

# Micro- and Nano Patterning by Innovative Photoresists and Photopolymers for Advanced Manufacture of Microelectronics & Photonics

M. Russew, C. Schuster, A. Voigt, M. Lohse, M. Heinrich,  
A. Schleunitz, and G. Grützner

EPIC Technology Meeting on Microelectronics and  
Photonics – Two Sides of One Coin  
SESSION 3: Lithography

12<sup>th</sup> November 2024

Specialized in providing **innovative resists, polymers, photopolymers and ancillaries**, we support our high-tech customers with high performance materials, technologies and process solutions



- *Established:* 1993
- *Employees:* ~ 55 (2024)
- *Location:* Berlin, Germany  
(Corporate office, logistics and manufacturing)
- *Facility:* 3.450 m<sup>2</sup> incl. clean room (300 m<sup>2</sup>)

- *Certifications:*  
ISO 9001:2015  
ISO 14001:2015



- *Fields of business activities:*

- Manufacturing: formulation / synthesis
- Distributorship  
(products of partner companies)

- Researching advanced materials and processes
- Lithographic Services

## Negative Photoresists

### UV lithography for ...



Single Layer  
Lift-off  
ma-N 400, ma-N 1400

### UV lithography for ...



Etch mask,  
Mould for electroplating,  
Pattern for microfluidic  
ma-N 400, ma-N 1400  
EpoCore, EpoClad  
SU-8, SU-8 2000, SU-8 3000

### E-Beam/ Deep UV lithography for ...



Etch mask,  
Stamp,  
Template manufacture  
ma-N 2400  
mr-EBL 6000

### Laser lithography/ Inkjetprinting for...

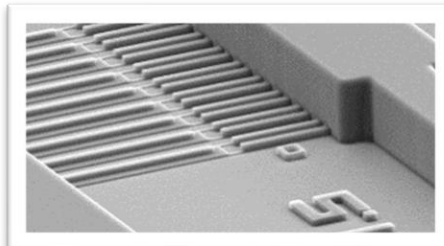


Mould fabrication,  
Stamp,  
Template manufacture  
mr-DWL  
InkEpo  
SU-8

### X-ray lithography for...

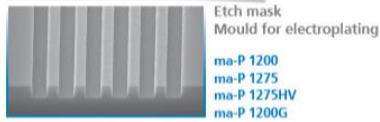


Mould for electroplating,  
Permanent applications,  
Gratings,  
Microoptical components  
SU-8  
mr-X



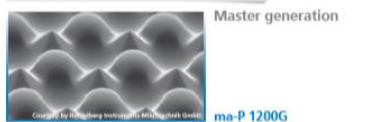
## Positive Photoresists

### UV lithography



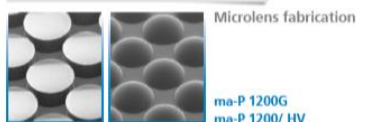
Etch mask  
Mould for electroplating  
ma-P 1200  
ma-P 1275  
ma-P 1275HV  
ma-P 1200G

### Greyscale lithography



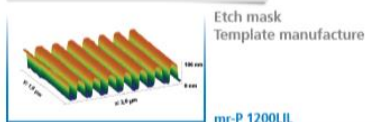
Master generation  
ma-P 1200G

### Thermal reflow

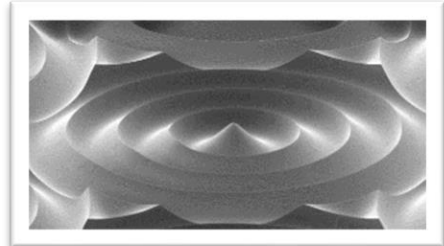


Microlens fabrication  
ma-P 1200G  
ma-P 1200/ HV

### Laser Interference Lithography



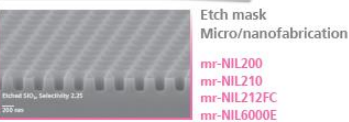
Etch mask  
Template manufacture  
mr-P 1200LIL



**HEIDELBERG**  
INSTRUMENTS

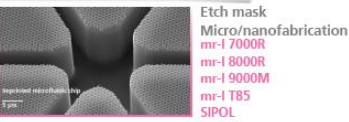
## Nanoimprint Materials

### UV-NIL, Photo-NIL



Etch mask  
Micro/nanofabrication  
mr-NIL200  
mr-NIL210  
mr-NIL212FC  
mr-NIL6000E

### Thermal nanoimprint



Etch mask  
Micro/nanofabrication  
mr-I 7000R  
mr-I 8000R  
mr-I 9000M  
mr-I T85  
SIPOL

### Alternative Processes



High throughput processes,  
Permanent applications  
Inkjet dispensing  
mr-UVCur265F

### Working stamps



Safe your costly master  
OrmoStamp®  
UV-PDMS KER-4690



## Hybrid Polymers

### Micro optical components



UV replication/ imprint  
Inkjet printing  
Stereolithography  
OrmoComp®  
OrmoClear®FX  
OrmoClear®series  
InkOrmo

### Optical waveguides



UV replication/ imprint  
UV lithography  
OrmoCore  
OrmoClad

### Bio applications

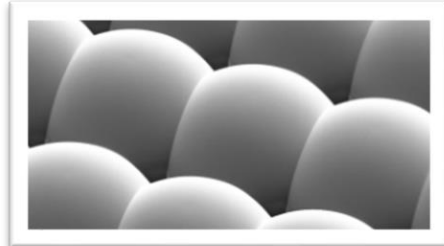


UV replication/ imprint  
Stereolithography  
OrmoComp®  
OrmoClear®FX

### Transparent polymer molds



UV replication/ imprint  
OrmoStamp®



**NIL**  
HEIL-TEC TECHNOLOGY

## Dry Film Resist

### Available materials:

mr-LamiRes | SUEX™, ADEX™ | MX5000, WBR2000



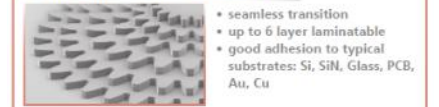
### Process Overview



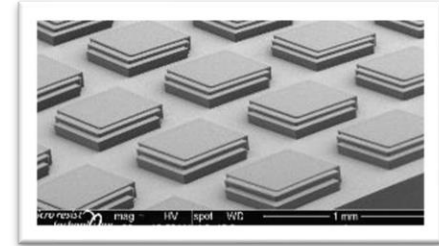
### Lithography



### Application: multilayer pattern

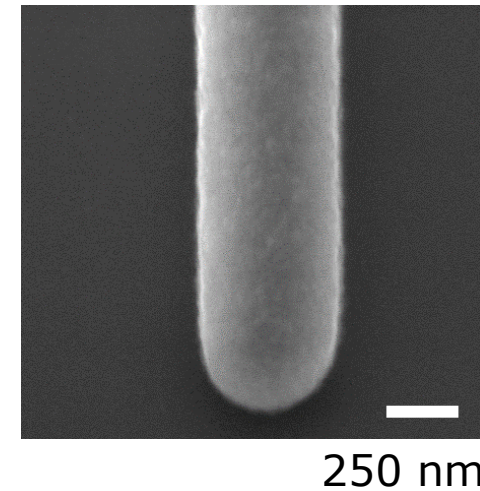
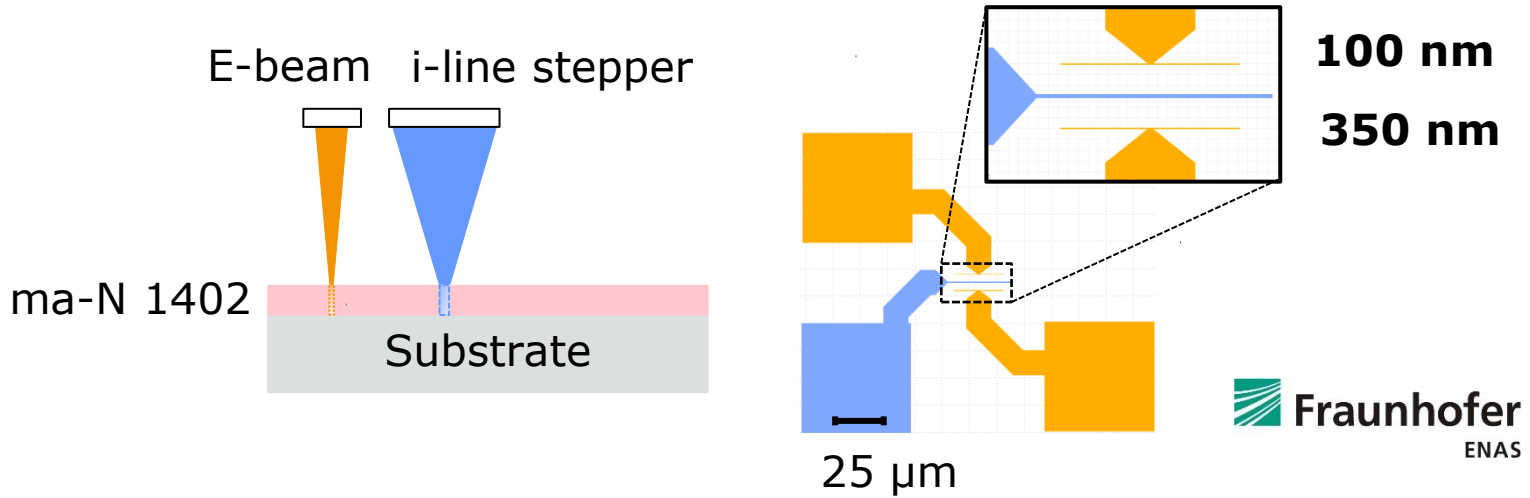


### Application: electroplating pattern

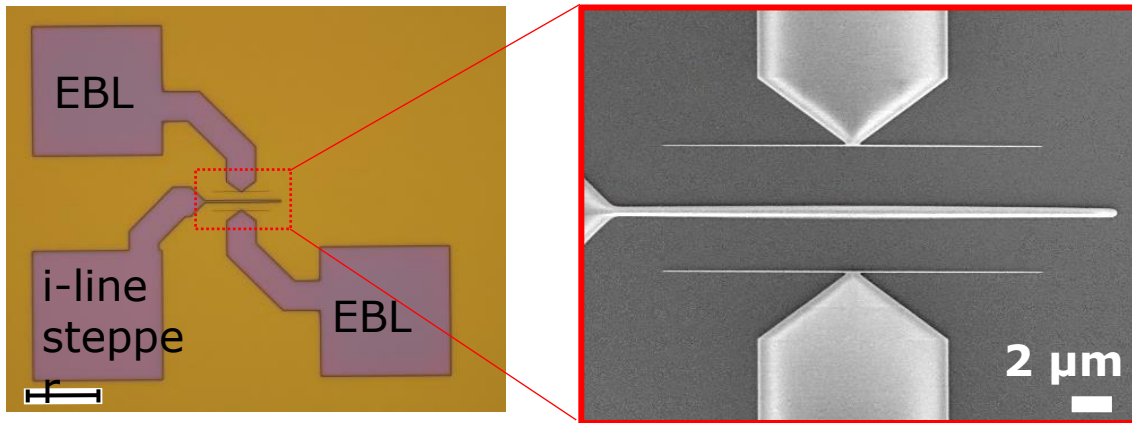


**micro resist technology**

## Intra-level mix-and-match<sup>[1]</sup>



Resolution, **i-line** stepper:  
**350 nm** with  
 2.35 µm pitch  
 at 115 mJ/cm<sup>2</sup> in  
 200 nm  
 thin ma-N1402

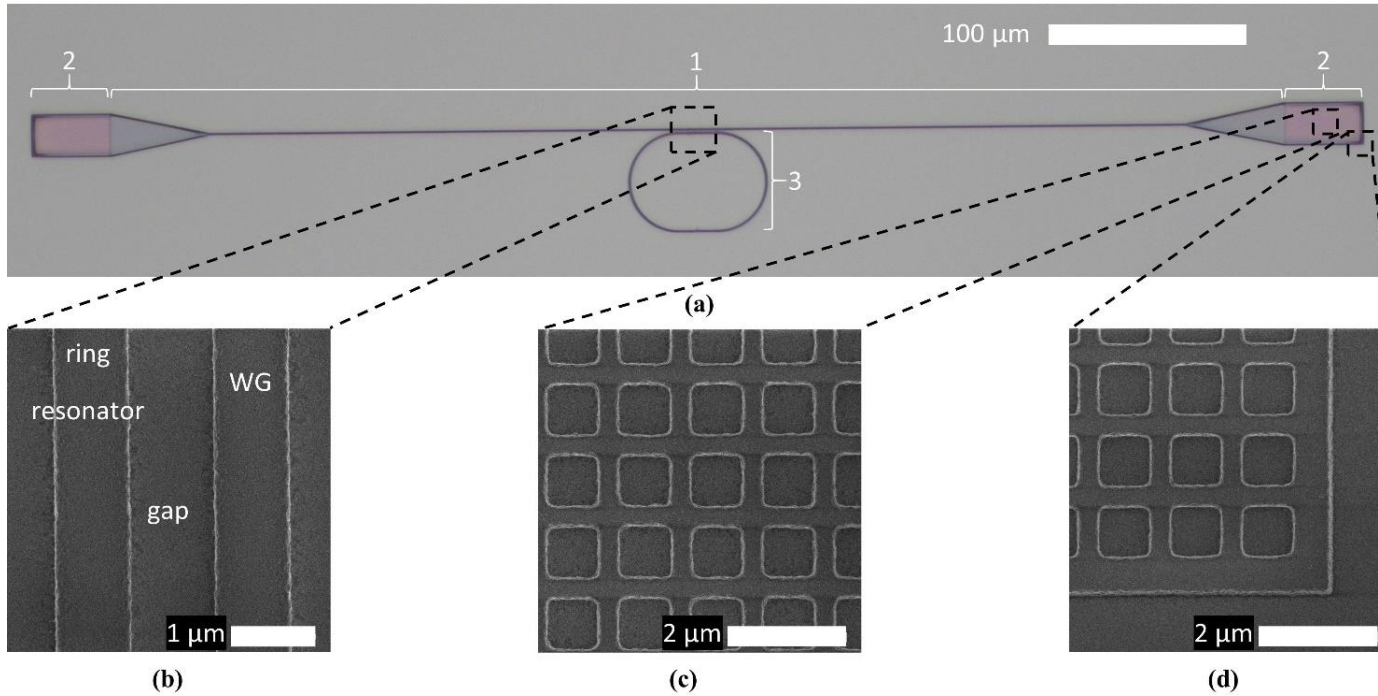


Resist ma-N 1402 patterned by EBL (nm) and i-line litho (µm)



C. Canpolat-Schmidt, Master Thesis, FhG ENAS, TU Chemnitz, 2022

Intra-layer mix & match (ILM&M) process enabled by **mr-EBL 6000 series** (e-beam resist)

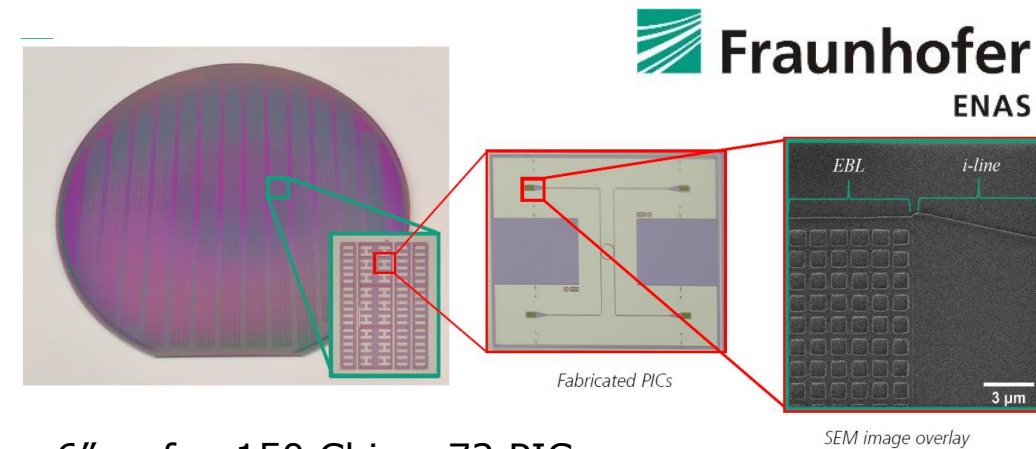


**i-line stepper exposure (365 nm):**

→ Preliminary PIC pattern

**e-beam lithography (50 keV):**

→ Fine tuning pattern accuracy



Fabrication of photonic integrated circuit (PIC) related waveguides (WG), ring resonators and coupling structures (for etching in LP-Si<sub>3</sub>N<sub>4</sub>)

Optical microscope image of: FT: 500 nm, (1) WG (900 nm width), (2) coupling structures (hole array, 800nm square holes, 400 nm line bars), (3) ring resonator (900 nm width, 0.5μm/ 1 μm gap to WG)

6" wafer, 150 Chips, 72 PICs:

2.5 h e-beam + 3 min i-line

(compared to 14 h e-beam only)

M. Reinhardt et al, Proc. SPIE 12802, EMLC 2023, <https://doi.org/10.1117/12.2675558>

S. Schermer et al, Oral presentation @ MNE 2023

## Negative Photoresists

### UV lithography for ...



Single Layer  
**Lift-off**  
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### UV lithography for ...



Etch mask,  
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### E-Beam/ Deep UV lithography for ...



Etch mask,  
Stamp,  
Template manufacture  
ma-N 2400  
mr-EBL 6000

### Laser lithography/ Inkjetprinting for...

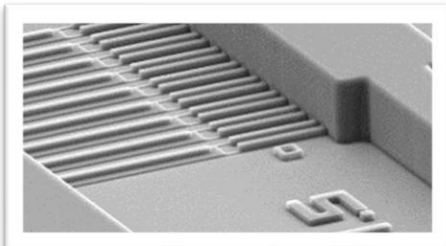


Mould fabrication,  
Stamp,  
Template manufacture  
mr-DWL  
InkEpo  
SU-8

### X-ray lithography for...

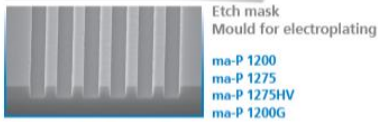


Mould for electroplating,  
Permanent applications,  
Gratings,  
Microoptical components  
SU-8  
mr-X



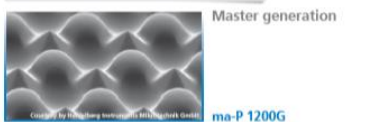
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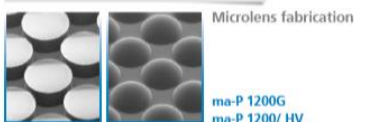
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ma-P 1275HV  
ma-P 1200G

### Greyscale lithography



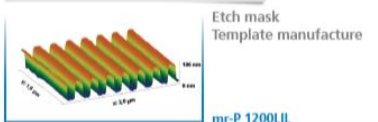
Master generation  
ma-P 1200G

### Thermal reflow

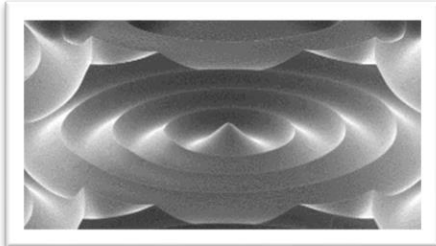


Microlens fabrication  
ma-P 1200G  
ma-P 1200/ HV

### Laser Interference Lithography



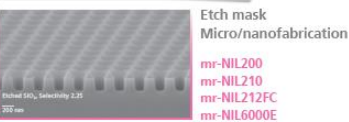
Etch mask  
Template manufacture  
mr-P 1200LIL



**HEIDELBERG**  
**INSTRUMENTS**

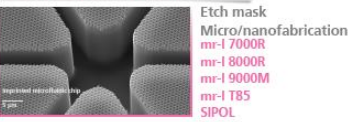
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Etch mask  
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Etch mask  
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### Alternative Processes



High throughput processes,  
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Inkjet dispensing  
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### Working stamps



Safe your costly master  
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UV-PDMS KER-4690



## Hybrid Polymers

### Micro optical components



UV replication/ imprint  
Inkjet printing  
Stereolithography  
OrmoComp®  
OrmoClear®FX  
OrmoClear®series  
InkOrmo

### Optical waveguides



UV replication/ imprint  
UV lithography  
OrmoCore  
OrmoClad

### Bio applications

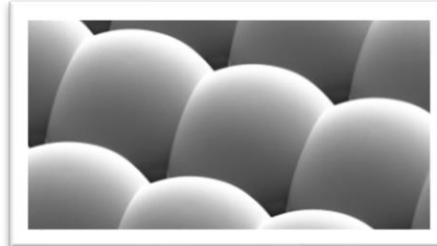


UV replication/ imprint  
Stereolithography  
OrmoComp®  
OrmoClear®FX

### Transparent polymer molds



UV replication/ imprint  
OrmoStamp®



**NIT**  
**HE TEL TECHNOLOGY**

## Dry Film Resist

### Available materials:

mr-LamiRes | SUEX™, ADEX™ | MX5000, WBR2000



### Process Overview



- three layer package
- negative tone behavior
- easy and very fast processing

### Lithography



- high aspect ratio > 5:1
- film thickness 5 to 500 µm
- vertical sidewalls

### Application: multilayer pattern

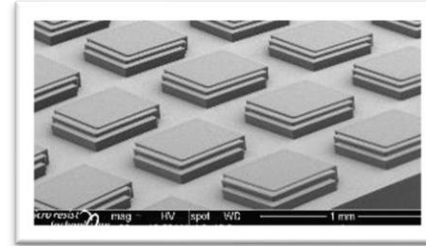


- seamless transition
- up to 6 layer laminatable
- good adhesion to typical substrates: Si, SiN, Glass, PCB, Au, Cu

### Application: electroplating pattern

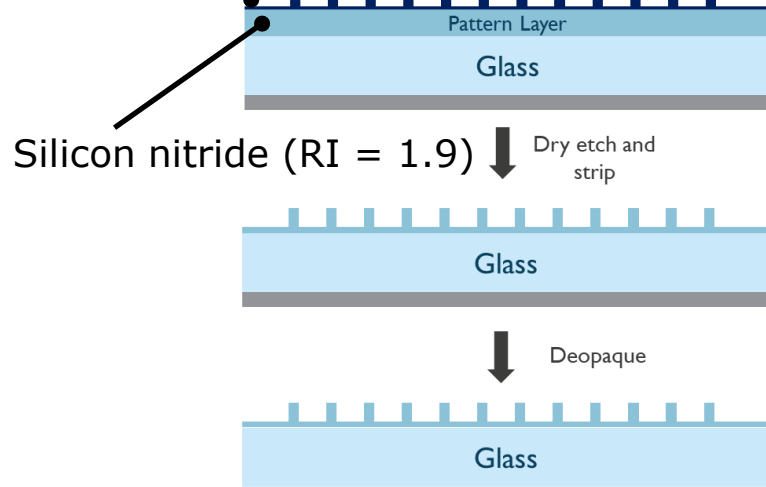


- good adhesion to Si, Au, Cu
- environmentally friendly
- chemical resistance

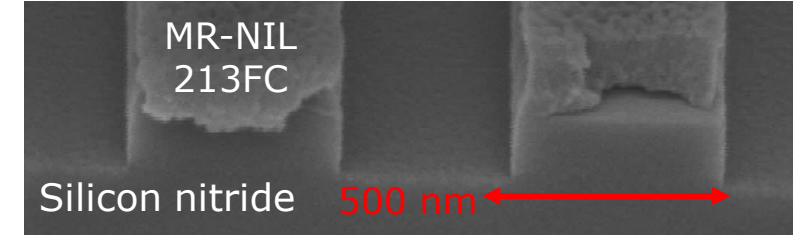
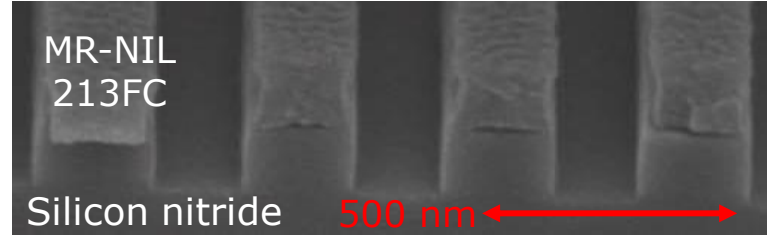


**micro resist technology**

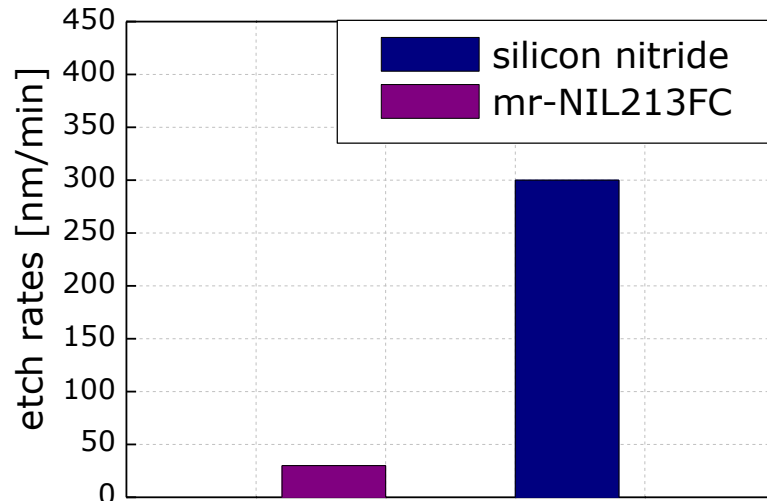
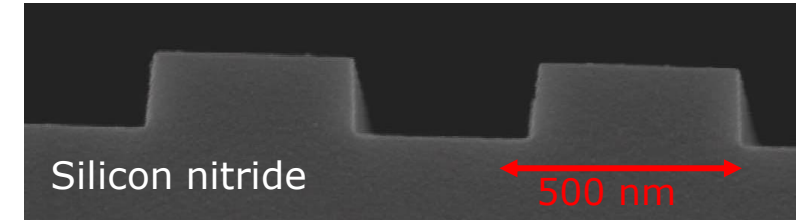
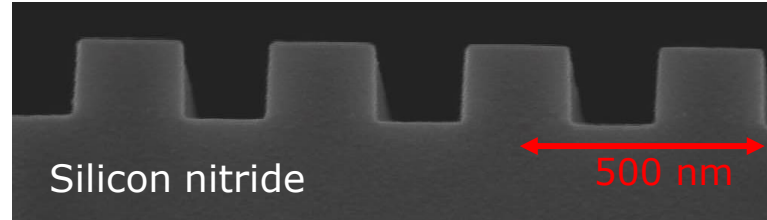
mr-NIL213FC\_XP



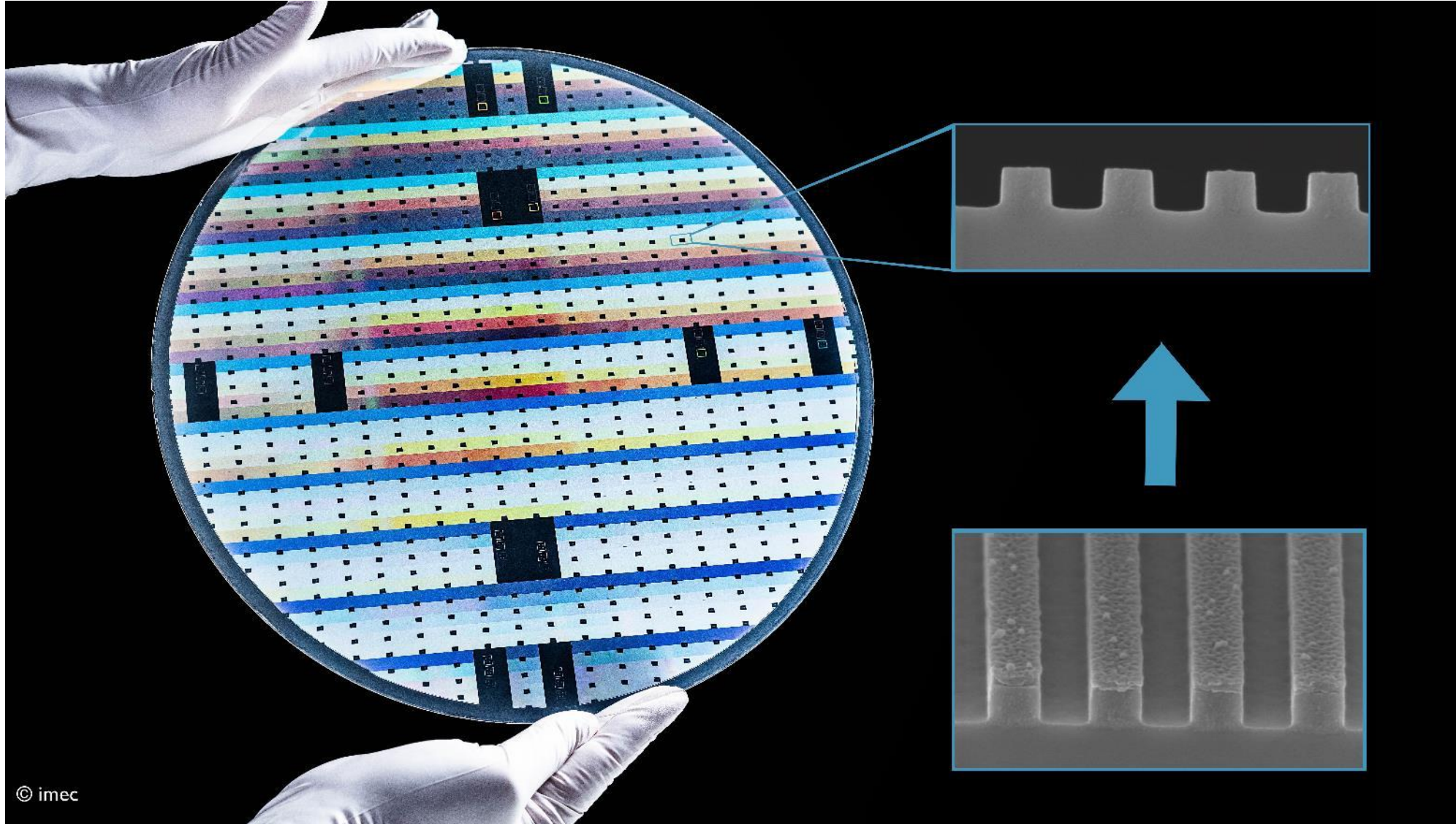
Dry etching



Dry etching + wet stripping



- Initial pattern transfer to silicon nitride on glass with etch selectivity >30:1 without the use of a hard mask.
- After optimization for uniformity, etch selectivity remains ~ **10:1** – 20:1 with <5% depth variation center-to-edge on **300 mm** substrates.



300 mm wafer  
etch into SiN for  
photonics

Courtesy of IMEC,  
Matt Traub,  
November 2024



## Negative Photoresists

### UV lithography for ...



Single Layer  
Lift-off  
ma-N 400, ma-N 1400

### UV lithography for ...



Etch mask,  
Mould for electroplating,  
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Template manufacture  
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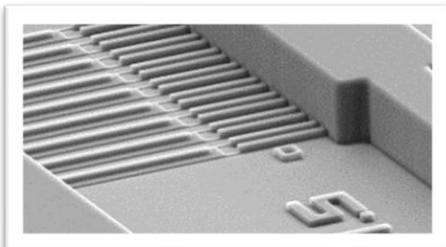


Mould fabrication,  
Stamp,  
Template manufacture  
mr-DWL  
InkEpo  
SU-8

### X-ray lithography for...

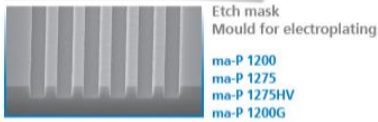


Mould for electroplating,  
Permanent applications,  
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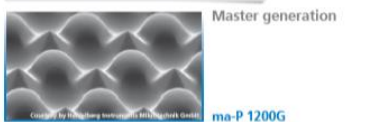
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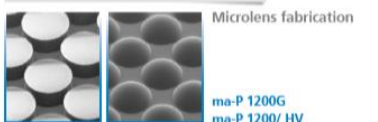
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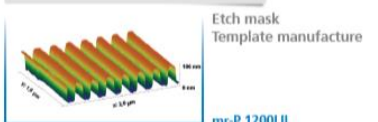
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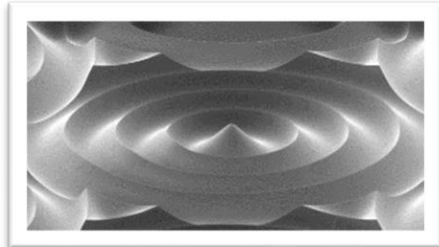


Microlens fabrication  
ma-P 1200G  
ma-P 1200/ HV

### Laser Interference Lithography



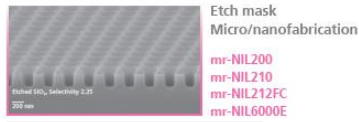
Etch mask  
Template manufacture  
mr-P 1200LIL



**HEIDELBERG**  
INSTRUMENTS

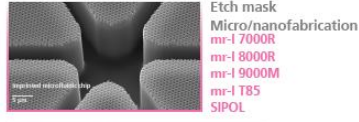
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### Working stamps

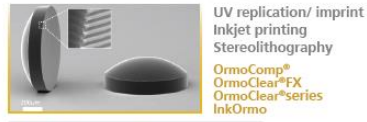


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## Hybrid Polymers

### Micro optical components



UV replication/ imprint  
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InkOrmo

### Optical waveguides



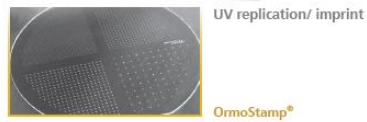
UV replication/ imprint  
UV lithography  
OrmoCore  
OrmoClad

### Bio applications

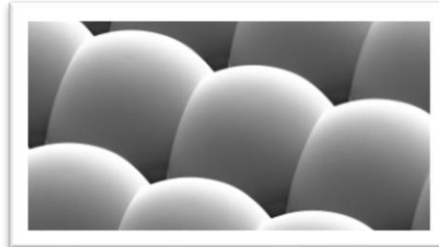


UV replication/ imprint  
Stereolithography  
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### Transparent polymer molds



UV replication/ imprint  
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HEIL-TEC TECHNOLOGY

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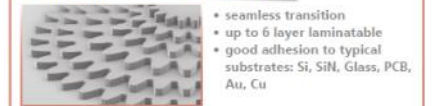
### Process Overview



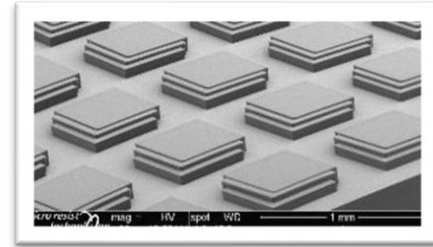
### Lithography



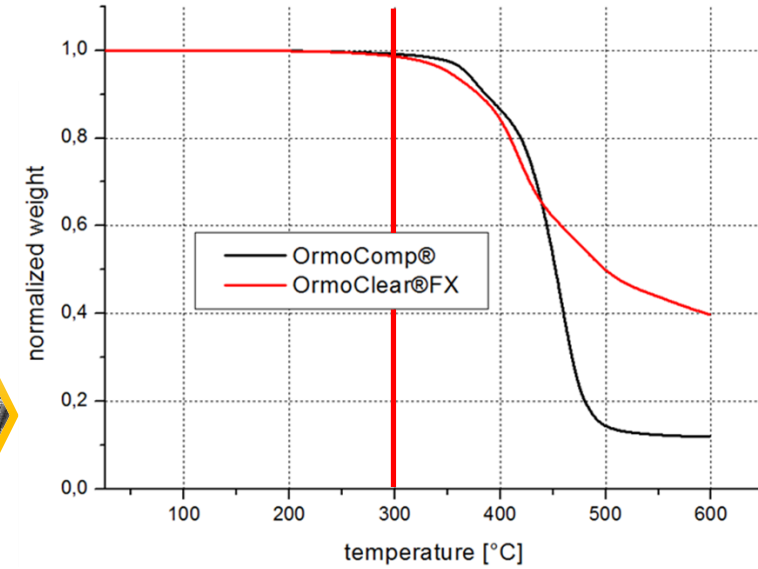
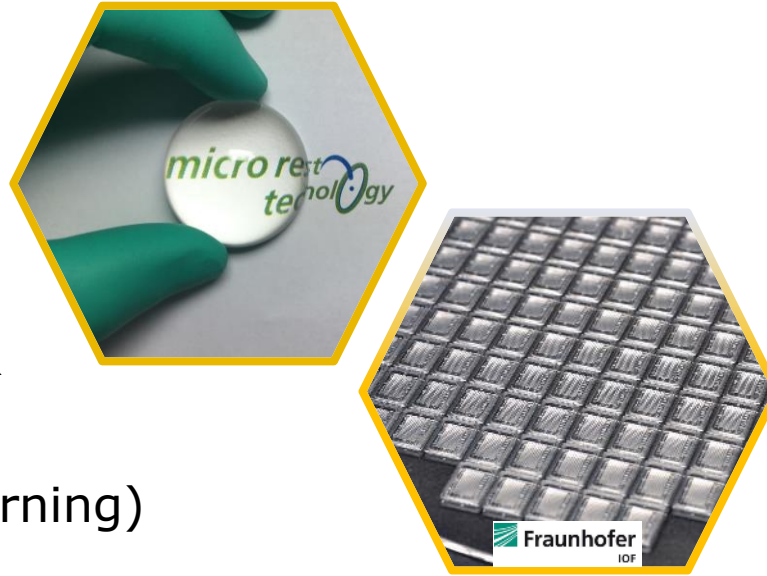
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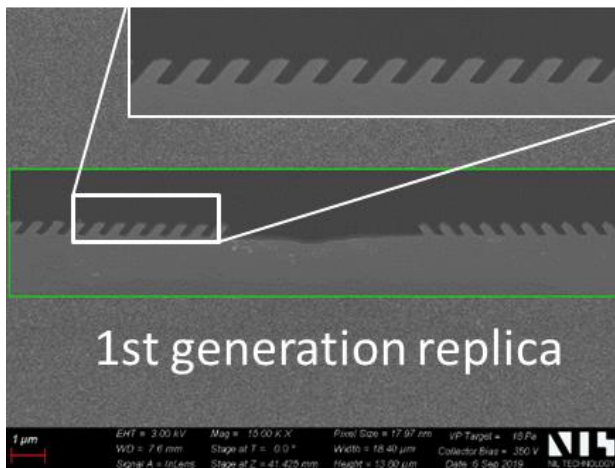
### Application: electroplating pattern



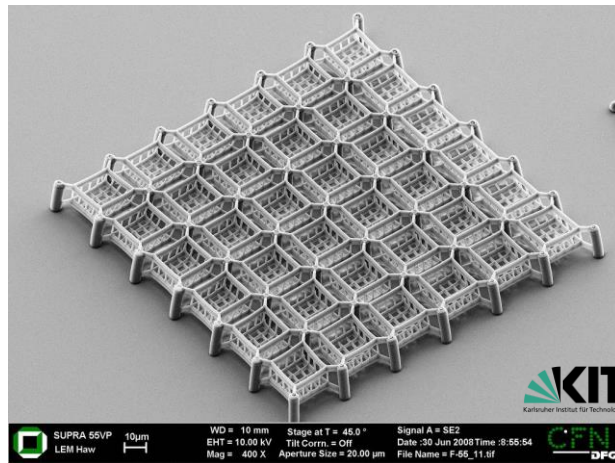
- High optical transparency
- High thermal stability (300°C)
- Sub-100nm resolution with high AR
- Large customer base (diverse patterning)



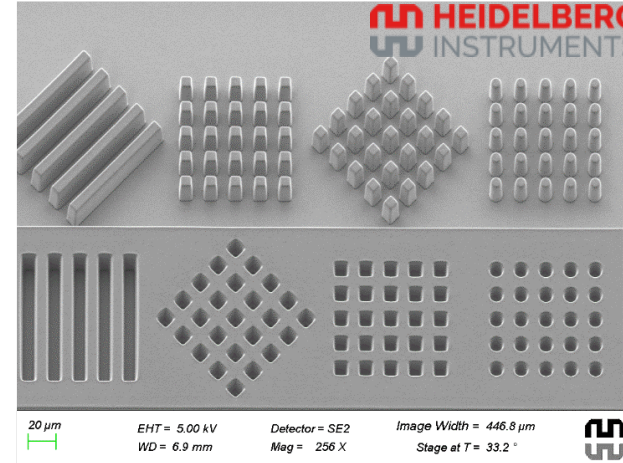
Direct imprint



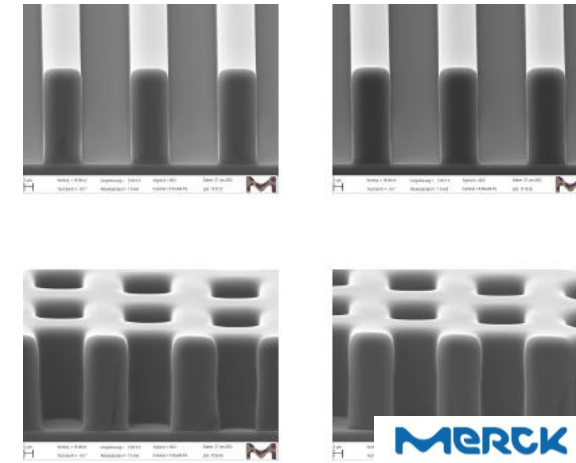
2-photon polymerization



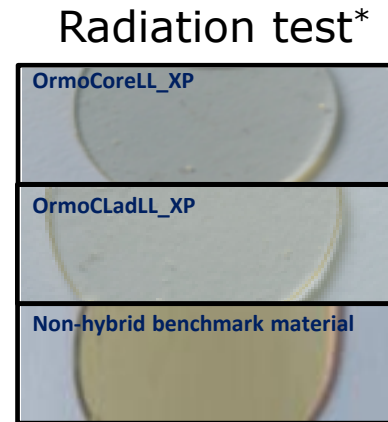
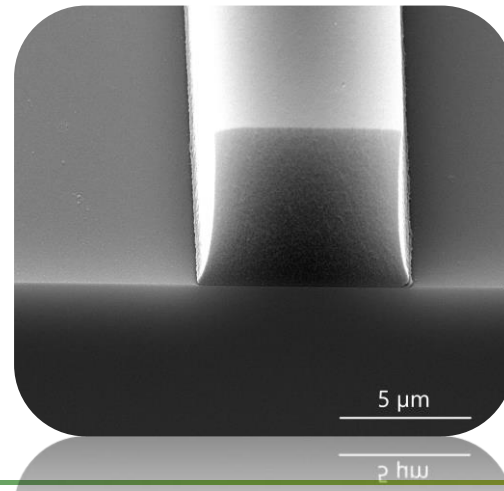
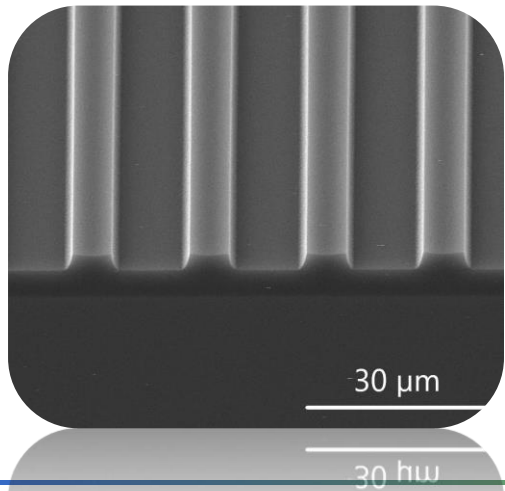
Direct laser writing



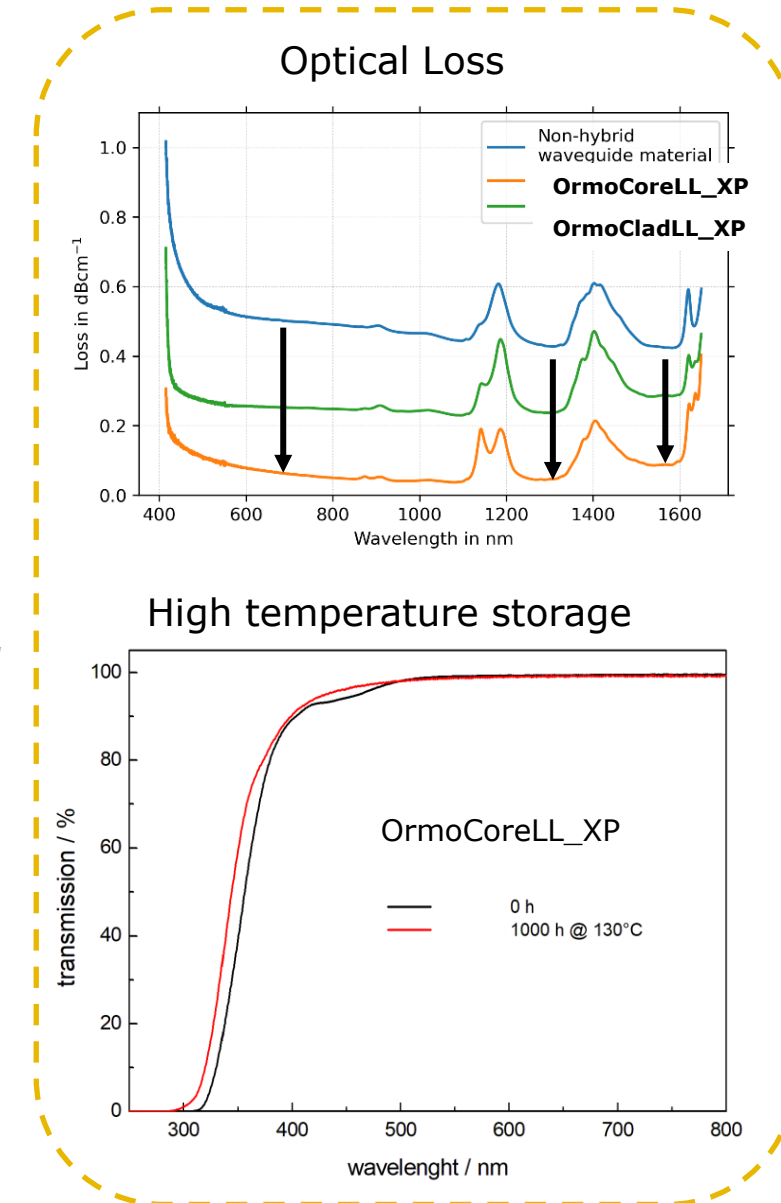
Photolithography



	OrmoClear®	OrmoCoreLL_XP	OrmoCladLL_XP
<b>Film thickness</b> range ( $\mu\text{m}$ ), 3000-6000 rpm	20-95	30-180	25-120
<b>Opt. Loss@1330/1550 nm</b> (dB/cm)	0.3/0.7	0.05/0.09	0.2/0.3
<b>%T @ 400 nm</b> (300 $\mu\text{m}$ ft)	96	96	98*
<b>n<sub>D</sub></b> (solid)	1.55	1.45	1.41



\*Hg lamp, 4h



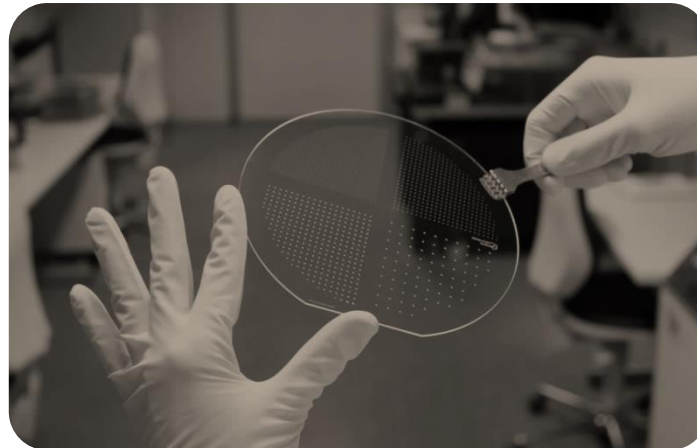
Micro- and nanopatterning techniques remains to be **versatile and diverse** for micro-electronics and photonics.

Demand on **specific resists and photopolymers (and/or systems)** continues to be high with new applications and processes to come.

MRT carries on to reach out for further **supply chain partners** in microelectronics and photonics to jointly address emerging technologies (tools, processes) and new applications (use cases).



**Technology + Material = Solution**



# THANK YOU !

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