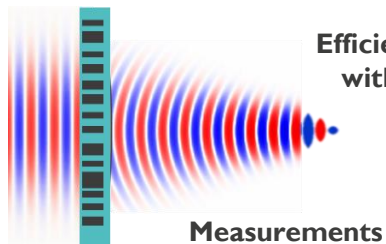


imec

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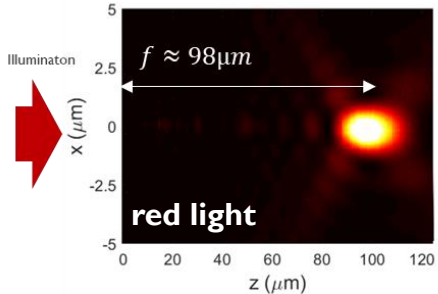
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Multilevel flat optics for SWIR and visible light



Efficient diffraction-limited flat lenses,
with good match with simulations

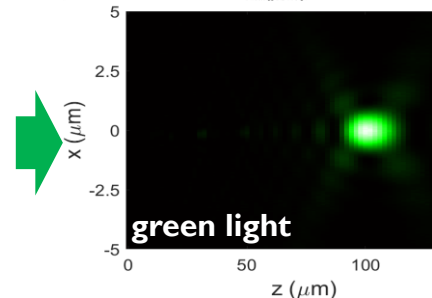
Measurements



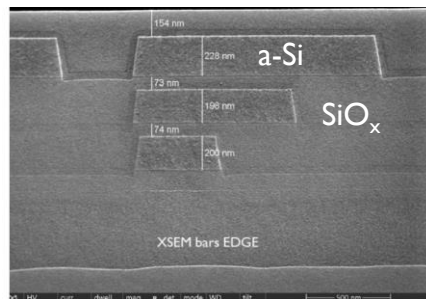
Illuminator

$f \approx 98\mu\text{m}$

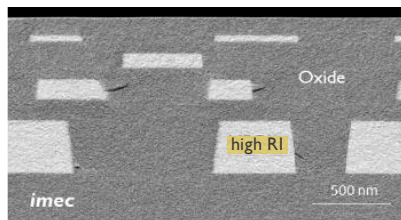
red light



green light



a-Si ideal for
SWIR and red light

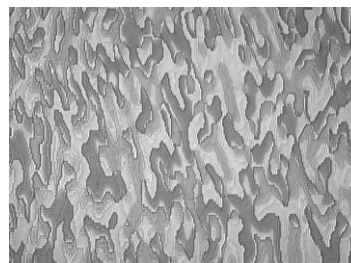
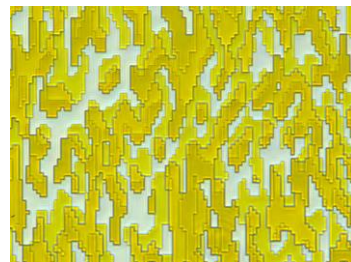


High RI oxide ideal for
green and blue light

Diffractive Optical Elements

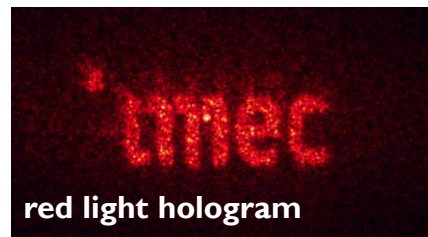
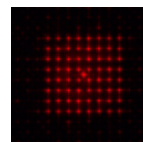


Beam splitter

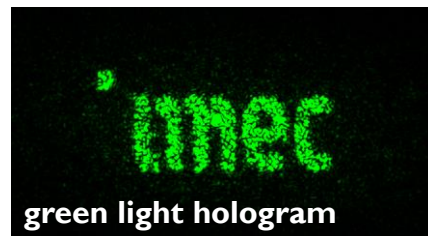


Hologram with the imec logo

Farfield diffraction pattern

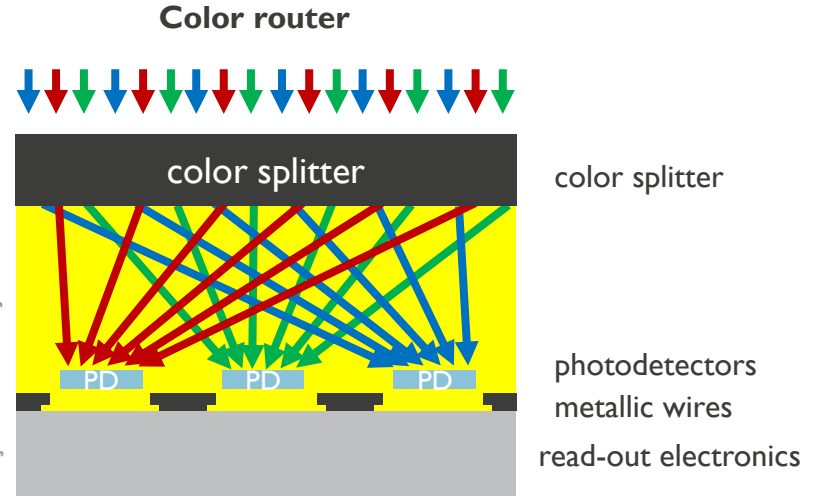
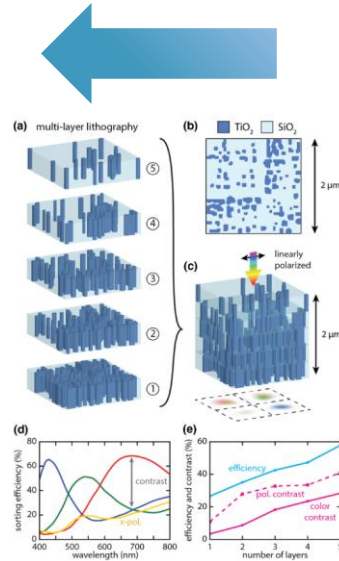
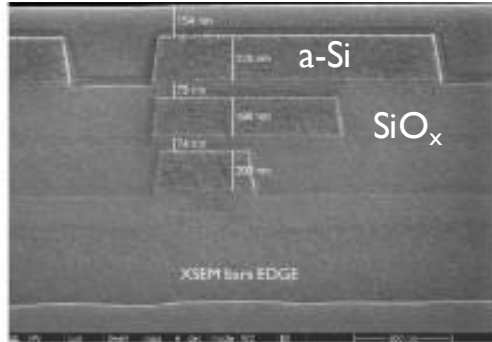


red light hologram



green light hologram

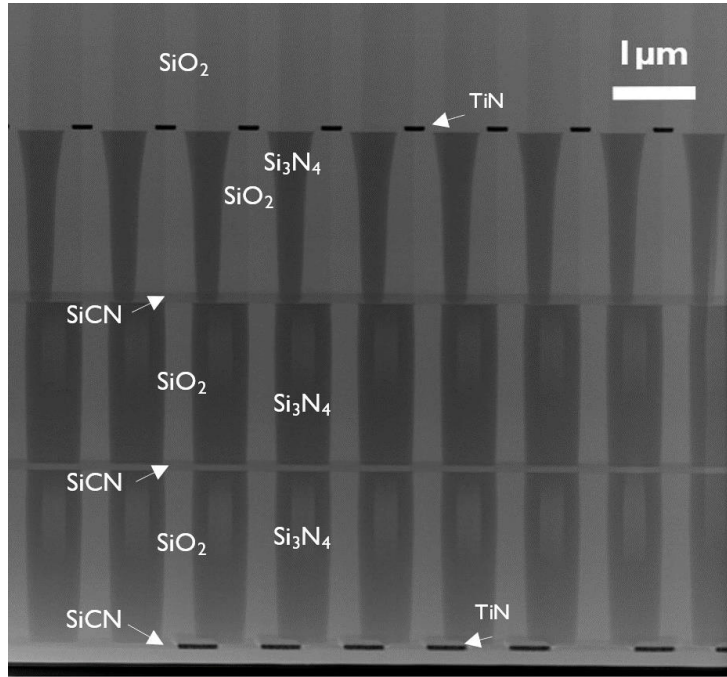
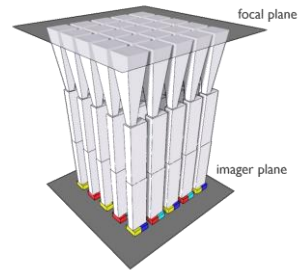
For larger efficiency we need color splitters not filters



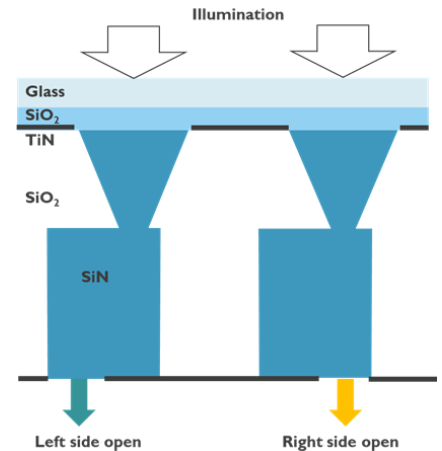
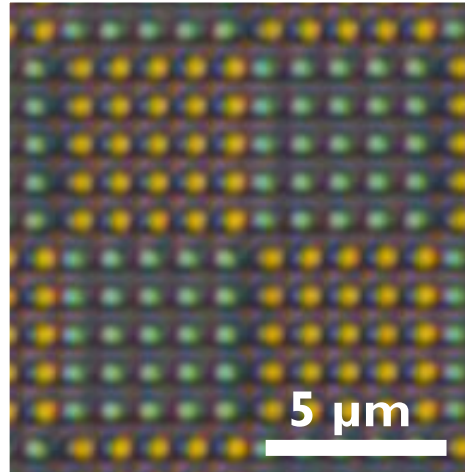
An ideal object would split the light according to color and redirect it to its respective sub-pixels.

Imager optics for pixel-level color and polarization splitting

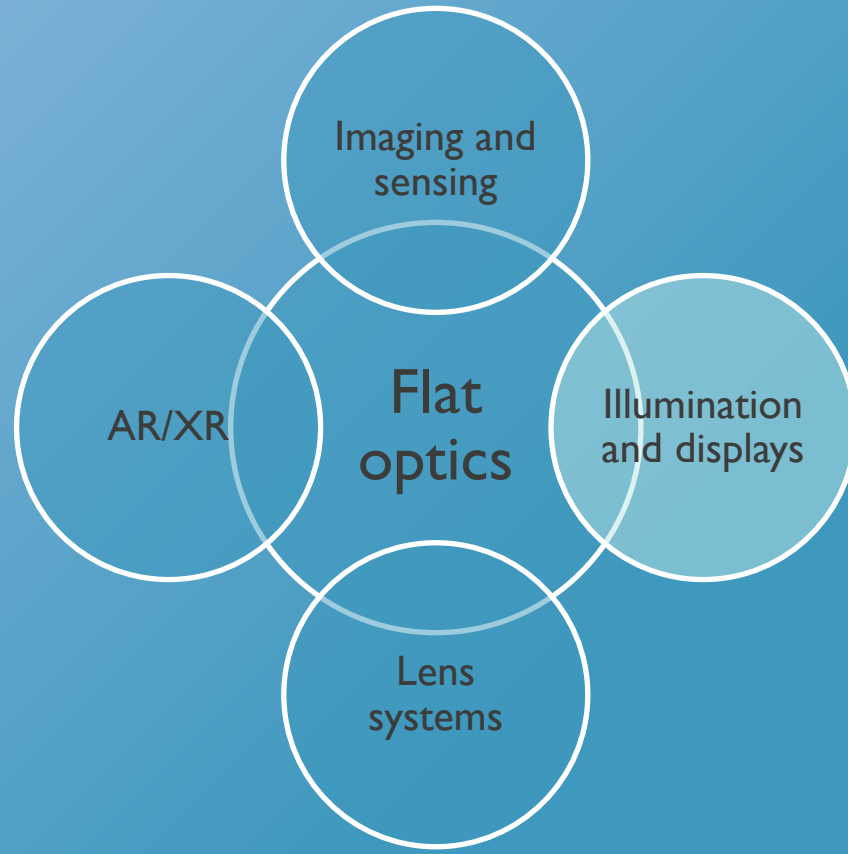
Color splitter enables sub-diffraction limit color splitting



- High aspect ratio Si₃N₄ waveguides in SiO₂ transferred to glass to measure the optical transmission characteristic.
- TiN blocks half of the exit
- Uniform white light illumination



Shuo K. *et al.*, Wafer-level-integrated vertical-waveguide sub-diffraction-limited color splitters, *IEDM 2023*



Imaging and
sensing

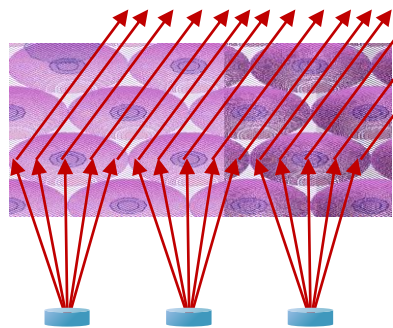
AR/XR

Flat
optics

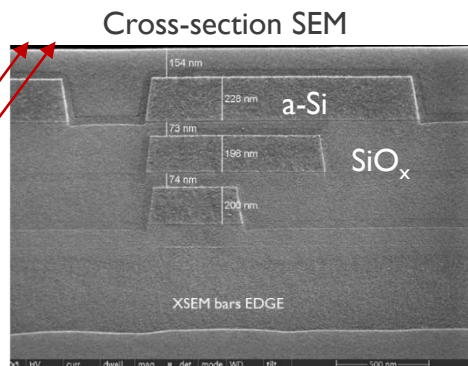
Illumination
and displays

Lens
systems

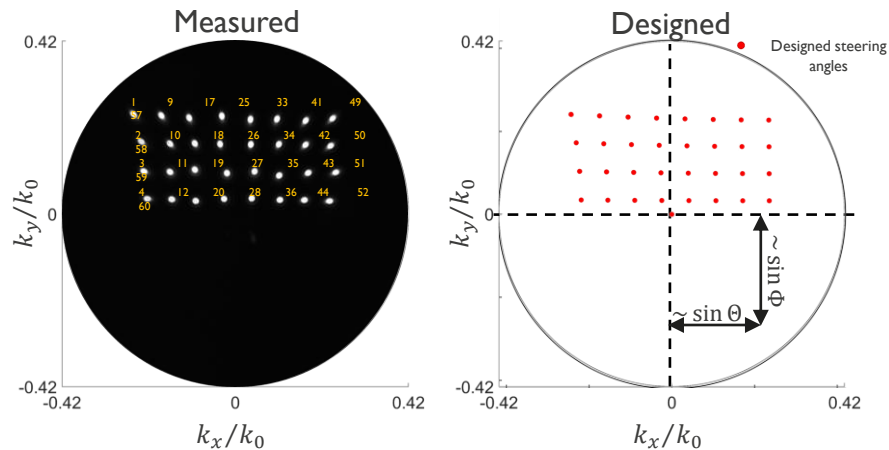
Flat optics for TOF LIDAR system



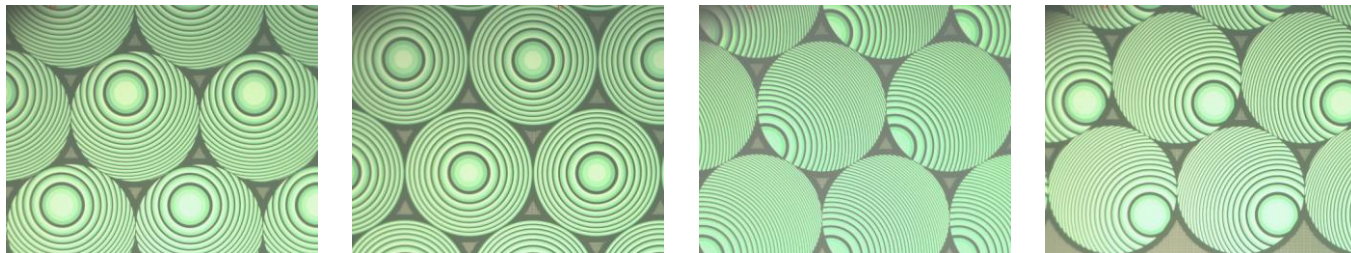
Light source
(VCSELs)

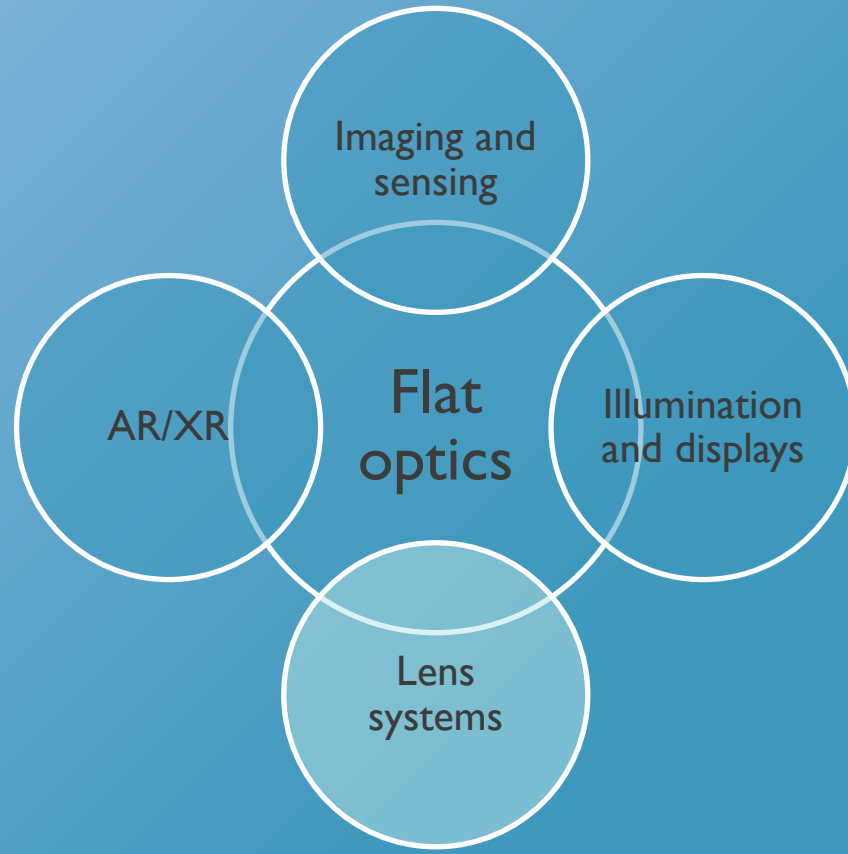


Cross-section SEM

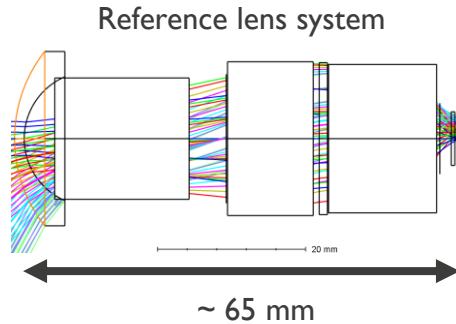


Top view microscope images



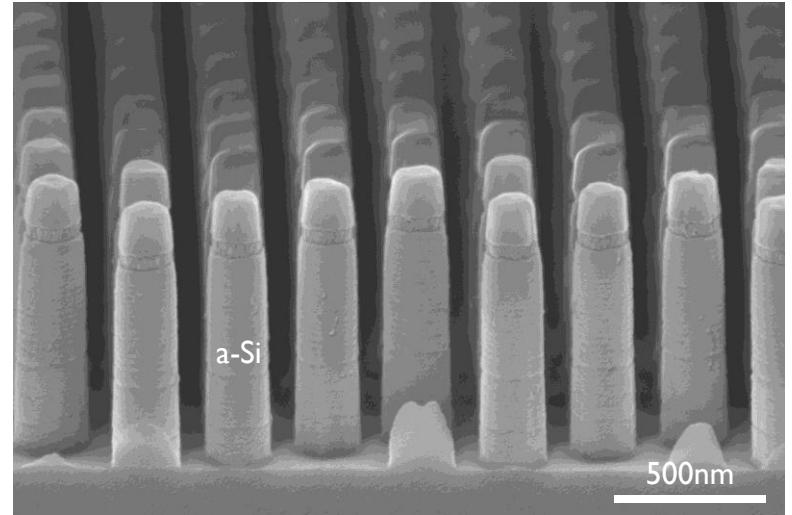
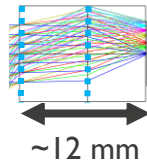


a-Si nanopillars for SWIR metasurfaces

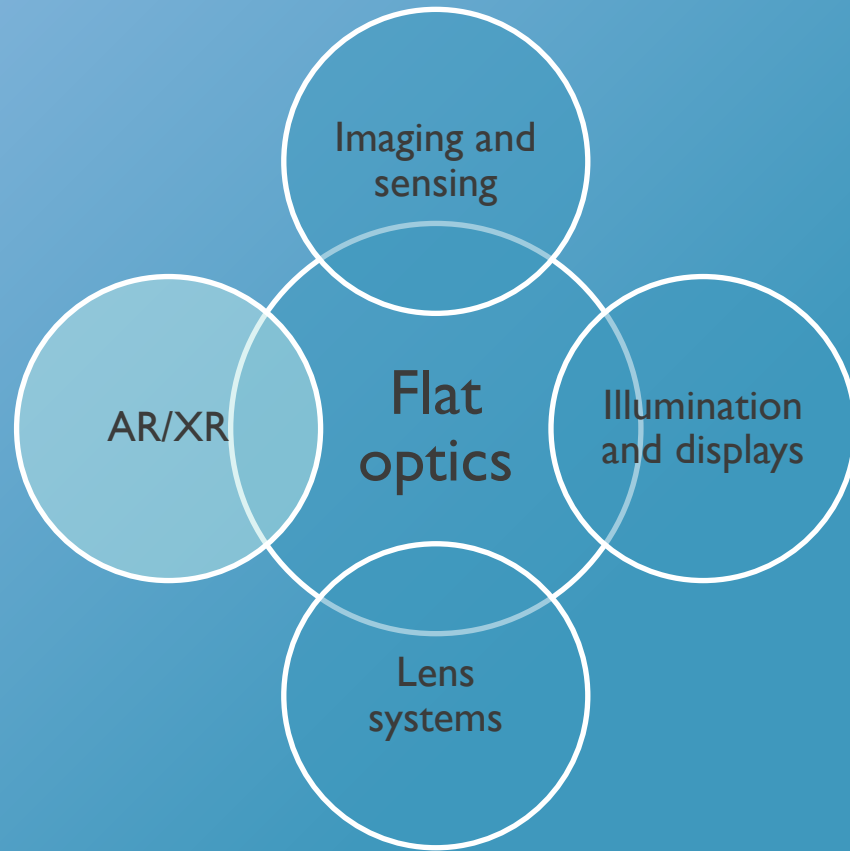


Equivalent optical system with two optical metasurfaces

Miniaturized compact lens system
Smaller by factor **x7**



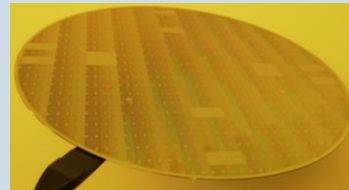
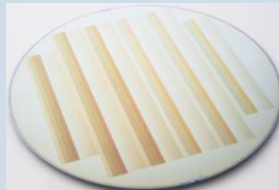
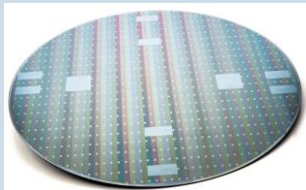
a-Si pillars for optical metasurface for $\lambda_0 = 940\text{nm}$



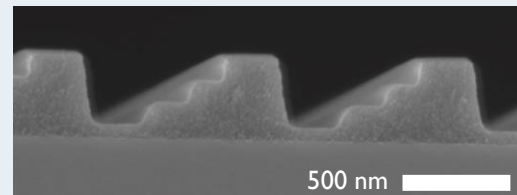
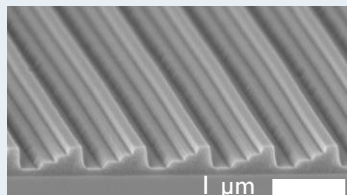
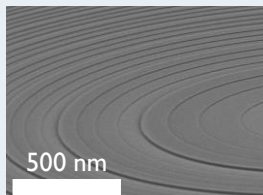
Nano imprint @imec

Key NIL features demonstrated

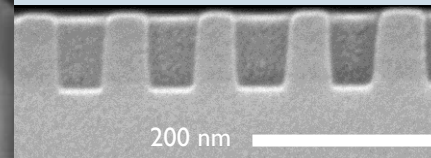
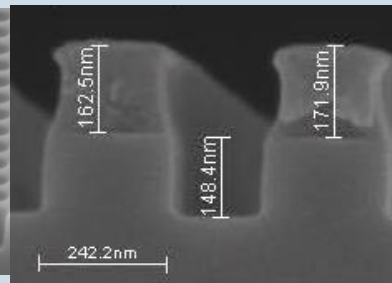
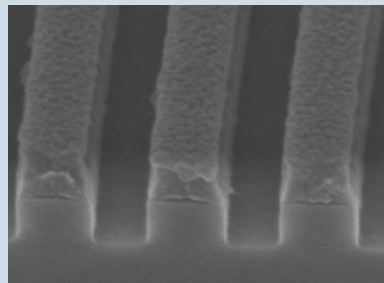
high-density large area patterning (up to 300mm wafers)



multi-level patterning in one single step



high resolution patterning (CDs down to 40nm)

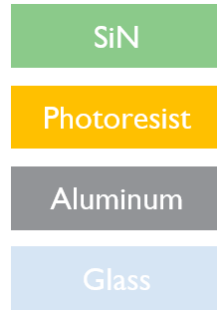
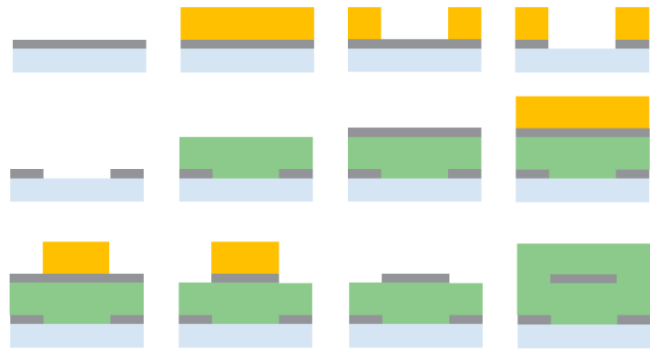


*etched wafers after NIL step

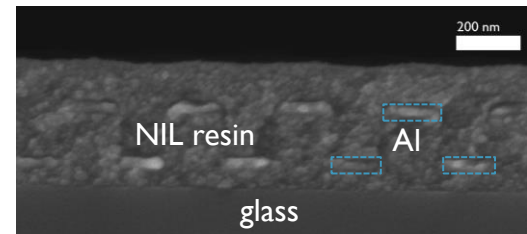
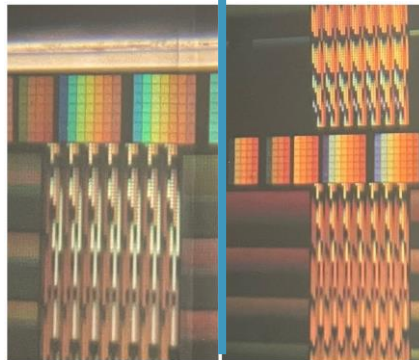
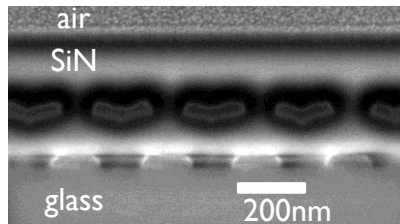
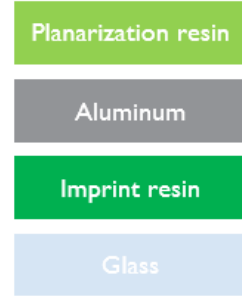
Plasmonic color filters with NIL

Conventional CMOS fabrication flow vs. NIL flow

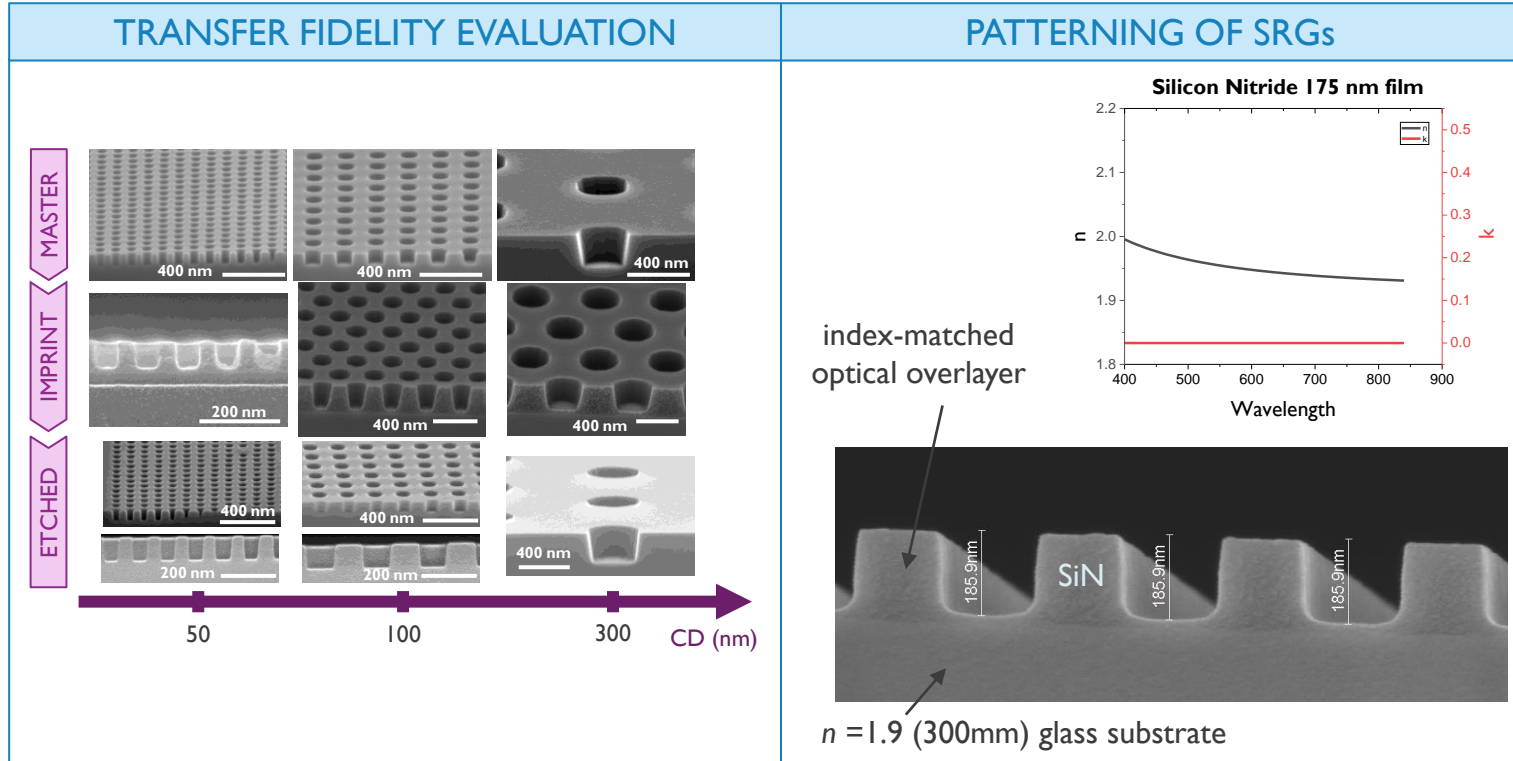
200 mm CMOS pilot line



NIL flow



DEVELOPMENT OF PROCESSES WITH DIFFERENT MATERIALS COMBINATION

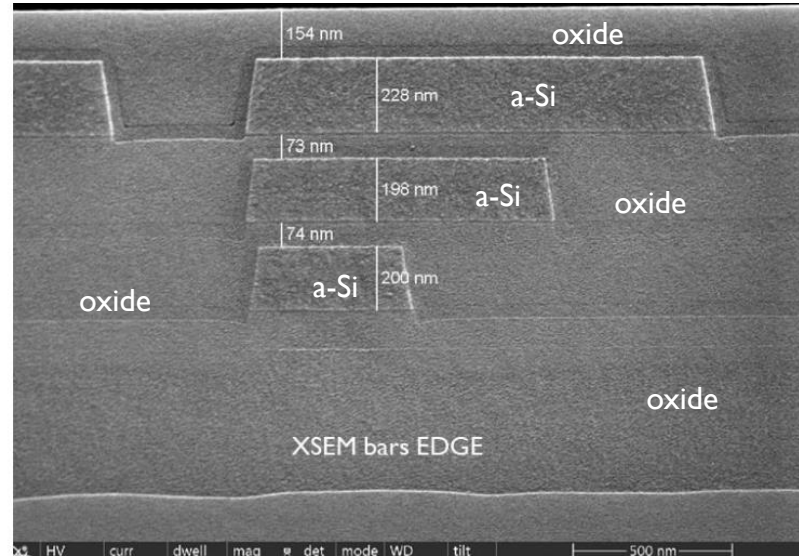
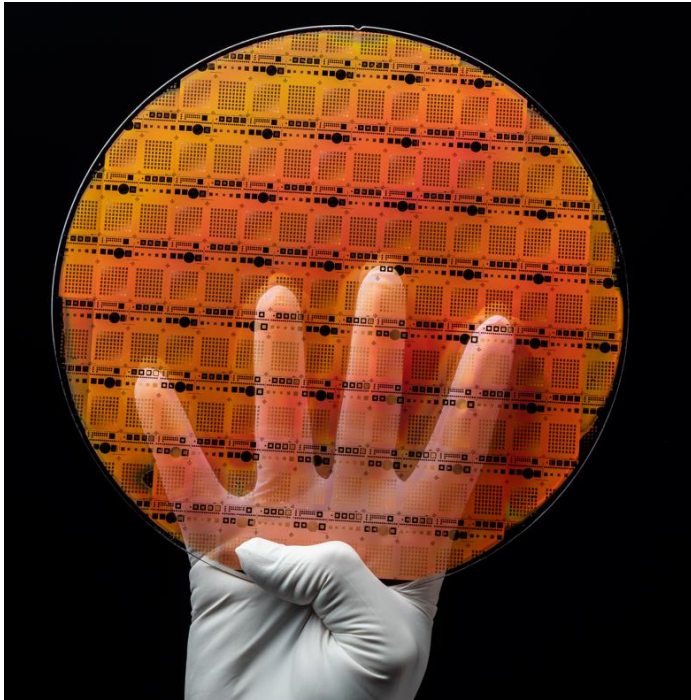


IMEC can support you from design to volume manufacturing

- Flat optics design, fabrication and characterization for
 - AR waveguides
 - Top optics on CMOS image sensors and other photodetector arrays
 - Light source functionalization
 - Bulk optics replacement
- Hereto, imec can provide
 - High aspect ratio patterning and filling
 - Multilevel flat optics on various substrates
 - NIL and/or DUV lithography on glass substrates



Multilevel flat optics on transparent substrates



- ✓ NIL/DUV lithography technology for sub-wavelength patterning.
- ✓ Transparent, CMOS, other substrates
- ✓ High refractive index materials ($a\text{-Si}$, TiO_x , NbO_x , SiN_x), NIL resins
- ✓ Multilayer flat optic device