Innovations in Photomask Production for Enhanced AR/VR Optics

Bríd Connolly
Martin Sczyrba

Dec 3rd 2024

Micro-optics SUMMIT & EXPO

Advanced manufacturing that enable the future of AR/VR

TEKSCEND PHOTOMASK

If YOU can imagine it, WE can image it.

Outline

- **Company Introduction**
- **XR device components**
- **What part does Photomask Technology play?**

Toppan Photomask to Rebrand as Tekscend Photomask | Tekscend Photomask

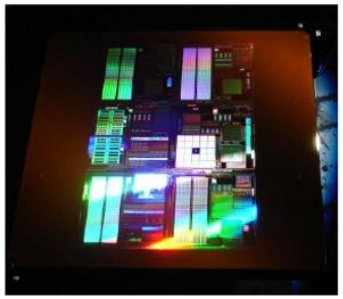
Tekscend Photomask Corp.(TPC)

The world's premier provider of photomasks for semiconductors

- **60+ Years** Dedicated to the Industry
- Global Customer Reach
- **8 Manufacturing Facilities** Strategically Located Globally
- Offering the World's **Most Advanced Lithography** Technology
- Including **Nanoimprint Molds** and Other Nano-Fabricated Products

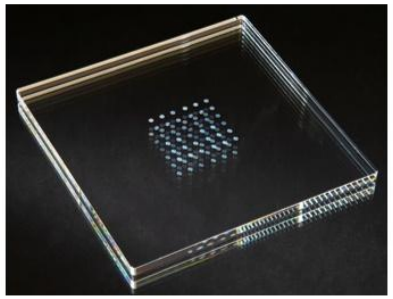
DUV reticle/photomask

Transmissive Mask Lithography



EUV Mask

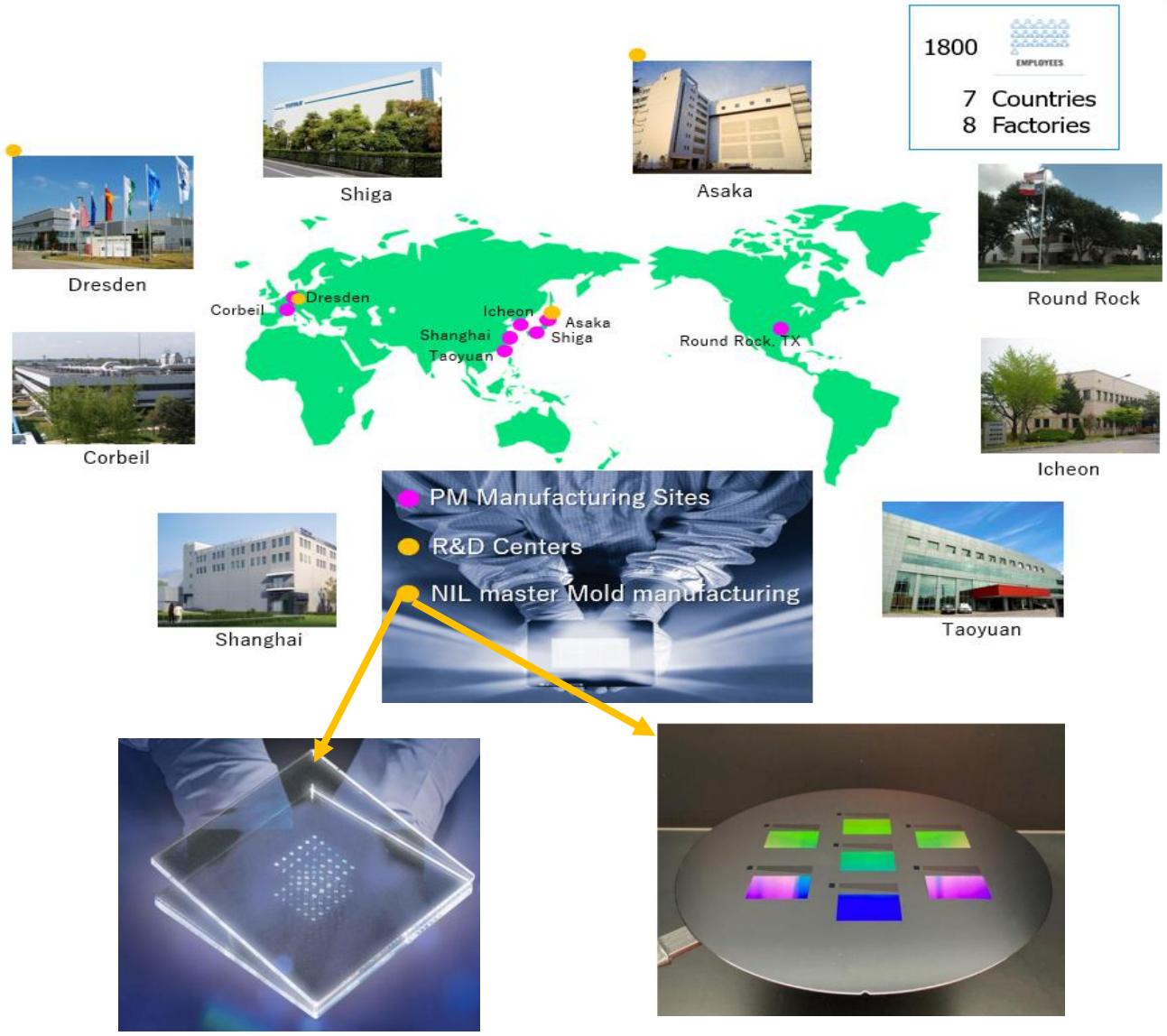
Reflective Mask Lithography



Nano Imprint Lithography master

Imprint Lithography

Tekscend PHOTOMASK



A TOPPAN group company

NIL Master molds from Dresden (Qz) and Japan (Si wafer)

XR Device is a system

composed of multiple modules to provide the individual functionalities

Image computing & connectivity (IC 'chips', WLO…):

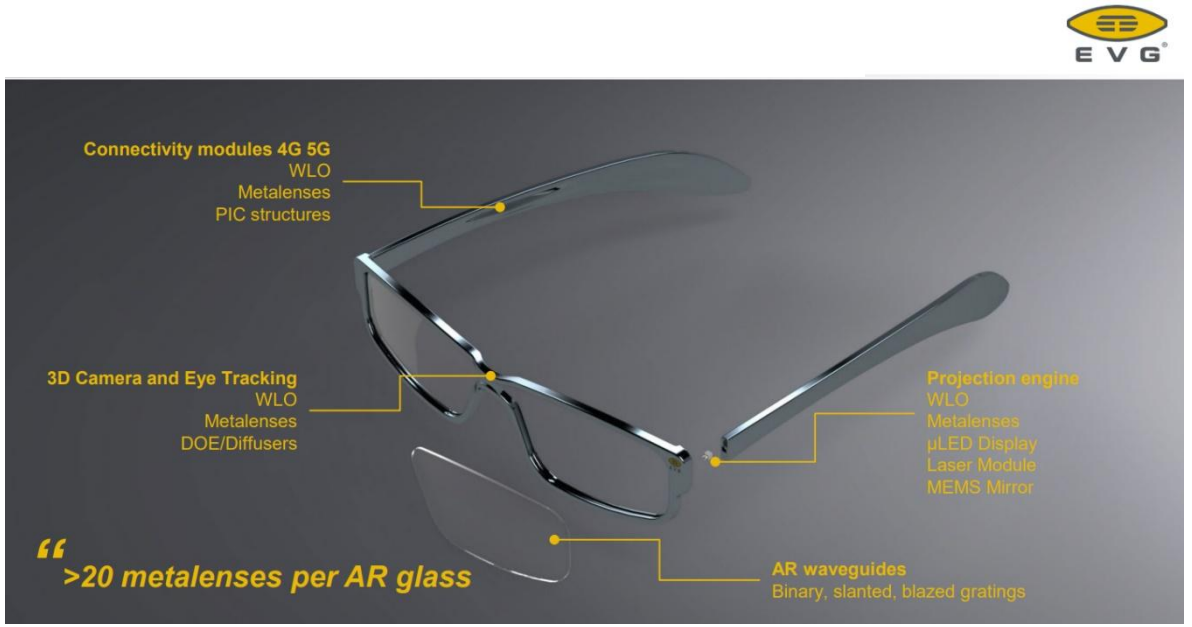
- **Projection** lithography : Photomasks

Sensing (sensors, metalenses, WLO):

- Projection lithography : Photomasks
- **NanoImprint** Lithography: Masters molds

Light steering (waveguides):

- Projection lithography → Photomasks
- NanoImprint Lithography → Masters molds
- **Proximity** lithography → Photomasks

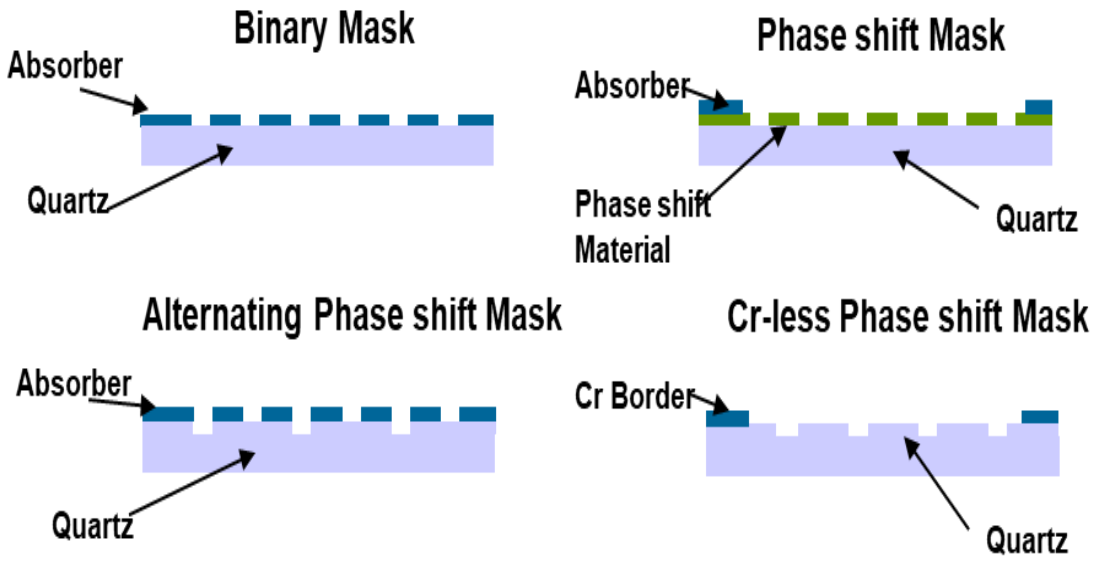


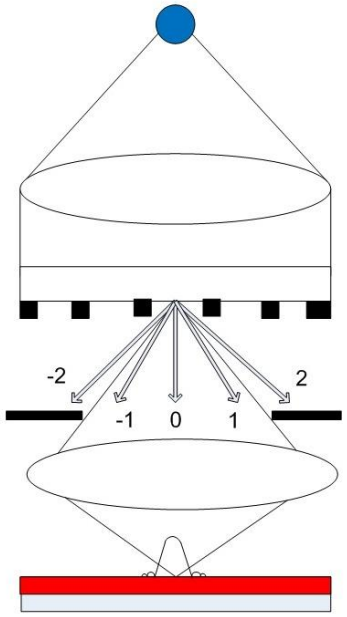
➔ each module is manufactured using a 'Replication' Template

➔ High quality templates for all lithography techniques are manufactured using **Photomask Technology** at industrial quality grades that enable the best performance

Projection Lithography

Generates the image by diffracted light created by a photomask



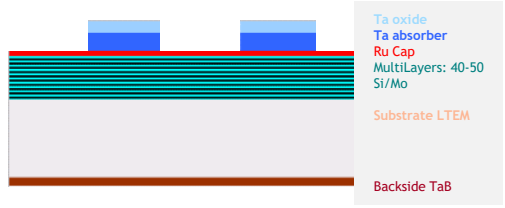


DUV Transmission mask
The pattern on a photomask is transferred with reduced size onto the surface of substrate.

- Many mask types with different absorbers are used for different applications
- EUV masks
- And many other mask types available
  - e.g. Greyscale etc.

EUV Mask

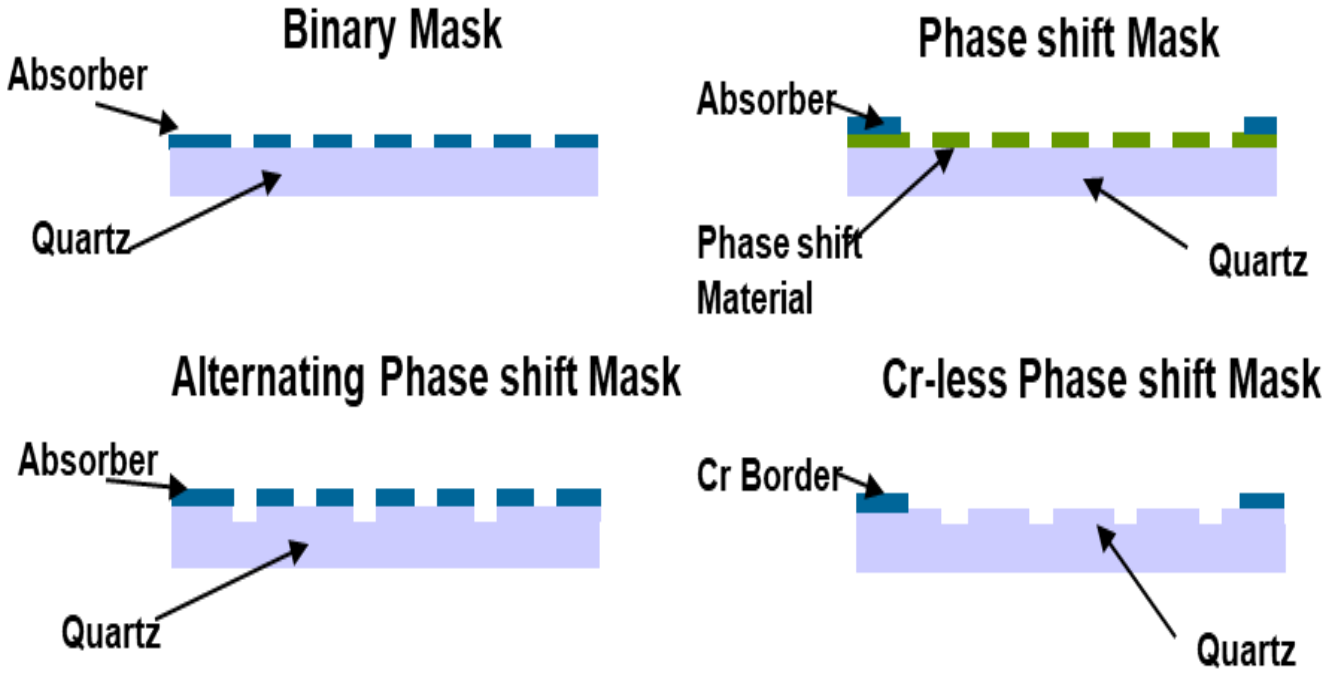
Reflective Mask Lithography

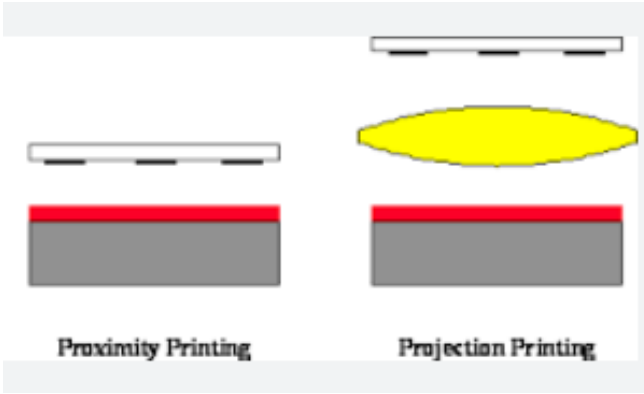


EUV : A reflective Mask

Proximity Lithography

Generates the image by near-field of light created by a photomask





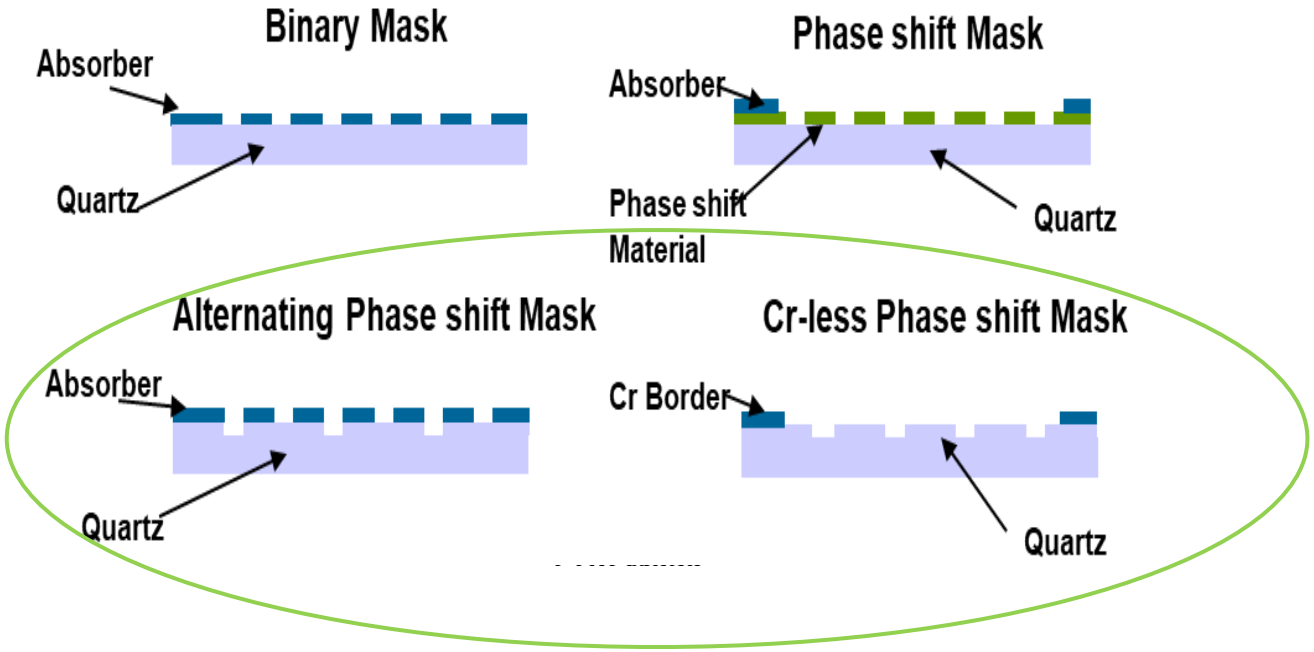
Proximity
The pattern on a photomask is transferred onto the surface of substrate. No reduction *

- Special application of phase shift photomasks
  - including DTL (Displacement Talbot Lithography) *
- Phase shift can be achieved by a dedicated attenuating material or by quartz etched pattern

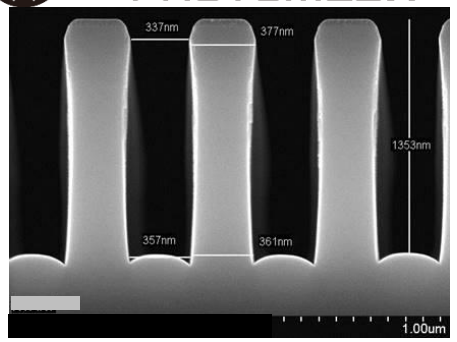
NIL Master & Optical Devices

NIL master: The pattern is <u>etched</u> into substrate and used as stamp

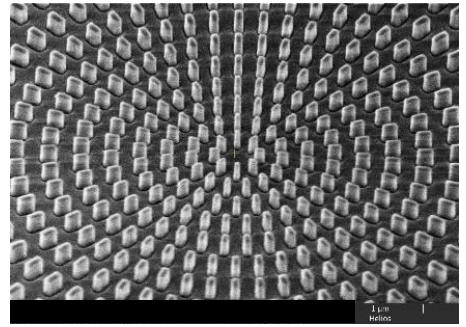
Optical devices: Patterned Quartz substrate is deployed as optical element



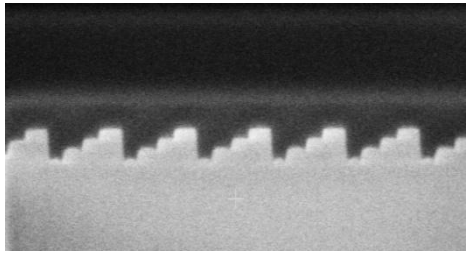
<u>Deep</u>-etch Quartz gratings
(e.g. laser applications)

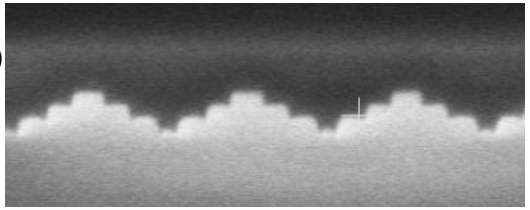


MetaLenses mold
(e.g. flat optics)



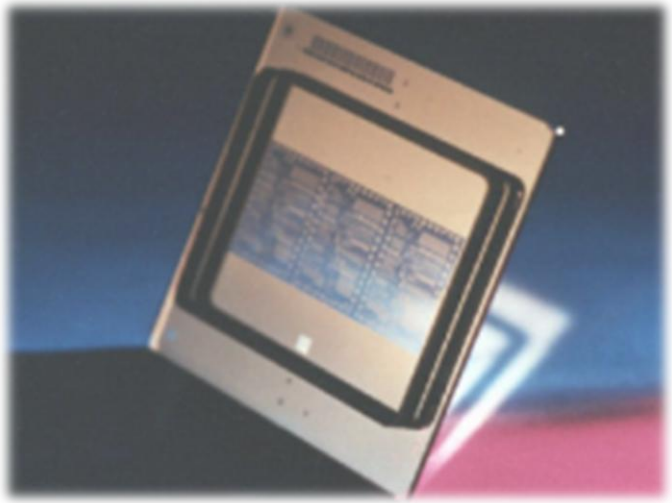
Multi-level gratings
(e.g. NIL master for AR glasses)



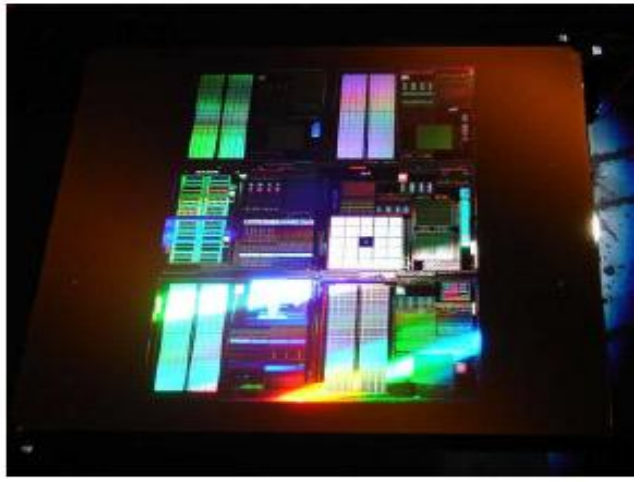


- Quartz etch products benefit from established mask making processes using same tool sets as for advanced photomask types.
- Volume shipments annually

PhotoMasks to NIL Mastering



Transmissive Mask Lithography



Reflective Mask Lithography

PhotoMask making:

- ✓ Patterning using **EBL**
- ✓ Etching perpendicular into the substrate/absorber
- ✓ High resolution and precision
- ✓ Highly controlled processes
- ✓ High level of cleanliness
- ✓ Industrialized process
- ✓ Established standards

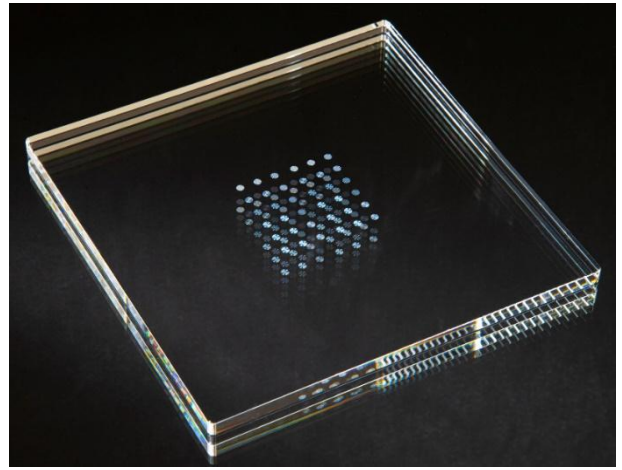
Photomask to NIL mastering

Photomask technology is well-suited to AR specifics by **adding**:

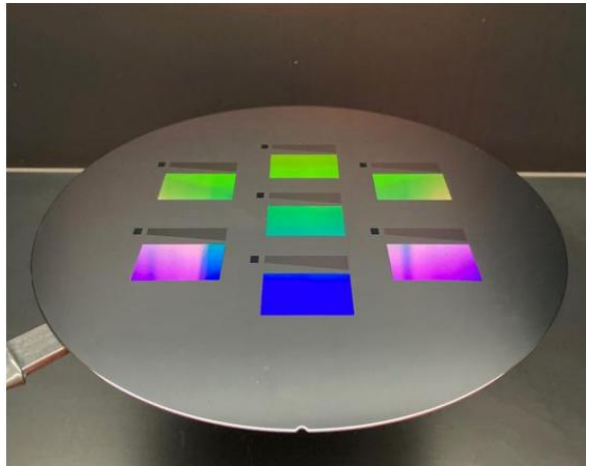
- ✓ Any angle features
- ✓ Arbitrary shaped patterns – **MBMW** litho
- ✓ Slanted/Blazed/Staircase etch profiles
- ✓ Variable Etch Depth slope in substrate

Nano Imprint Lithography

Metalens Application

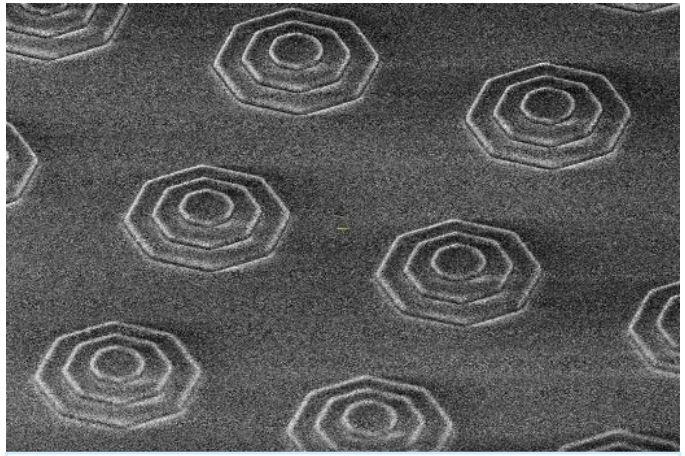


AR/VR/MR Application

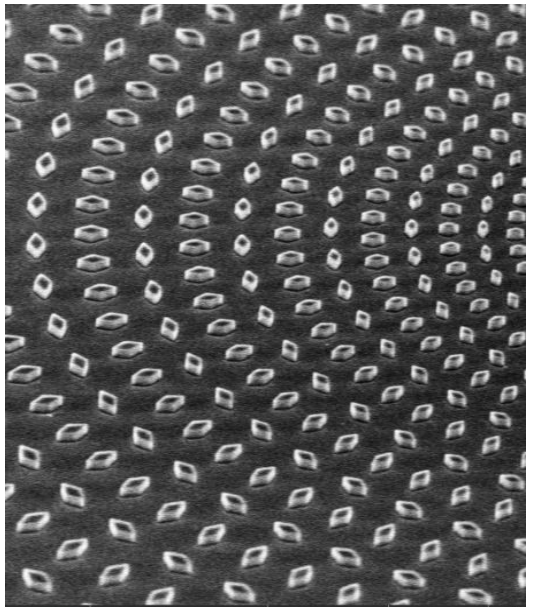


EBL – EBeam Lithography
MBMW-**M**ulti**B**eam**M**ask**W**riter

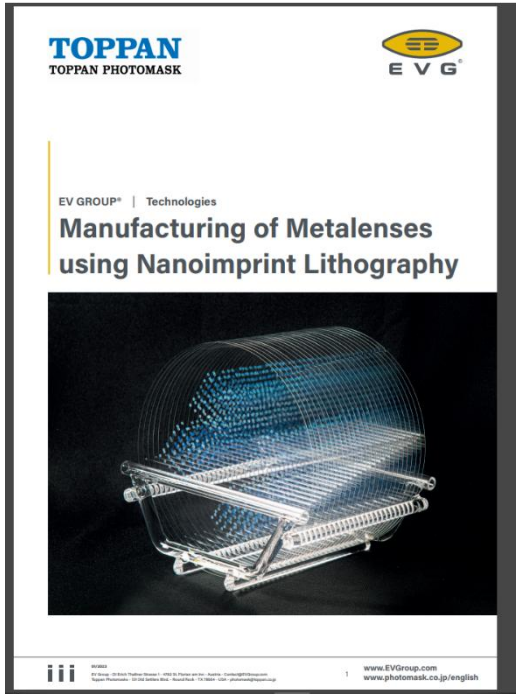
Patterning ..... 3D patterns

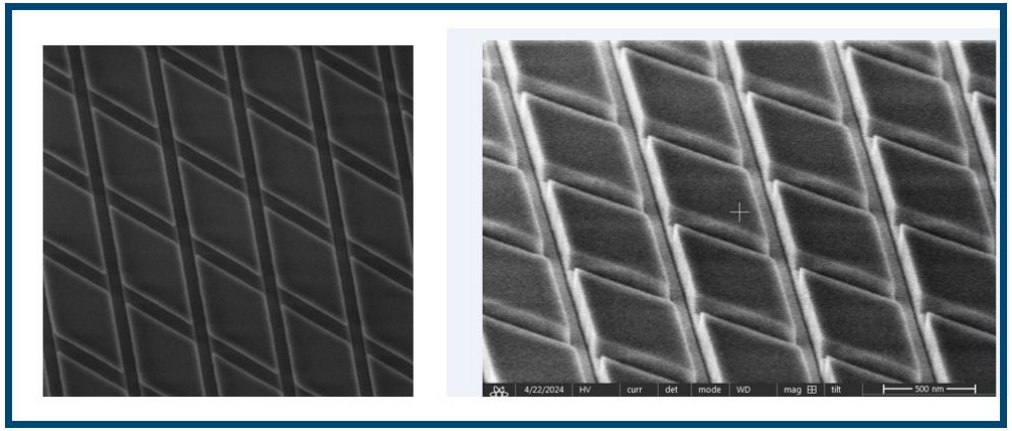


Octogon pyramids



Meta-atoms of 65nm sized etched into Quartz



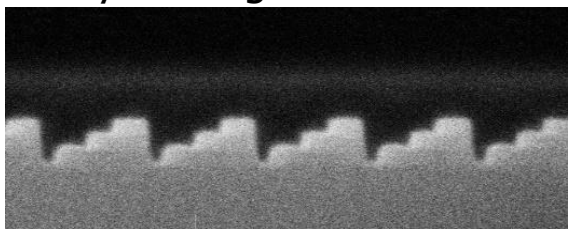


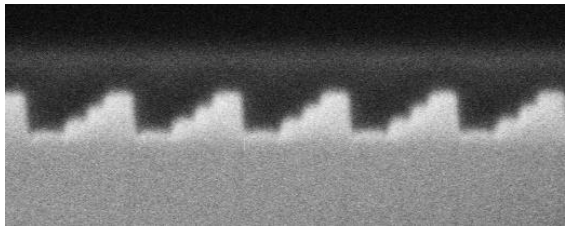
Overlapping Grids with different depths

Gratings with 2D/3D etching

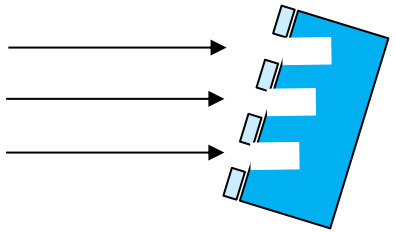
Multisteps Staircase

- **Multi-level EBL exposure for optimum overlay**
- Binary etching

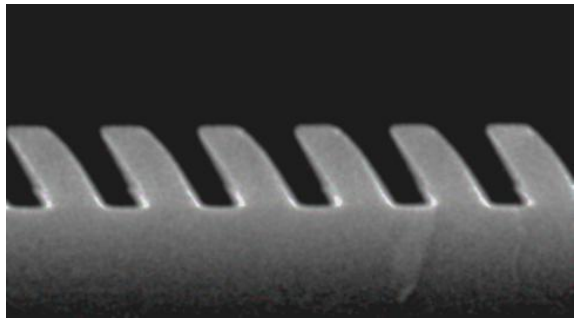




Slanted

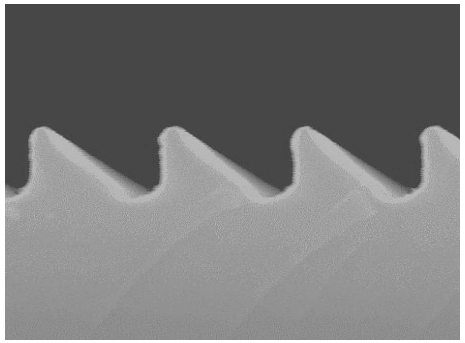


- **Etching** with the mask tilted at given **orientation and angle**



Blazed

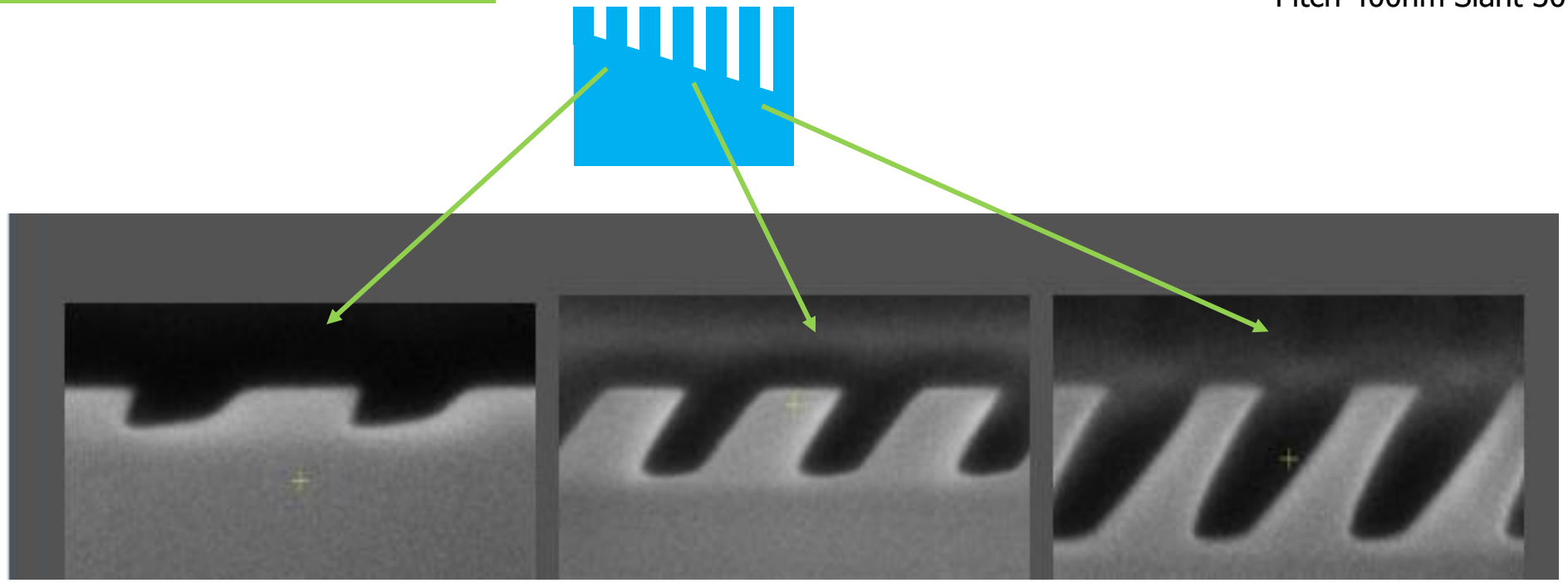
- Etching : **Specific etch** strategy to realise the **Blazed** shape



Gratings: Variable Etch Depth

Variable Etch Depth Slanted

Depth profile 50nm to 350nm
Pitch 400nm Slant 30°



- Slanted, or binary, etch realized with **continuously varying etch depth**
- **Non-linear** depth profiles also possible

Summary

- Photomask technology is the foundation of any ‘replicate’ Template for design transfer using lithographic processes onto substrates, to generate the various modules in XR systems.

- The XR industry can benefit from the well established industrialized processes and controls in place to serve other industries.

It is possible to deliver all replicate template types for the modules on ARVR systems,

➔ just advise on the requirements and your ideas for the future !

Photomask technology is an enabler for AR/VR Optics and systems

Thank You for your attention

Tekscend Photomask