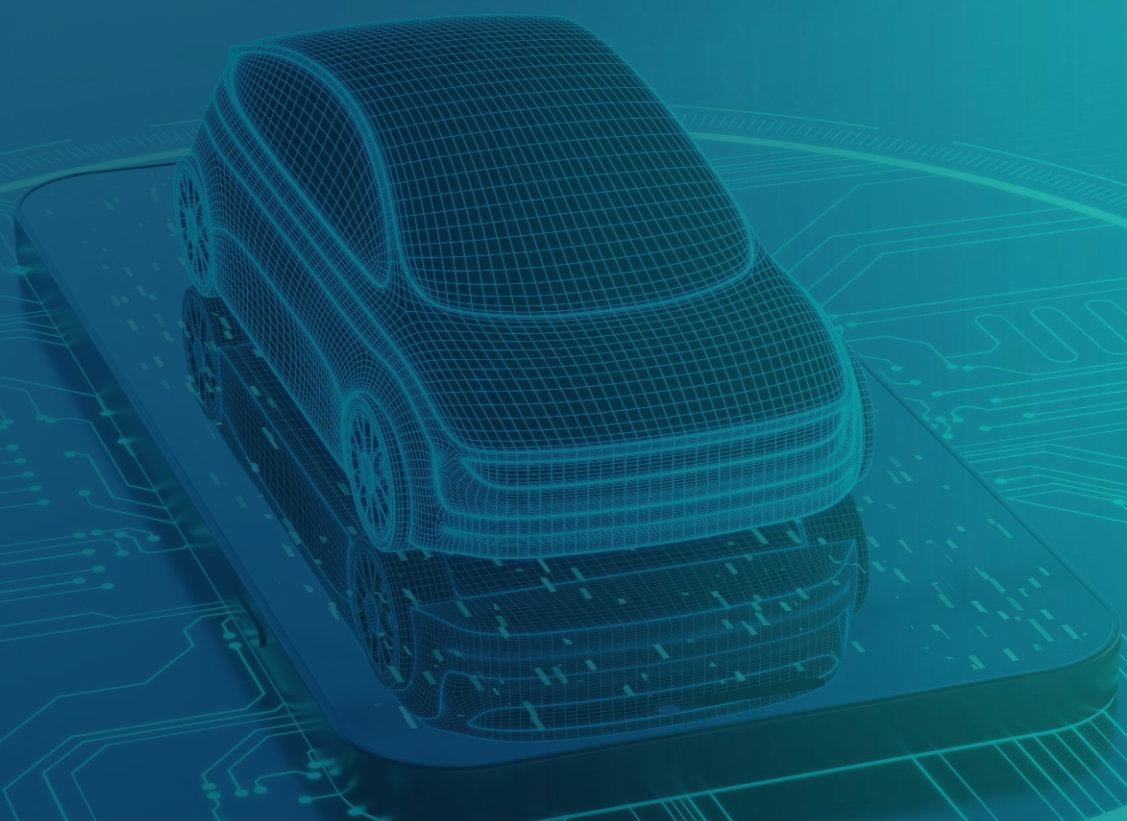




# *Optimizing AR/HR coatings for InP Edge-emitting Lasers*

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daniel.sa\_pereira@buhlergroup.com  
+49 (0) 151 72516233



# Leybold Optics at a glance



## Leybold Optics Hub – Raleigh, USA

- Machine refurbishing
- Application center

## Center of Competence – Owatonna

- Sputtering components

## Leybold Optics Hub – Alzenau, Germany

- Machine manufacturing
- Application center

## Center of Competence Leipzig

- Ion Beam figuring & trimming
- Measurement technology

## Center of Components Hasselroth

- Fabrication of key technology components

## Leybold Optics Hub – Beijing, China

- Machine manufacturing
- Application center



300 mCHF  
Turnover



650  
FTE employees  
worldwide



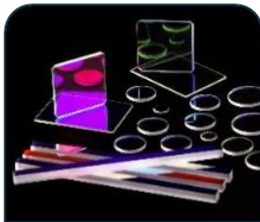
3500+  
Installed system



7%  
of turnover for  
innovation

BU Optics

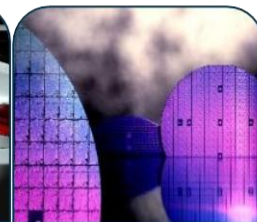
BU Energy



Precision



Automotive



Semiconductor



Consumer



Ophthalmic



Glass

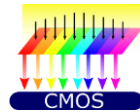


Flexible

# Leybold Optics Semiconductor

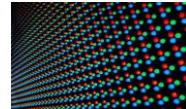
## Sensing ●●●●

Proximity Sensors, Ambient Sensors, Facial Recognition, Hyperspectral Imaging, Solid State LiDAR, CIS



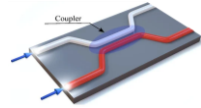
## Lighting and Display ●●

LED, microLED, VCSEL, EEL, LCoS



## Photonic Integration ●●●

PICs, Metasurfaces, Augmented Reality, Waveguides, Optical Modulators, Datacom, Diffractive Optical Elements



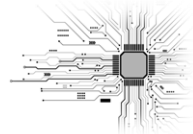
## RF connectivity ●●●

SAW/BAW filters, Wafer Bonding, POI



## Frontend Semiconductor ●●

Hard Masks, HAMR, Encapsulation, Trench Fillings, Gate Oxides



### INACO



SHINCRO

### IBS Series



### SYRUSpro Series



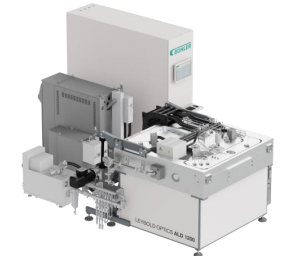
### IBT Series



### HELIOS Series



### ALD 1200



### LTE Series

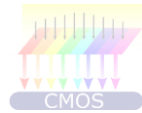


● Sputtering ● Evaporation ● Ion Beam Trimming ● Atomic Layer Deposition

# Leybold Optics Semiconductor

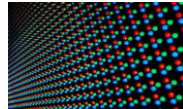
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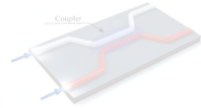
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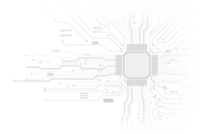
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SHINCRO

### IBS Series



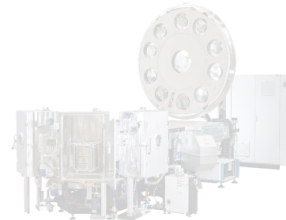
### SYRUSpro Series



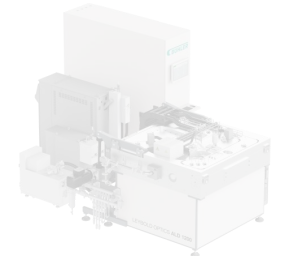
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### HELIOS Series



### ALD 1200



### LTE Series



● Sputtering ● Evaporation ● Ion Beam Trimming ● Atomic Layer Deposition

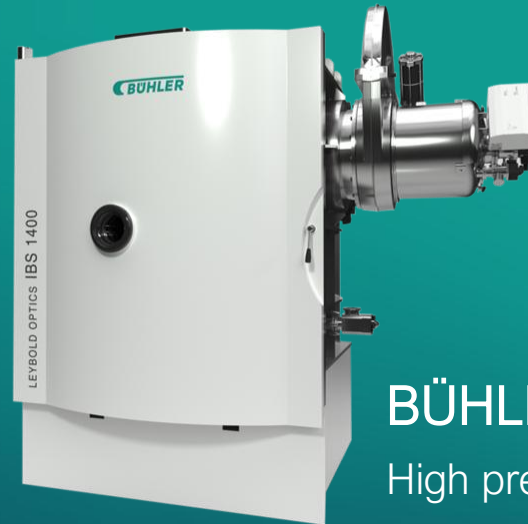
# STRATEGIC ALLIANCE

## SHINCROn | BÜHLER

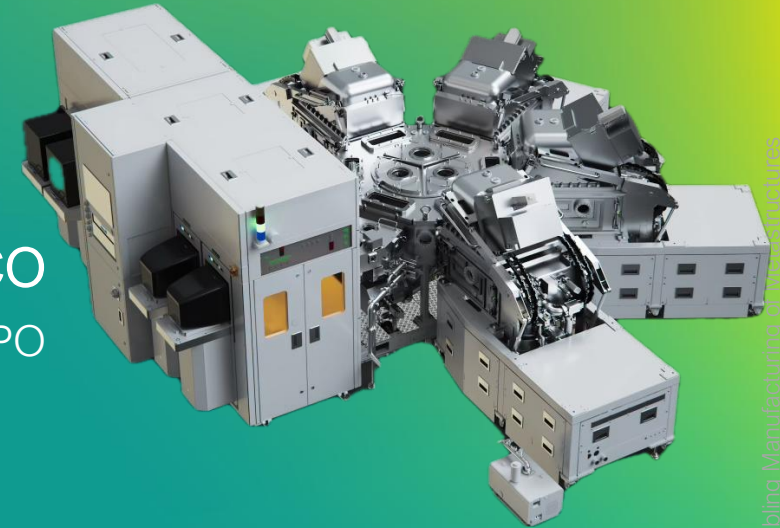
### Our shared ambition

To combine our strengths and offer customers greater access to advanced thin-film coating technologies and expertise.

Shincron's INACO  
LN homoepepitaxial growth for CPO



BÜHLER's IBS  
High precision filters on III-V semiconductor lasers



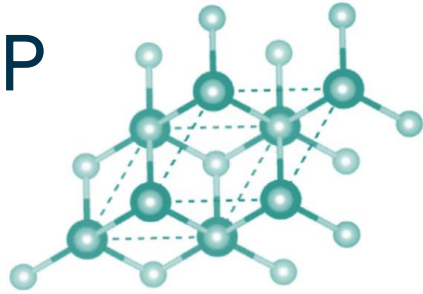
Together, we bring a broader perspective on coating and manufacturing challenges

# InP Edge-Emitting Lasers

## AR/HR coatings challenges

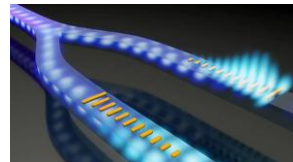
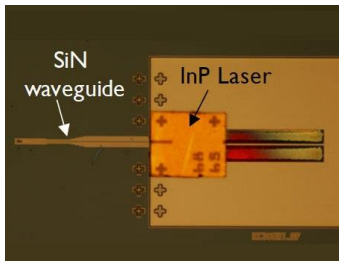
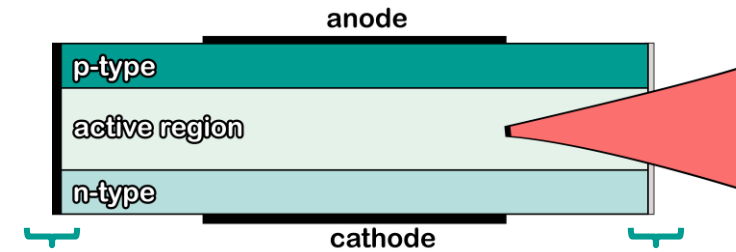


InP



### Applications (1100 – 1600 nm):

- Fiber-optic telecommunications
- Data-center optical transceivers
- Fiber-to-the-home networks
- Optical communication
- LiDAR and Sensing
- Silicon Photonics/co-packaged optics
- (...)



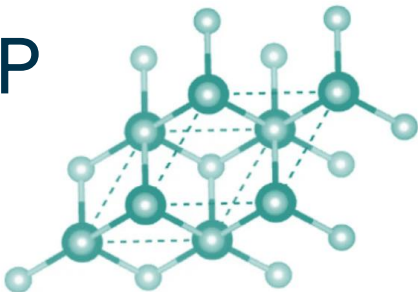
| High-reflectivity (HR) coating                | Anti-reflective (AR) coating                                         |
|-----------------------------------------------|----------------------------------------------------------------------|
| High reflectivity at target wl.<br>(R~95-99%) | Very Low reflectivity at target wl.<br>(R<0.1%, ideally below 0.05%) |
| High intracavity laser damage threshold       | High output laser damage threshold                                   |
| Low optical absorption                        |                                                                      |
| Low roughness                                 |                                                                      |
| High repeatability                            |                                                                      |
| No damage to laser diode material surface     |                                                                      |
| Good adhesion to laser diode material         |                                                                      |

# InP Edge-Emitting Lasers

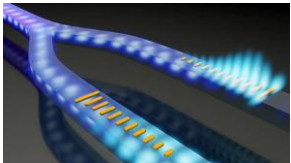
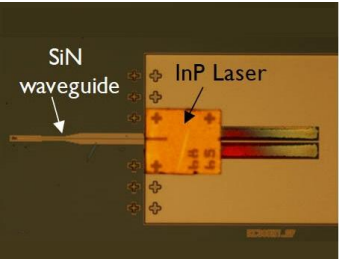
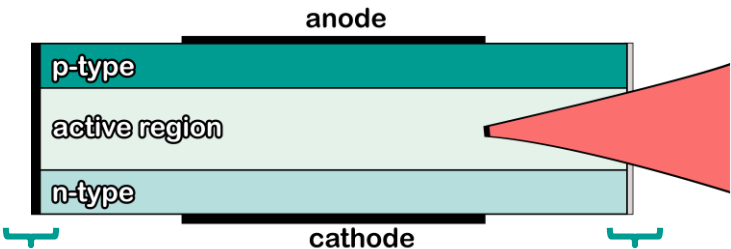
## AR/HR coatings challenges



InP

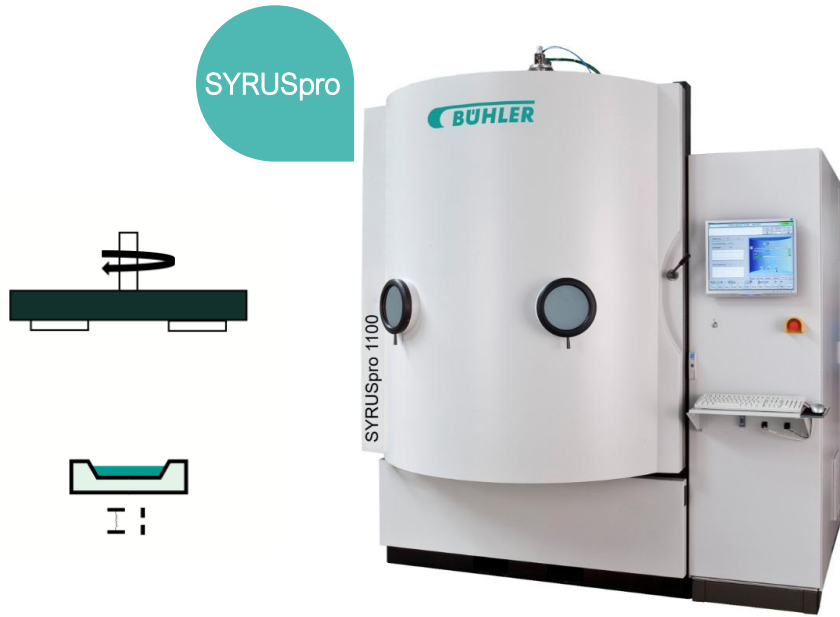


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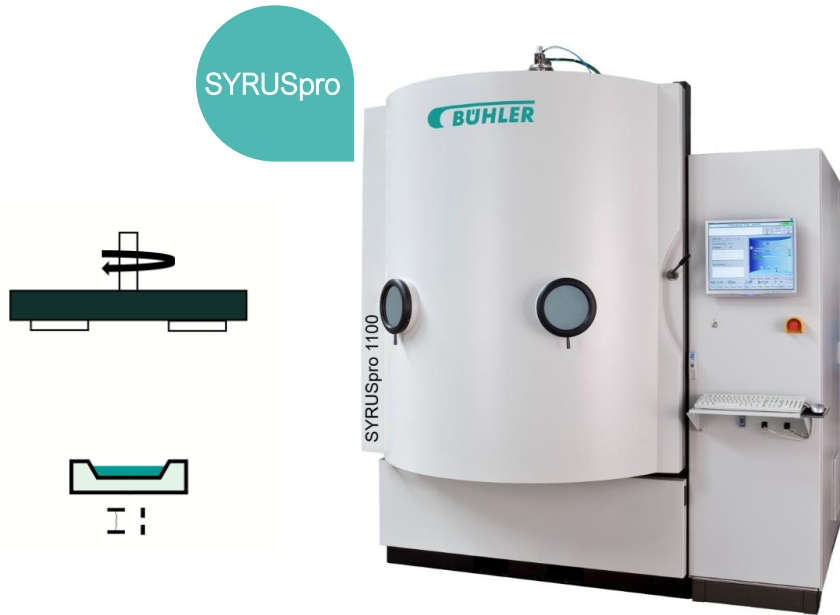
# Solutions for AR/HR coatings on EEL



## Main Features e-beam Evaporator:

- Modular batch coating system
- Multiple chamber sizes and multiple substrate fixing options for optimized throughput
- Adaptable configuration for e-beam, VTE and PIAD\*
- Flipping mechanism for consecutive AR/HR coatings

# Solutions for AR/HR coatings on EEL



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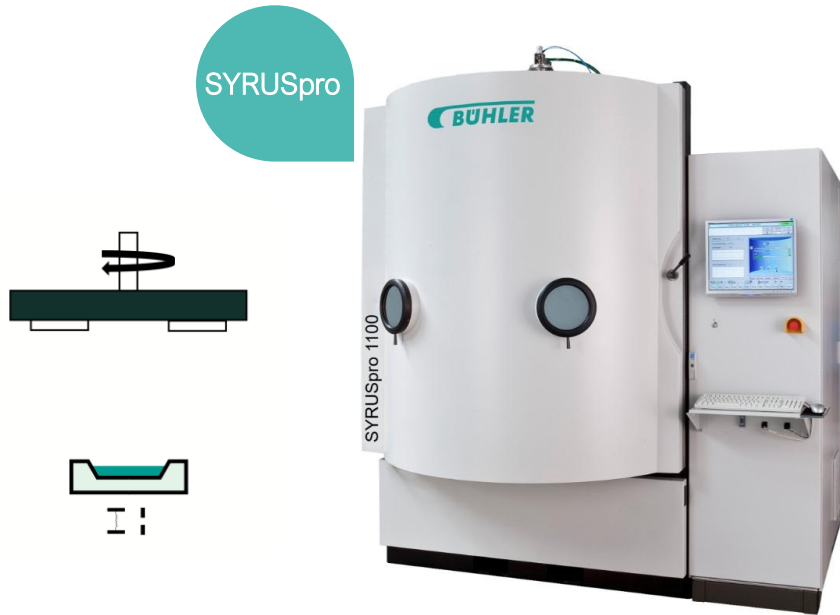
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## Main Features Ion Beam Sputtering:

- Coating of substrates up to Ø600 mm
- Various substrate holder possibilities
- Movable target tower
- RF Sputter and Assist sources
- Integrated Load Lock

# Solutions for AR/HR coatings on EEL



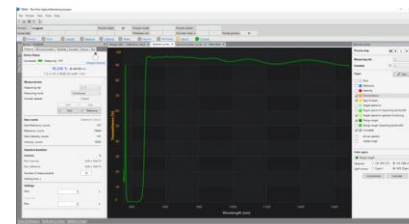
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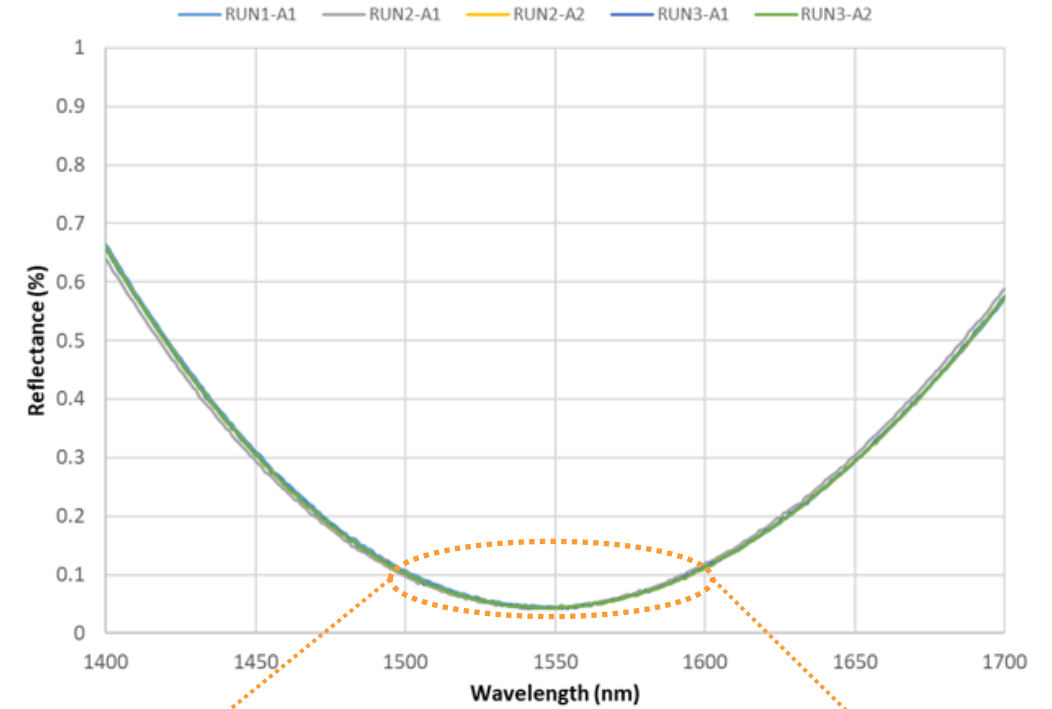


\*PIAD – Plasma Ion-Assisted Deposition; VTE – Vacuum Thermal Evaporation;

# Solutions for AR/HR coatings on EEL

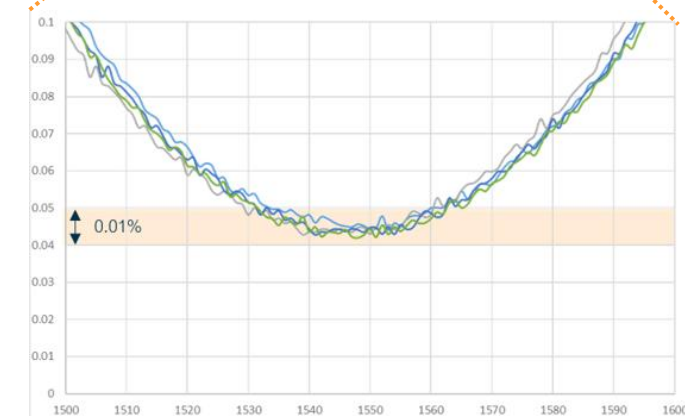


## AR performance @ 1550 nm



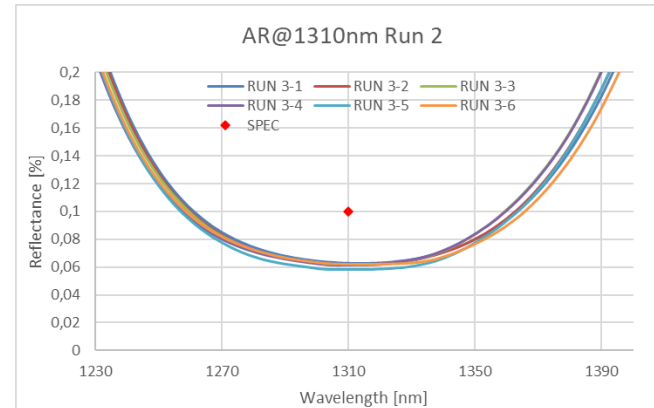
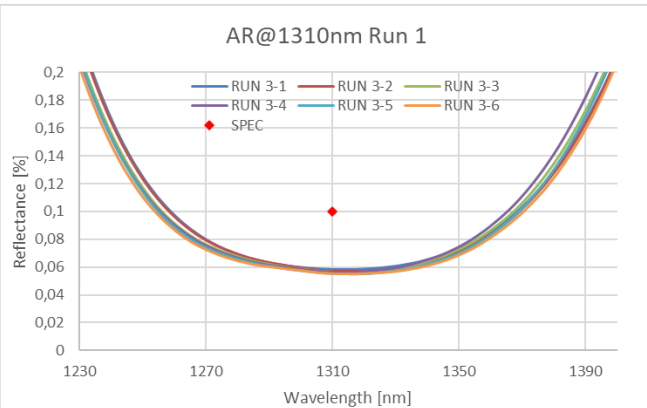
### Performance Details:

- Spectral Coating Reflectance (@ 1550nm): <0.05 %
- Spectral Reflectivity R% repeatability of <0.01% at target WL (1550 nm) over 3 runs
- Thickness Uniformity < +/-1% (within run and run-to-run)
- Optically monitored
- Simple 3-layer design



# Solutions for AR/HR coatings on EEL

## AR performance @ 1310 nm



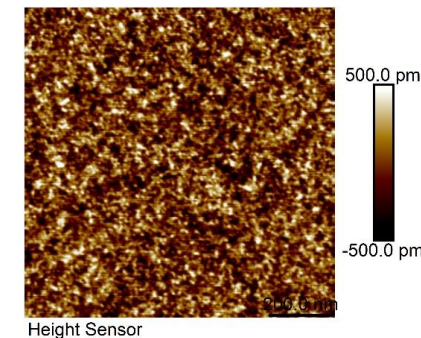
### Performance Details:

- Spectral Coating Reflectance (@ 1310nm): <0.07 %
- Spectral Reflectivity R% repeatability of <0.01% at target WL (1310 nm) over 2 runs
- Thickness Uniformity < +/-0.25 % (within run and run-to-run)
- Optically monitored
- Design based on  $\text{SiO}_2$  and  $\text{Ta}_2\text{O}_5$ , Roughness < 0.5 nm rms (single layer)
- Reduced scattering leading to increase LIDT\*

IBS

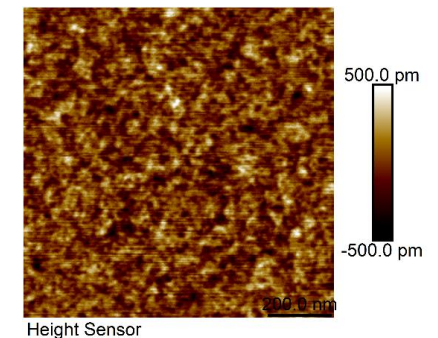


$\text{SiO}_2$



Height Sensor

$\text{Ta}_2\text{O}_5$



Height Sensor

# Conclusion

SYRUSpro



Solution for:

- Lowest cost per piece
- Highest adaptability/customizability
  - Highest material flexibility
- Low scattering and absorption
- High laser power performance

IBS



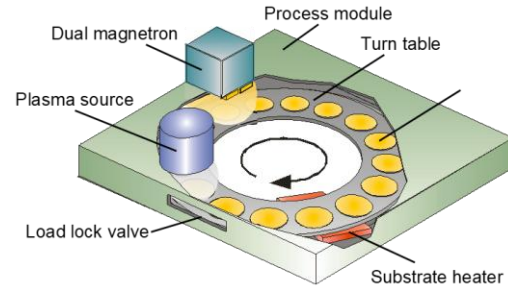
Solution for:

- Highest thickness uniformity
  - Highest film density
- Lowest scattering, absorption
  - Lowest roughness
- Highest laser power performance

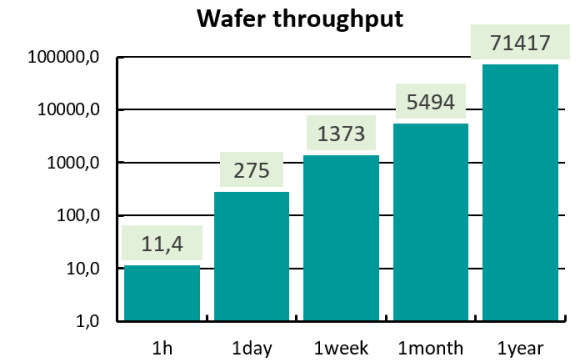
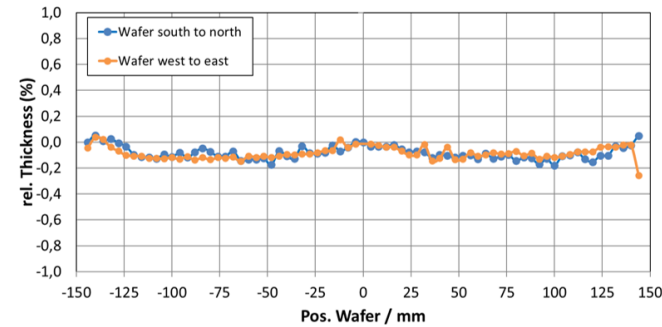
# Solutions for AR/HR coatings on EEL

## High throughput batch coating systems

### Magnetron Sputtering



### Highest Uniformity and Throughput

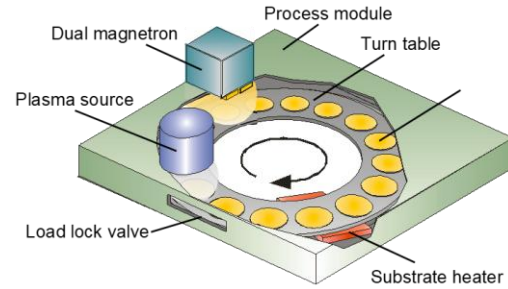


(SiO<sub>2</sub> 1250 nm thick single layer, 0.5% WiW uniformity)

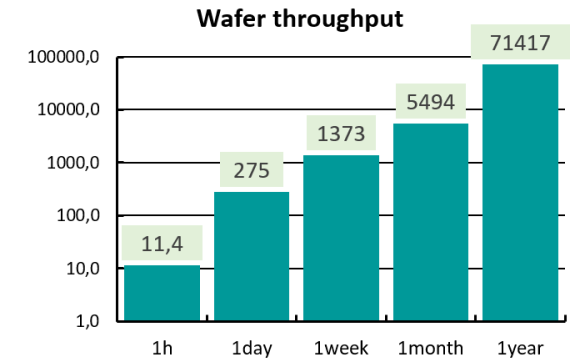
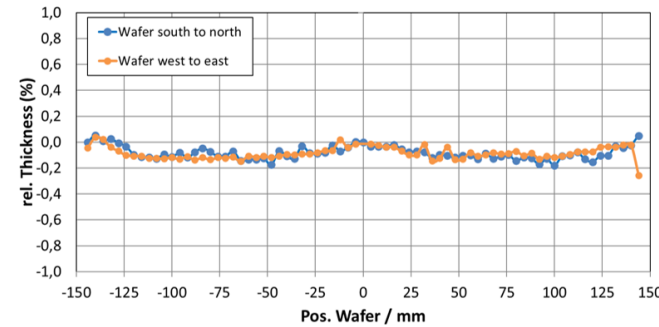
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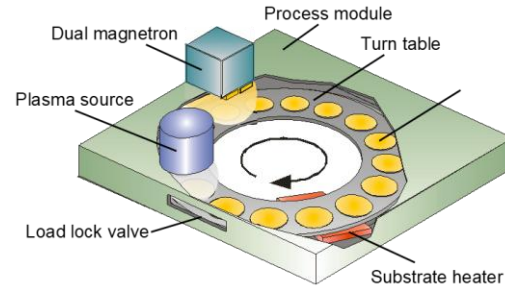
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+ Conformality? Not a problem

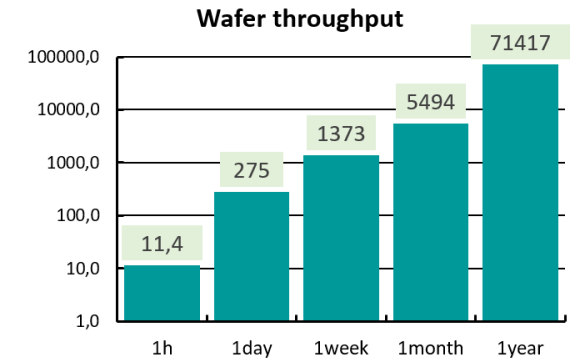
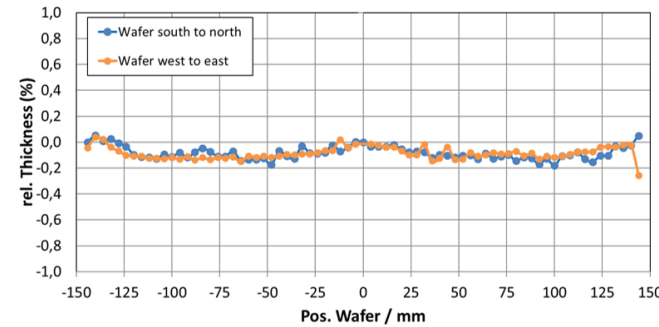
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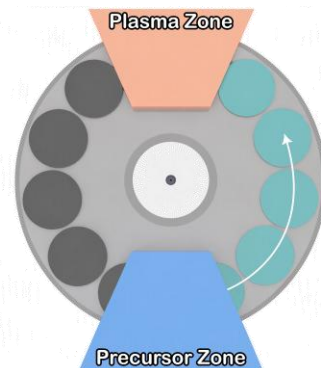
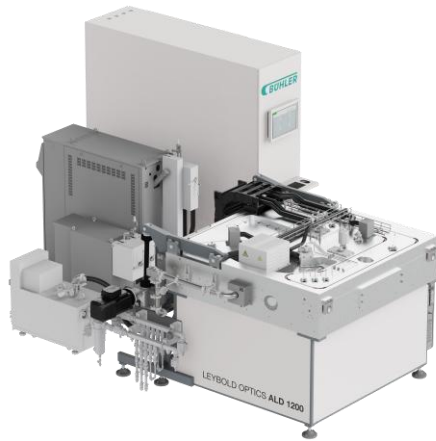


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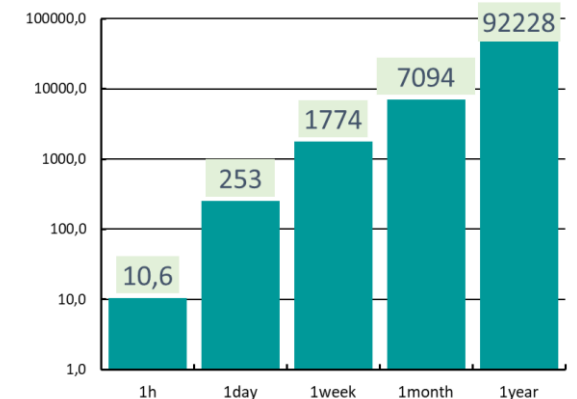
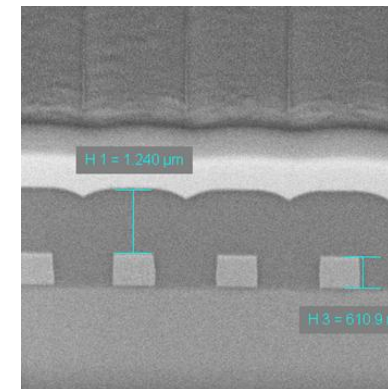


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### Spatial Atomic Layer Deposition



+ Conformality? Not a problem





Thank you for your attention

