Optical coating systems and processes

complete solution for the production of high end optical coatings

Optatec 2008, 17th June 08

Dr. Karl Matl

LEYBOLD OPTICS

Leybold Optics GmbH

LEYBOLD OPTICS - At a Glance

- Headquarters: Alzenau, Germany
- Shareholder: EQT, Sweden
- Employees: 430 (260 at Headquarters)
- Subsidiaries:
  - EUROPE: Benelux, France, Germany, Italy, Liechtenstein, Spain, Sweden, UK
  - AMERICAS: USA
  - ASIA: China, Japan, Korea, Taiwan
- Sales: appr. € 120 Mill. (2007)
- Products: Thin Film Coating Equipment and Customer Support
- Applications: Ophthalmics, Precision Optics, 3-D coatings, Web, R&D - and Special Systems (Dresden), Display, Architectural Glass, Solar (sputtering, PECVD).

Global Reach

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Germany
Alzenau-HQ

Germany
Subsidiary
Dresden

China
Subsidiary

US
Subsidiary

SYRUS*pro* – Evaporation systems portfolio

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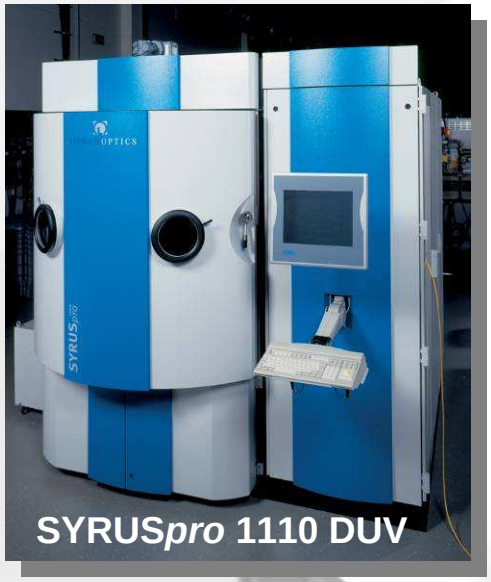
SYRUS*pro* 710


SYRUS*pro* 1110 DUV


SYRUS*pro* 1510


SYRUS*pro* 910


SYRUS*pro* 1110

Optics systems portfolio – Helios und DLCcs

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Helios – high precision sputtering system for optical coatings

DLCcs – compact PECVD – system für DLC - coatings

SYRUS*pro* - 1110

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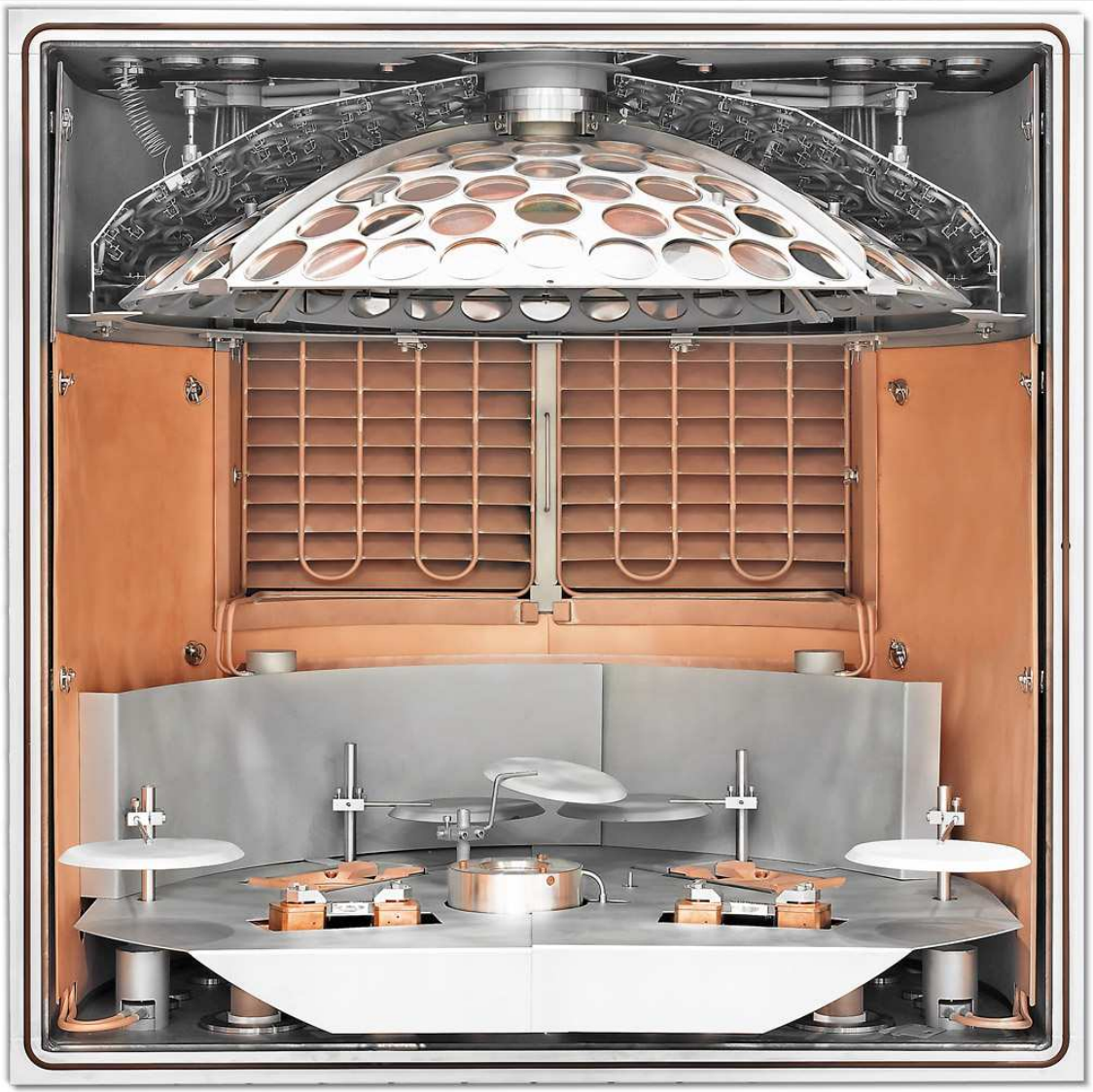
System equipment :

- Calotte system – 1000 mm diameter
- APSpro – source
- Evaporator HPE6, 2 pc
- Thermal evaporator, 2 pc
- Heater from top
- OMS - 5000



SYRUS*pro* - 1110

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APS*pro: High Output Plasma Source*

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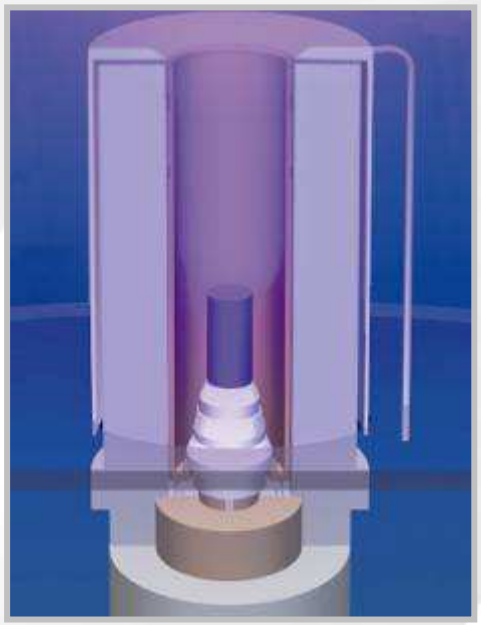
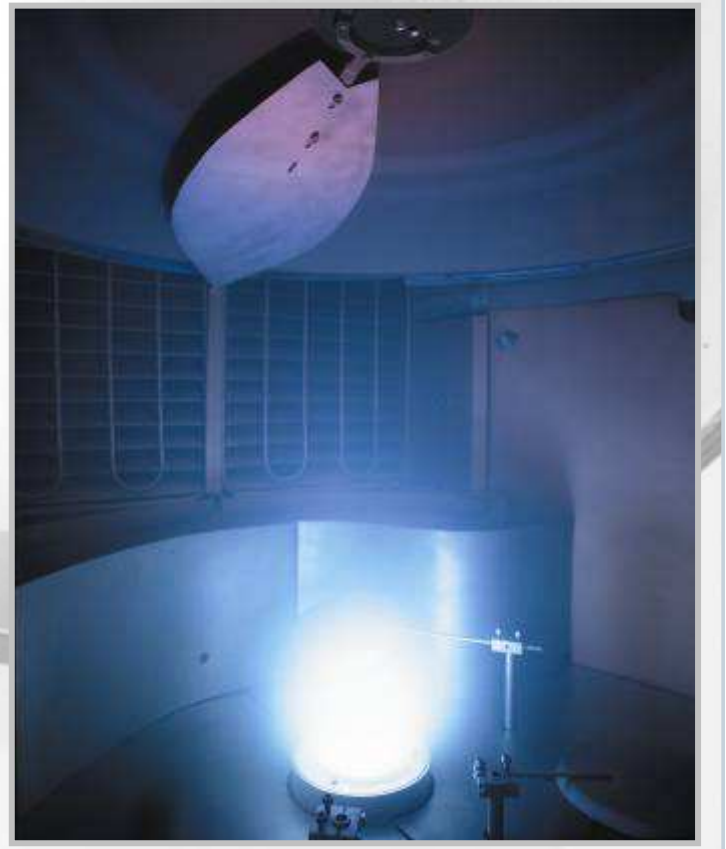
The APS*pro* - **A**dvanced **P**lasma **S**ource
for deposition of highly dense and
temperature shift-free films with high deposition rates





- Fully dense, shift-free films
- Low temperature for thermally sensitive materials
- Increased wide useful substrate area for excellent distribution over large diameters

Insitu optical monitoring – OMS 5000

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Optical in – situ – monitoring directly on calotte

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Motivation :

- **Limiting factors in production due to tooling factor between testslide and substrate :**
  - **accuracy of optical layer thickness on substrate**
  - **reproducibility from batch to batch**
- **Next step in innovation :**
  - **optical monitoring directly on the substrate on the calotte**
- **Breakthrough in accuracy :**
  - **Elimination of tooling factor by direct monitoring**

Direct optical monitoring on calotte

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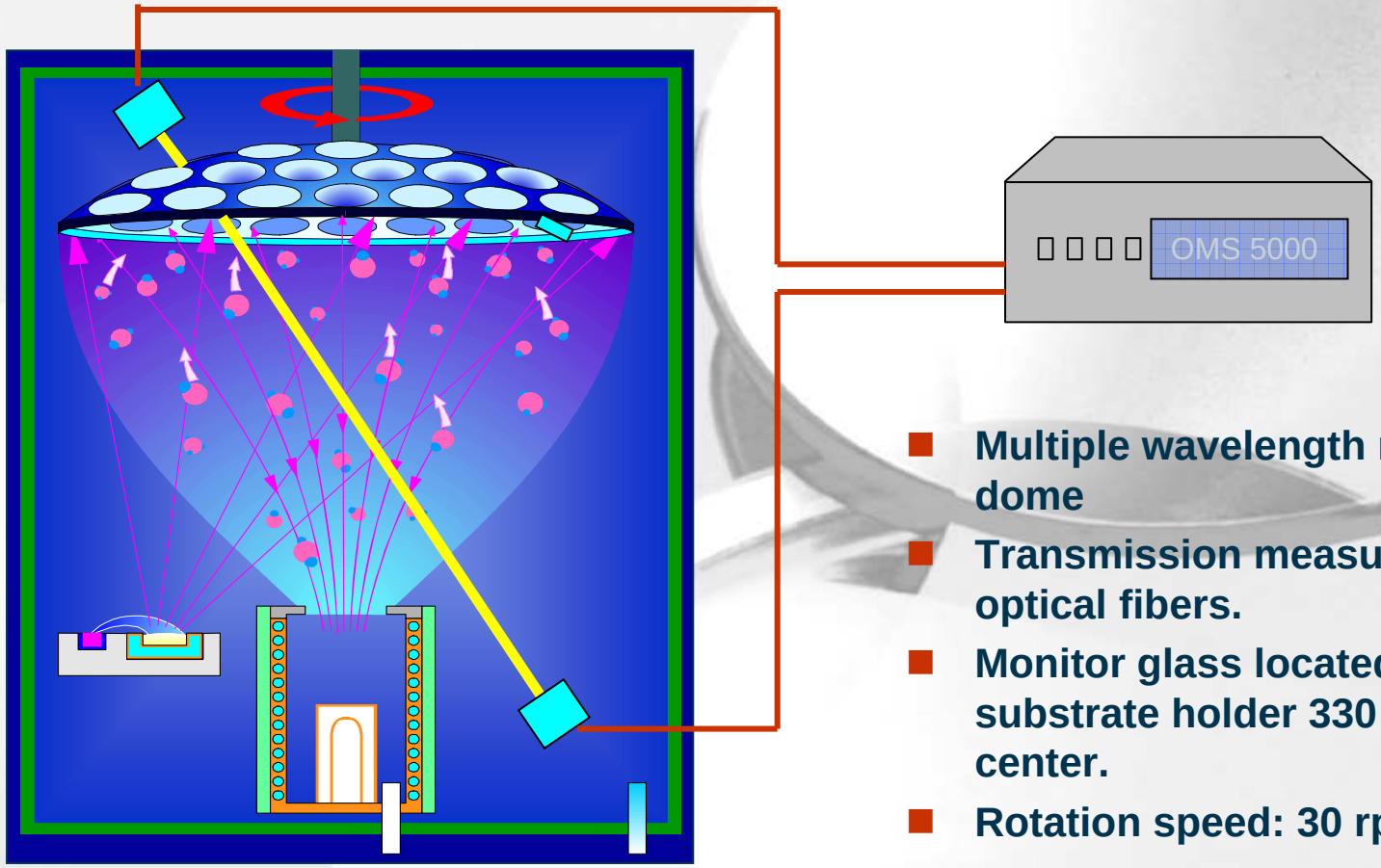
SYRUS*pro*1100 PIAD Box Coater with direct monitoring in intermittent mode



- Multiple wavelength monitoring on dome
- Transmission measurement with optical fibers.
- Monitor glass located on the substrate holder 330 mm out of center.
- Rotation speed: 30 rpm.

Direct optical monitoring on calotte, SYRUSpro 1110

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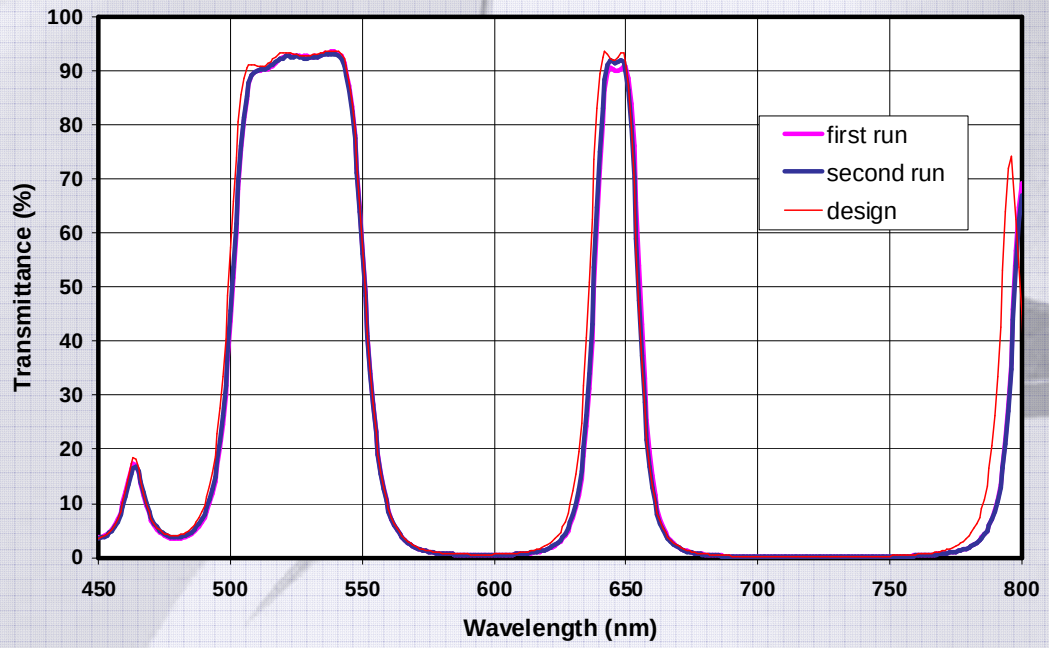
PlAD Box Coater with direct monitoring, coated as designed

Biosensor Application with TiO_2/SiO_2 (1st and 2nd Run)



Optical Performance of the monitor glasses on calotte

Direct optical monitoring on calotte, SYRUSpro 1110

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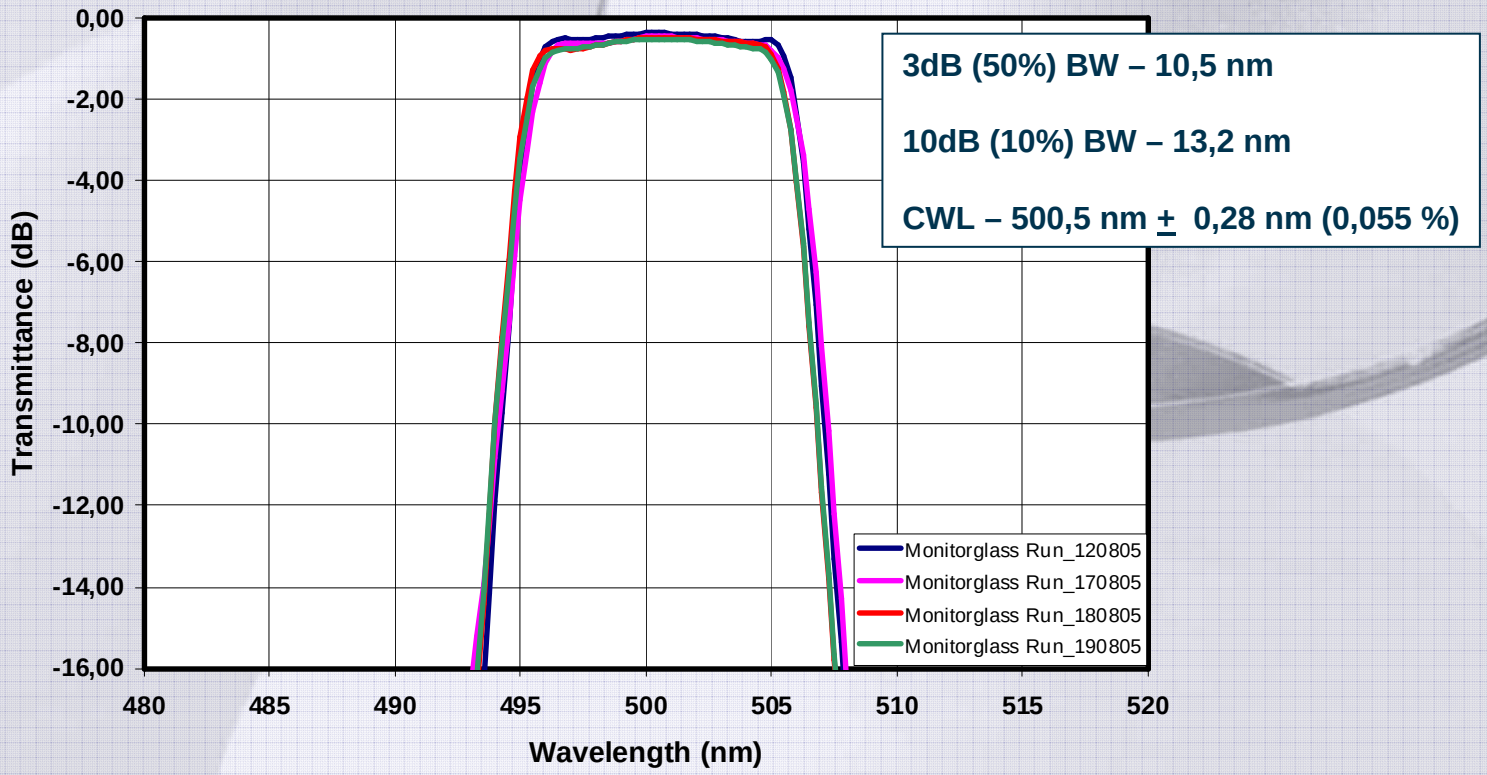
PIAD Box Coater with direct monitoring

6-Cavity Filter with TiO_2/SiO_2 (4 consecutive Runs)



Optical Performance of the monitor glasses on calotte

Direct optical monitoring on calotte, SYRUSpro 1110

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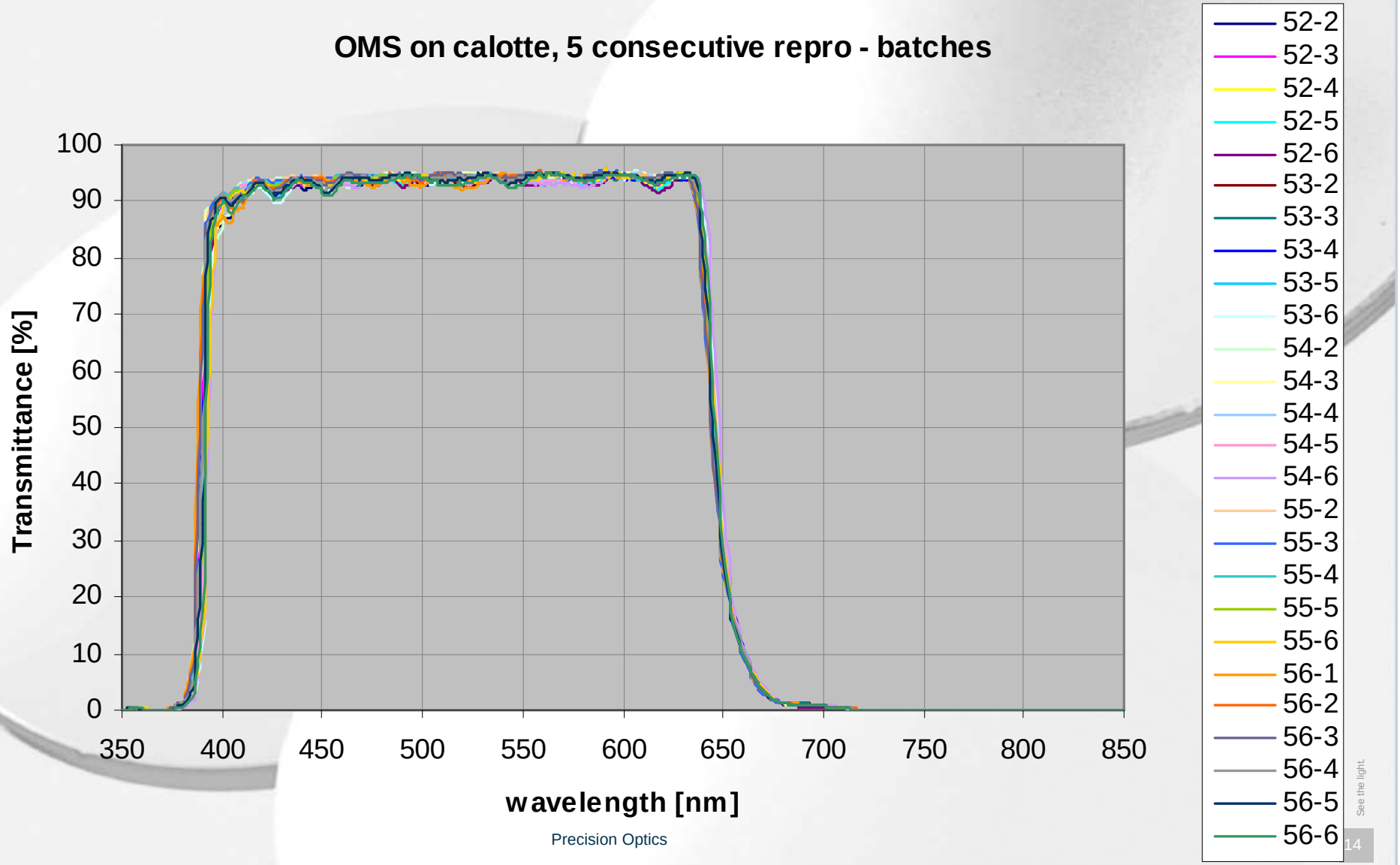
- **5 consecutive batches – all substrate positions (25)**



Direct optical monitoring on calotte, SYRUSpro 1110

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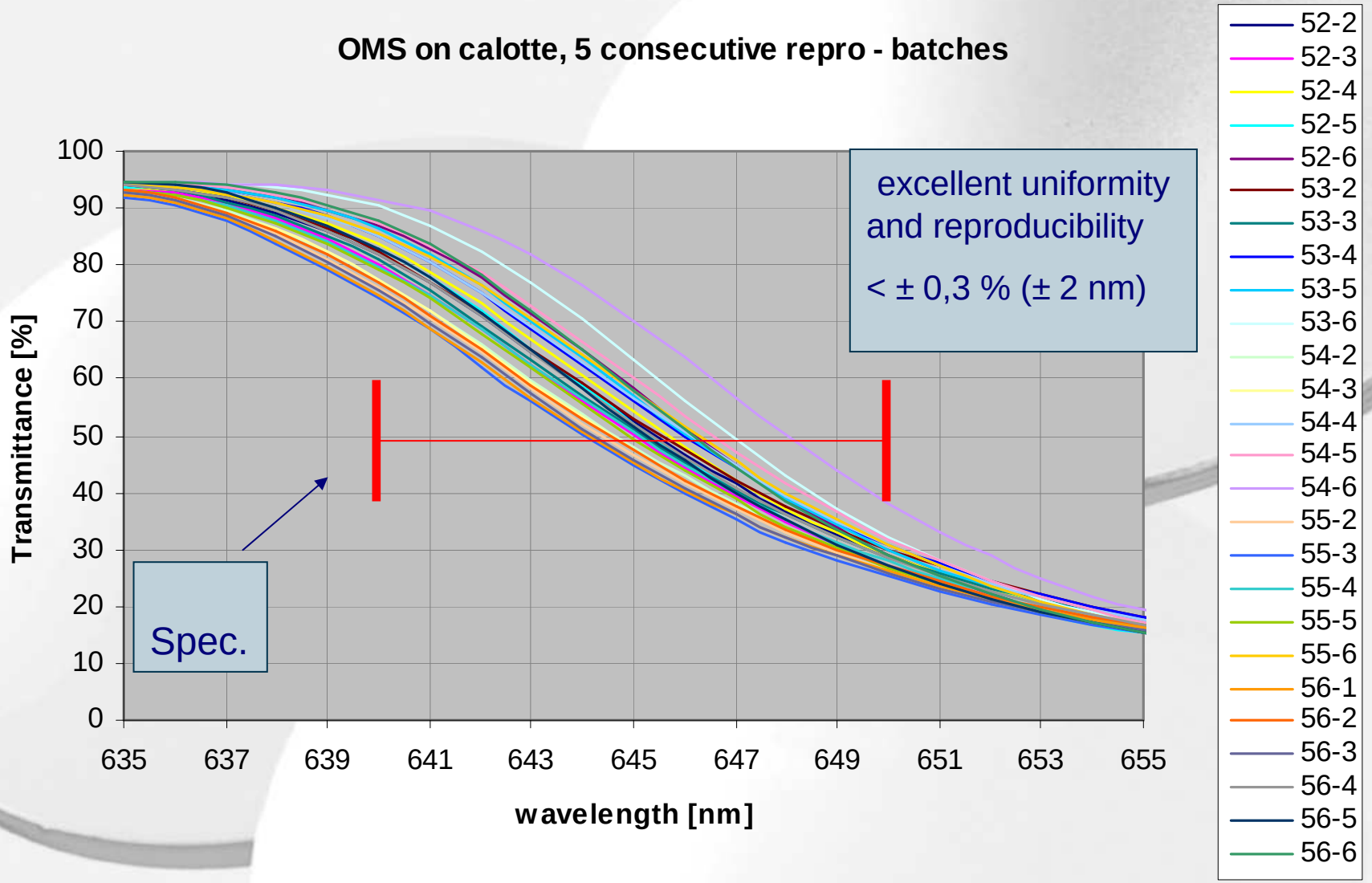
- **5 consecutive batches – all substrate positions**



Optical in – situ – monitoring - Results on full calotte

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Summary :

- Excellent reproducibility was demonstrated with direct monitoring on the testslide on calotte in a SYRUSpro 1100 PIAD Box Coater (± 0,055%, 330mm out of center).

- With direct monitoring calibration runs can be widely avoided.

- Uniformity and repeatability achieved was ± 2 nm at 645 nm (± 0,3 %) on all radial positions of a 1 m diameter calotte (for IR – cut filter, 40 layers)

- Increased production yield is expected with direct monitoring since a variable tooling factor doesn't exist.

- For optical monitoring with test slide changer, the most unsafe is the outside position with the highest number of substrates, with OMS 5000 on calotte this uncertainty eliminated

- **Direct optical monitoring on calotte with OMS 5000 opens new dimensions for accuracy, repeatability and yield in mass production**

SYRUS*pro* 1100 DUV

for 248 nm and 193 nm

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SYRUS*pro* 1100 DUV

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System equipment :

- Planetary system – 400 mm diameter planet plate
- APSpro – source
- Evaporator HPE6, 2 pc
- Thermal evaporator, 2 pc
- Heater from bottom
- OMS - 5000

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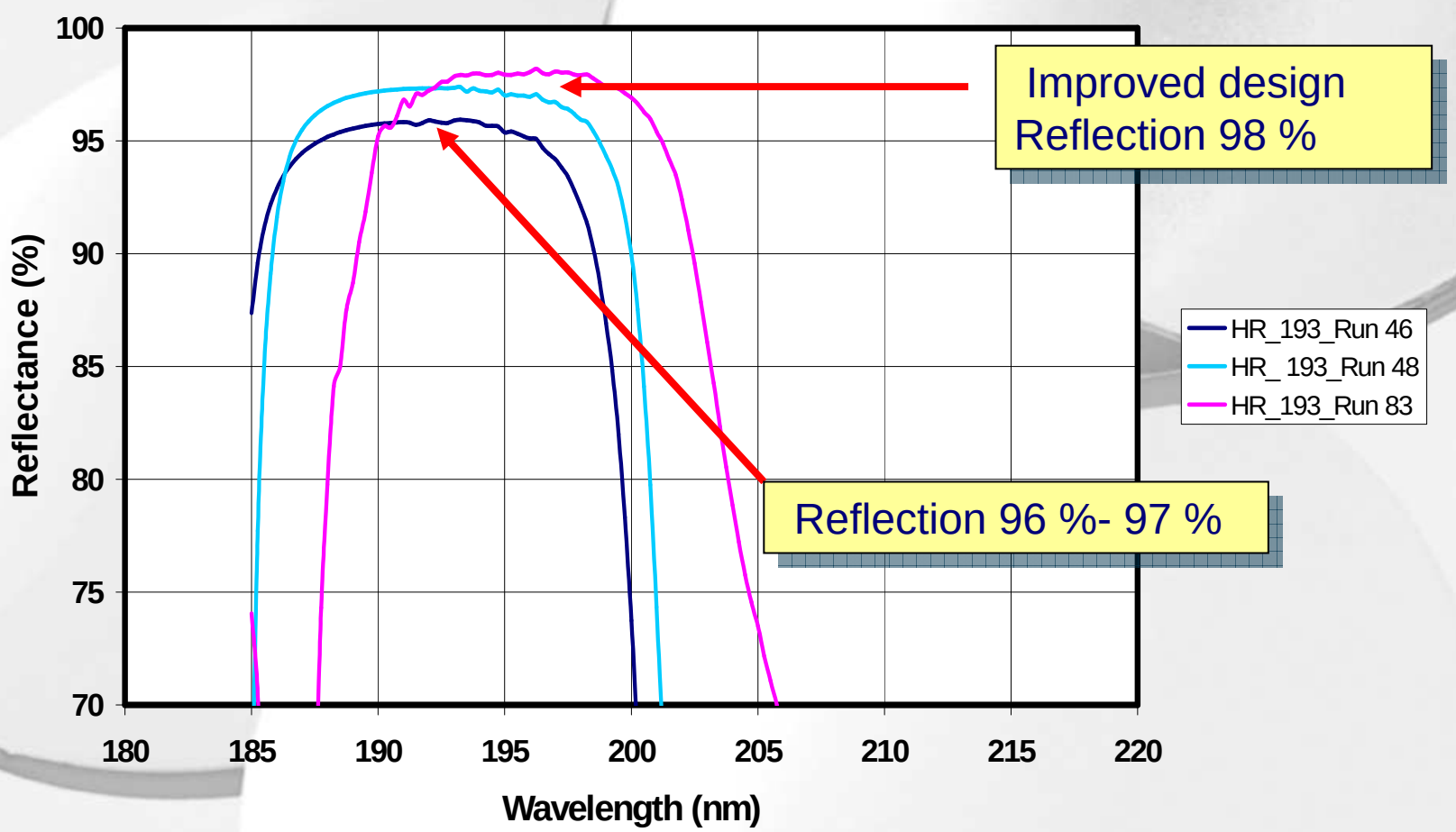
Low loss, high reflectivity and environmental stable coatings with APS at 193 nm

APS assisted DUV HR Mirror with Al2O3/SiO2



SYRUS*pro* 1510

high throughput and high precision

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SYRUS*pro* – 1510 with planetary, system equipment

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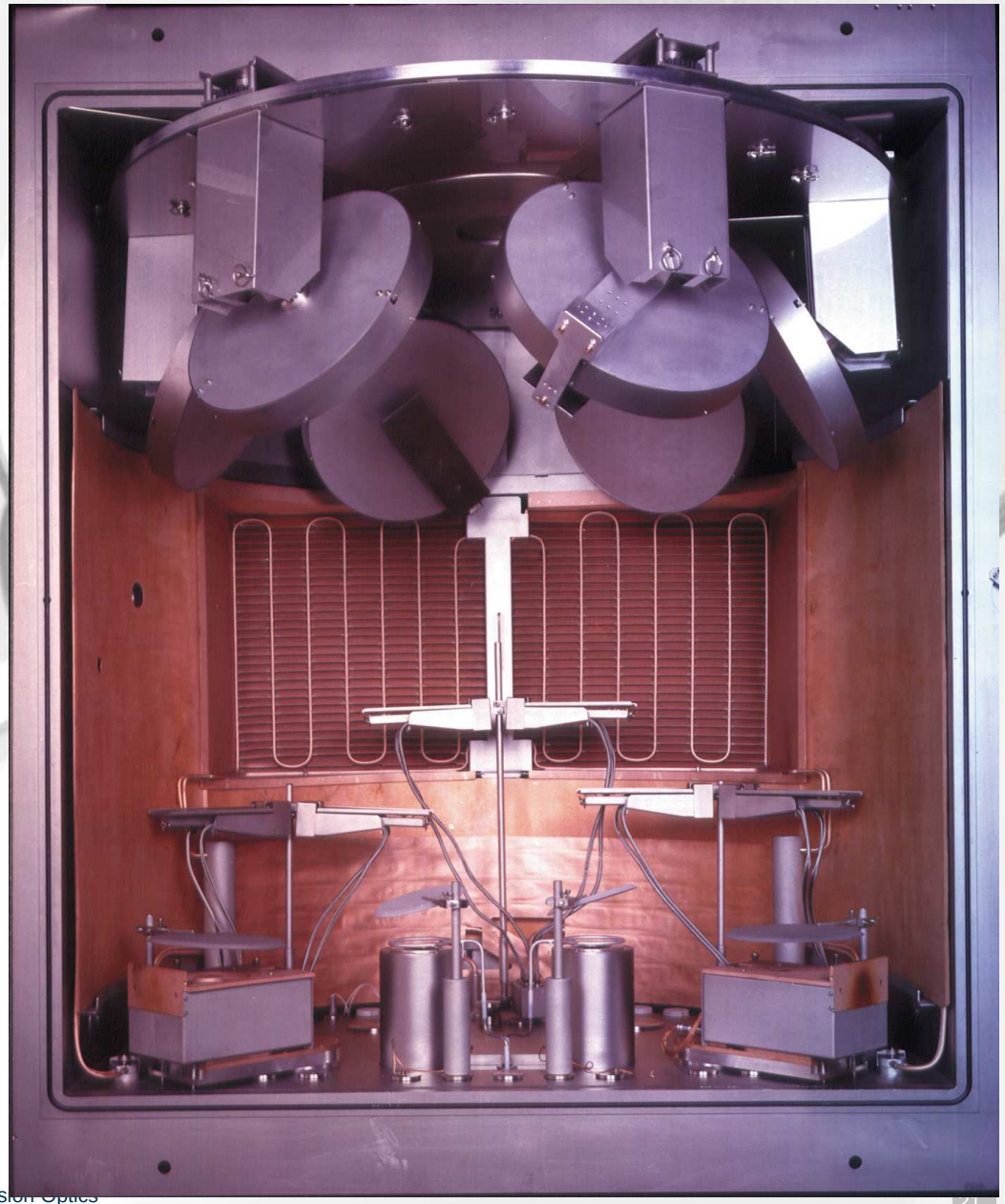
System equipment :

- Planetary system – 524 mm diameter planet plate, 6 pc
- APSpro – source, 2pc
- Evaporator HPE12/10, 2 pc
- Heater from bottom
- OMS – 5000 with testslide - changer



SYRUSpro 1510 with calotte and direct monitoring

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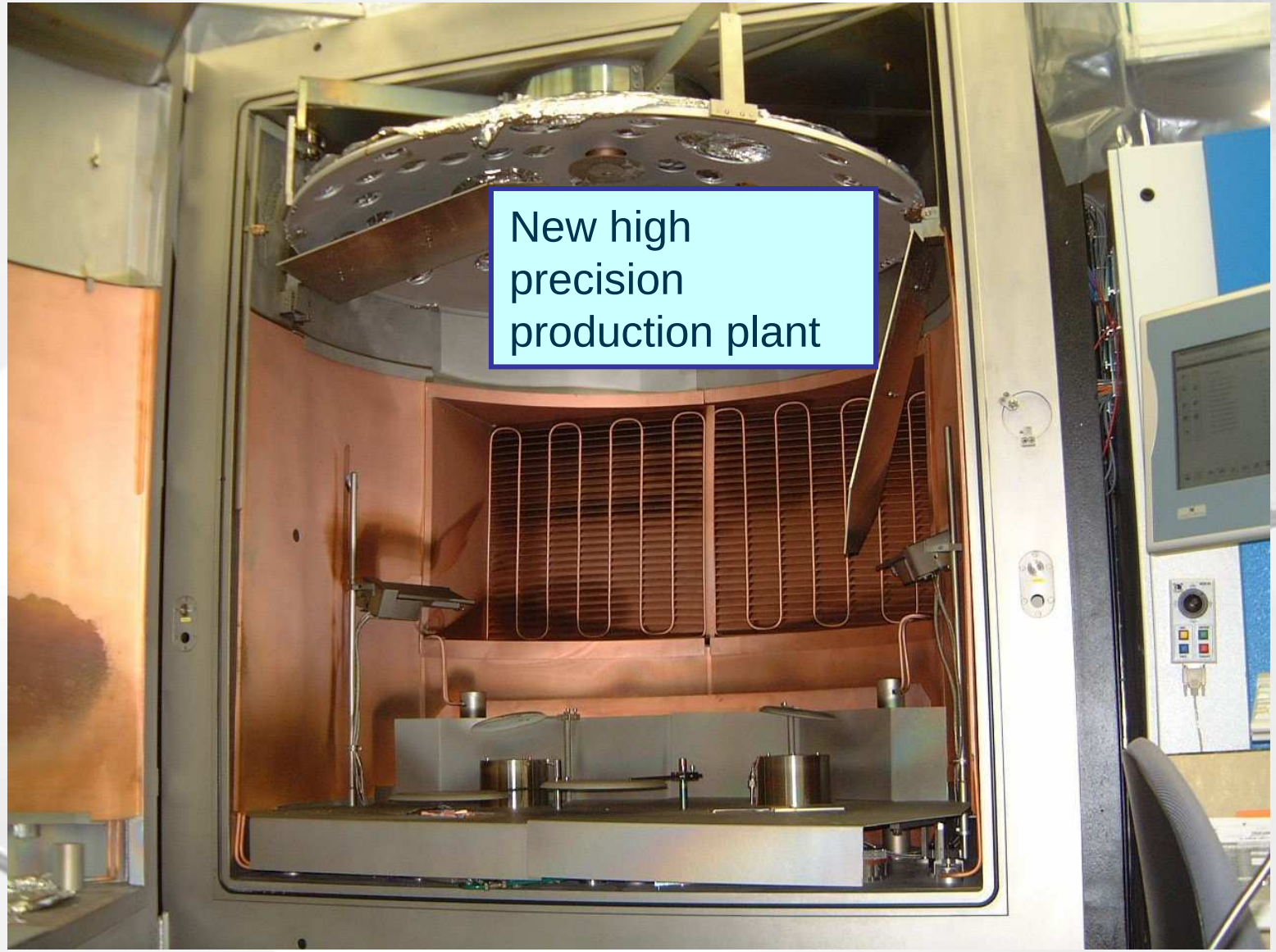

HPE 12 – new large volume e – beam gun evaporator

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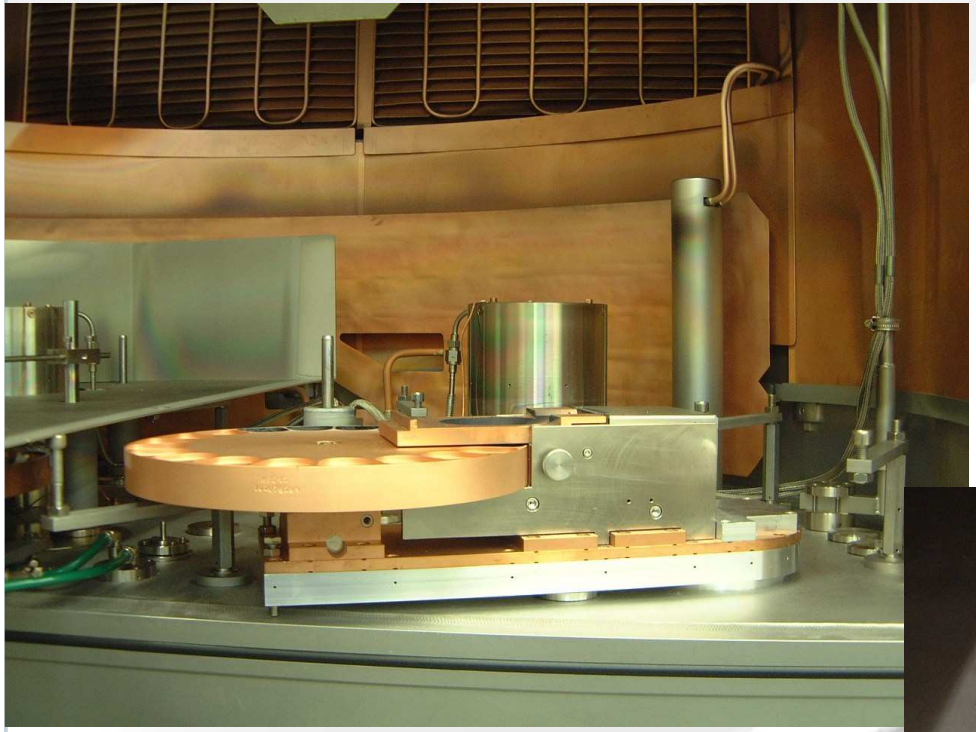
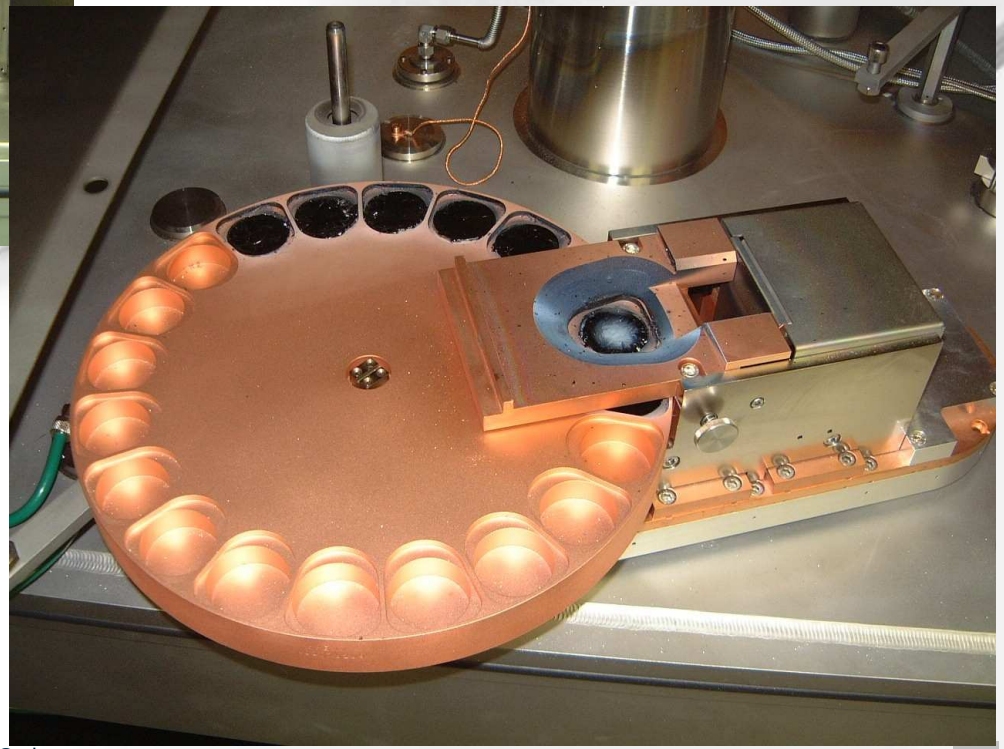


- compact design
- turnable around flange for optimum position



- high volume
  20 pockets crucible

Direct optical monitoring on calotte, SYRUSpro 1510

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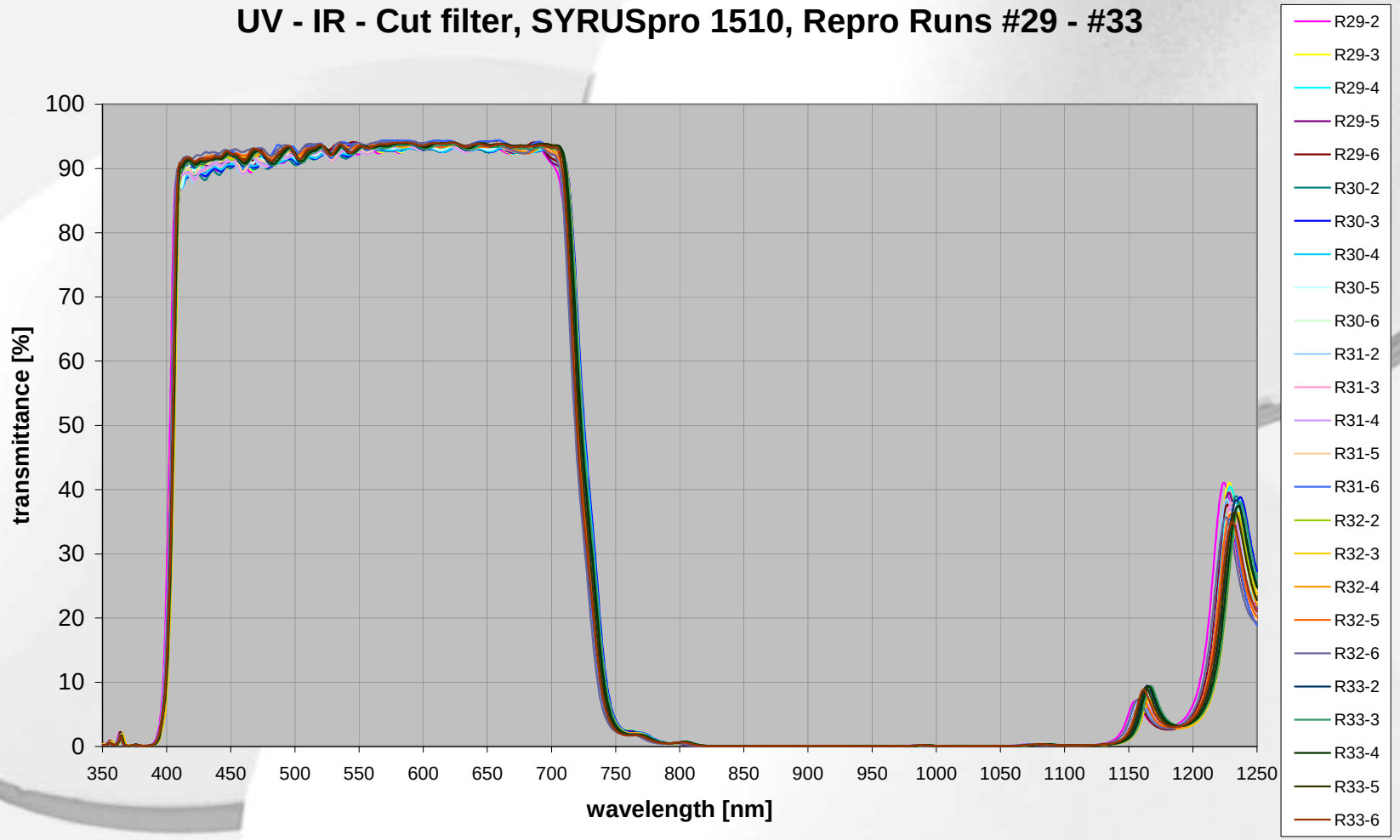
- **5 consecutive batches – all substrate positions (25)**

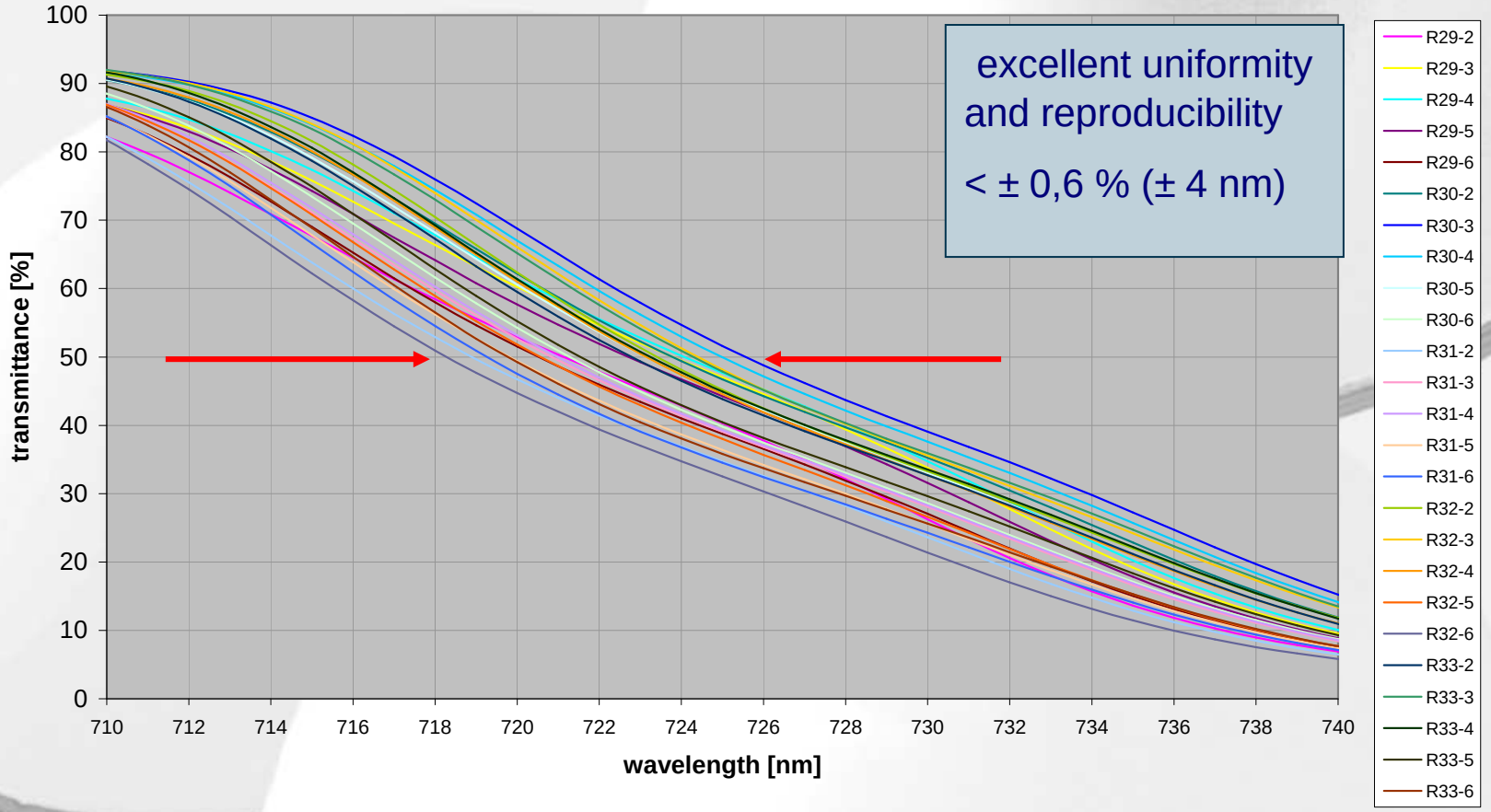


Direct optical monitoring on calotte, SYRUSpro 1510

LEYBOLD OPTICS

- **5 consecutive batches – all substrate positions**

UV - IR - Cut filter, SYRUSpro 1510, Repro Runs #29 - #33



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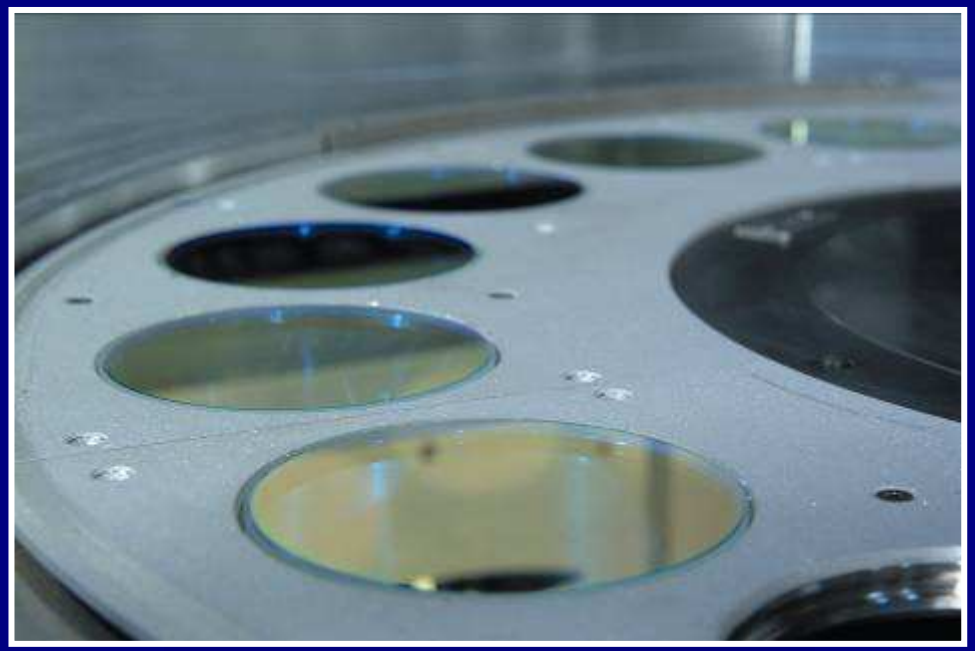
Features of SYRUSpro 1510 for shiftfree filters :

- Equipped with a full high precision calotte (diameter 1400 mm), movable uniformity masks
- New e – beam – gun evaporators HPE 12 for large volume
- Direct optical monitoring on calotte with OMS 5000 installed, for highest accuracies in repeatability and uniformity over the calotte
- APSpro plasma sources for highest deposition rates and excellent layer quality

HELIOS

High precision thin film filter production by magnetron sputtering



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HELIOS Technology

- Magnetron Sputtering with 2 MF Dual Mag
  - Plasma Assisted Reactive Process
  - Sputtering from Metal Target or DC-conducting Oxide Target
  - 1 Dual Mag for high - , 1 Dual Mag for low Index material
  - Co-sputtering with 2 Dual Mag for medium indices
- Dynamic Deposition on rotating Substrate Turn-table
- In-situ direct on Substrate Optical Thickness Control
- Load Lock with automated Single Substrate Handling System

HELIOS – Service Position Production Tool

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- **Helios with automated single substrate load lock**

  - Door in service position for cleaning, shutter open

HELIOS – Service Position Production Tool

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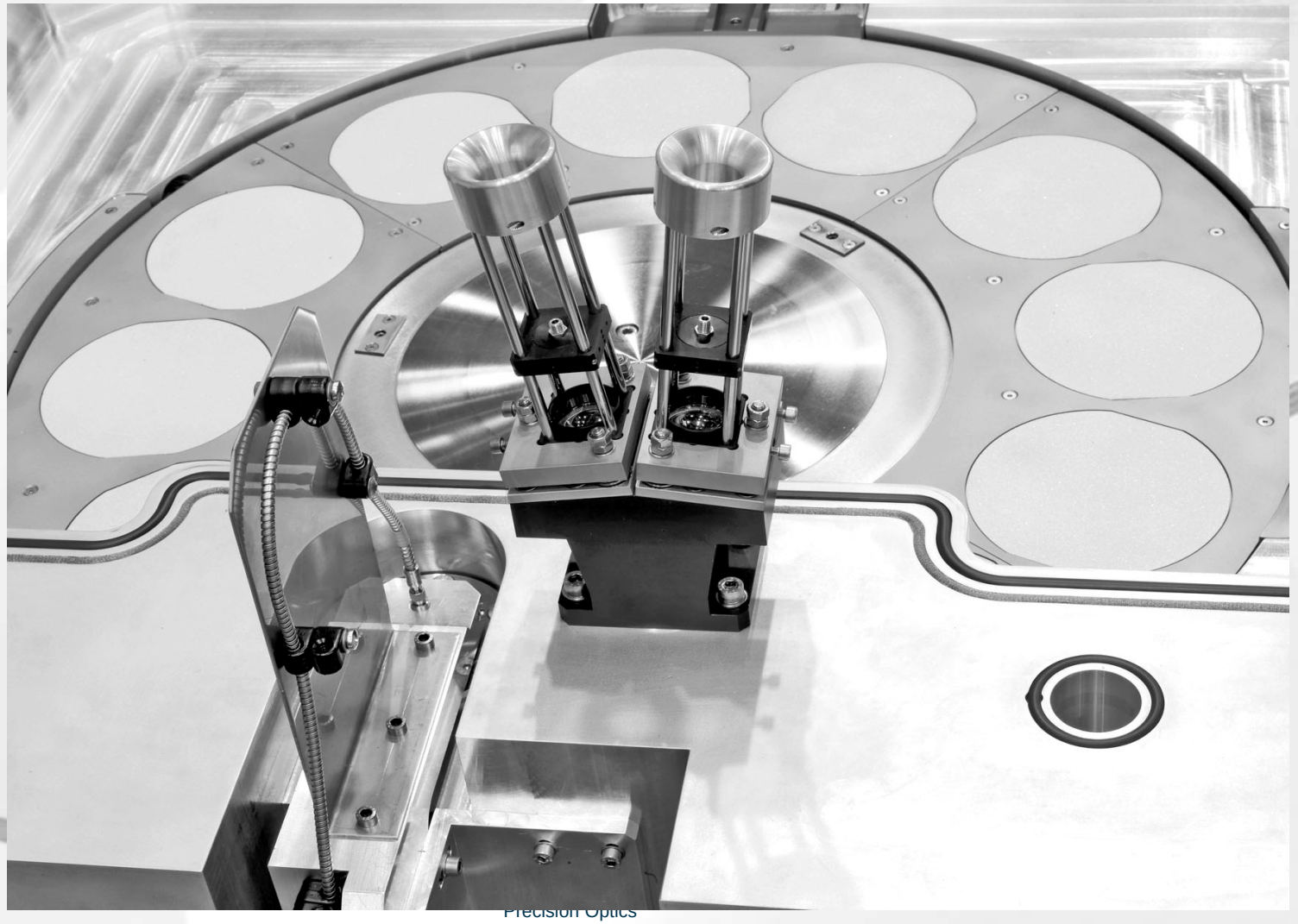
- **Helios with automated single substrate load lock**

  - substrate holder and OMS 5000 in transmission and reflection



HELIOS – Service Position Production Tool

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- **Helios with automated single substrate load lock**

  - view into the load lock with single substrate holder

Principle of PARMS

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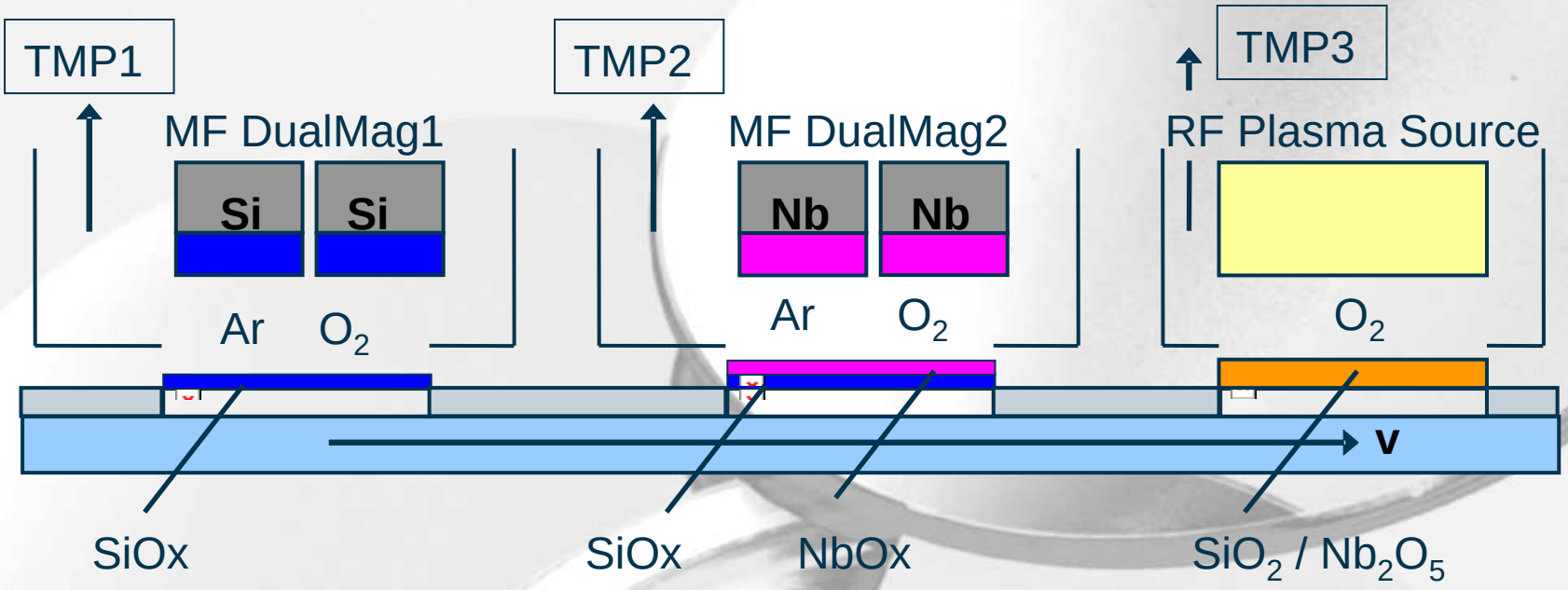
- **Reactive Assist Process with RF – Plasma Source**



1.	**Thin layer/rotation**	**Thin layer/rotation**	**Thin layer/rotation**
	(SiOx, absorbing)	--------	(SiO_2, **non** absorbing)
	:		
N1.	**Final thickness of SiO_2 single layer**		
2.	---------	(NbOx, absorbing)	(Nb_2O_5, **non** absorbing)
	:		
N2.	**Final thickness of Nb_2O_5 single layer**		
	:		

HELIOS – Single layer Results

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- **Layer Results**

  - Optical properties, surface roughness and dynamic deposition rate of 500 nm thick single layers.

Material	Ref. index n @ 550nm	Roughness RMS [nm] (Si 0.1)	Rate [nm/s]
SiO_2	1.485	0.36	0.45
Ta_2O_5	2.17	0.21	0.6
Nb_2O_5	2.37	0.25	0.55

HELIOS – Results with Lab HELIOS

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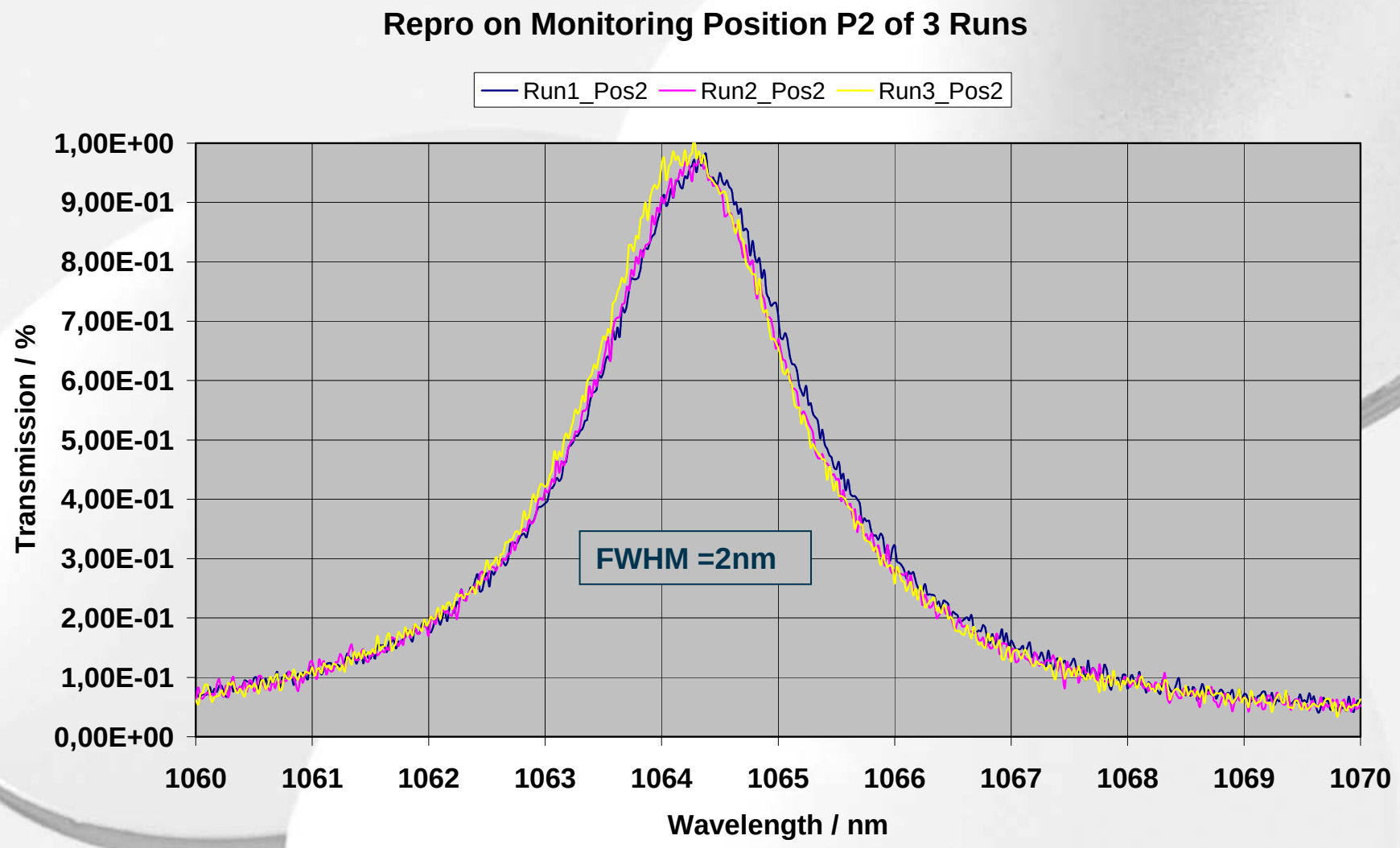
Results of NBPF Runs at 1064nm (Result with OSA)



Notch Filter Results

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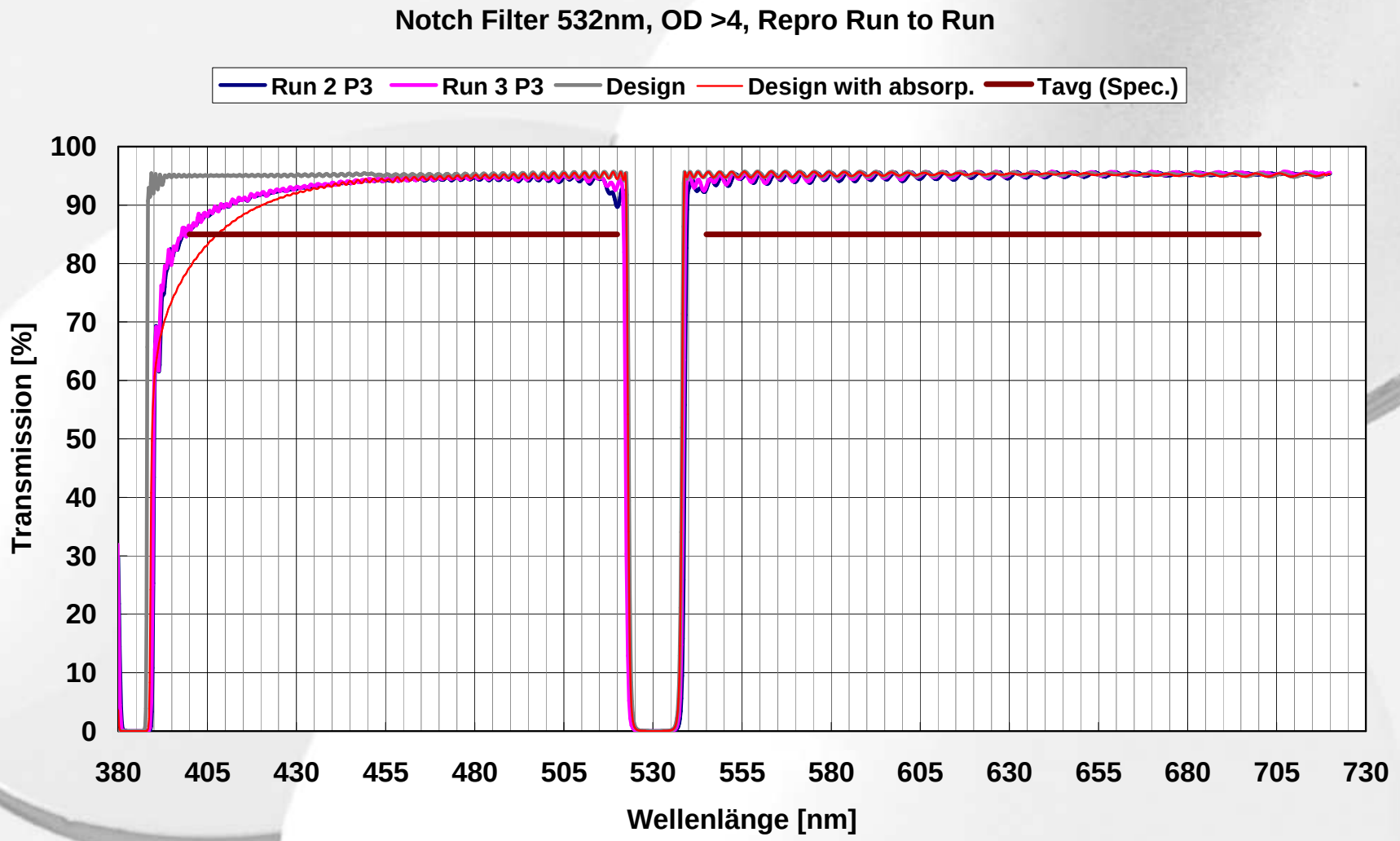
Single Notch Filter, *Repro Run to Run (AOI 0°)*



Notch Filter Results

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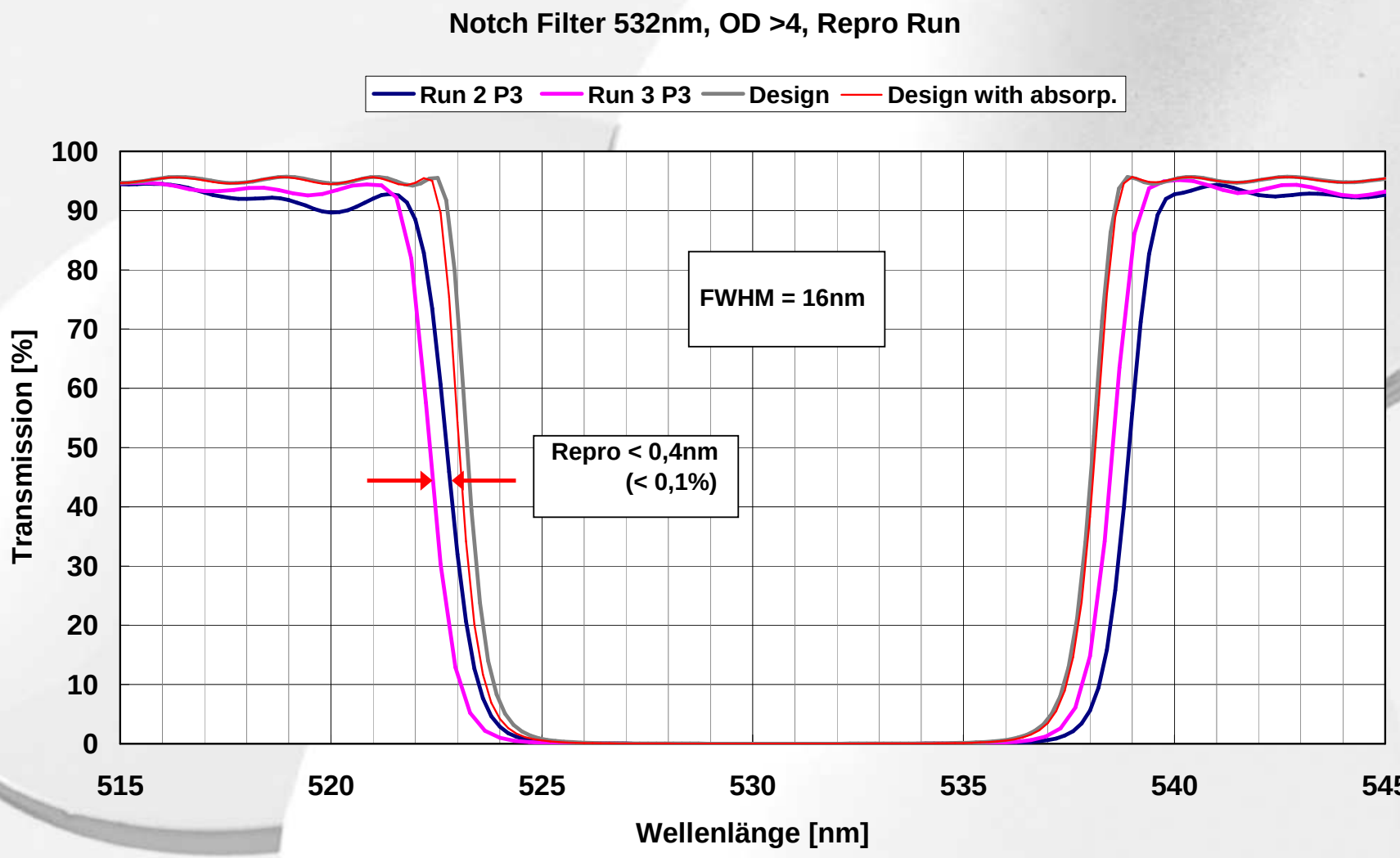
Single Notch Filter, *Repro Run to Run*



Notch Filter Results

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Multi_Notch Filter (AOI 10°)

Development done in co-operation with MSO, Jena

Filter Design

- **Layer material:** Nb2O5, SiO2
- **No. of layer:** 198
- **Total thickness:** 20µm
- **Thickness Nb2O5:** > 16µm
- **Thickness Control:** Optical combined with time

⇨ **Total Process Time < 14h**

Notch Filter Results

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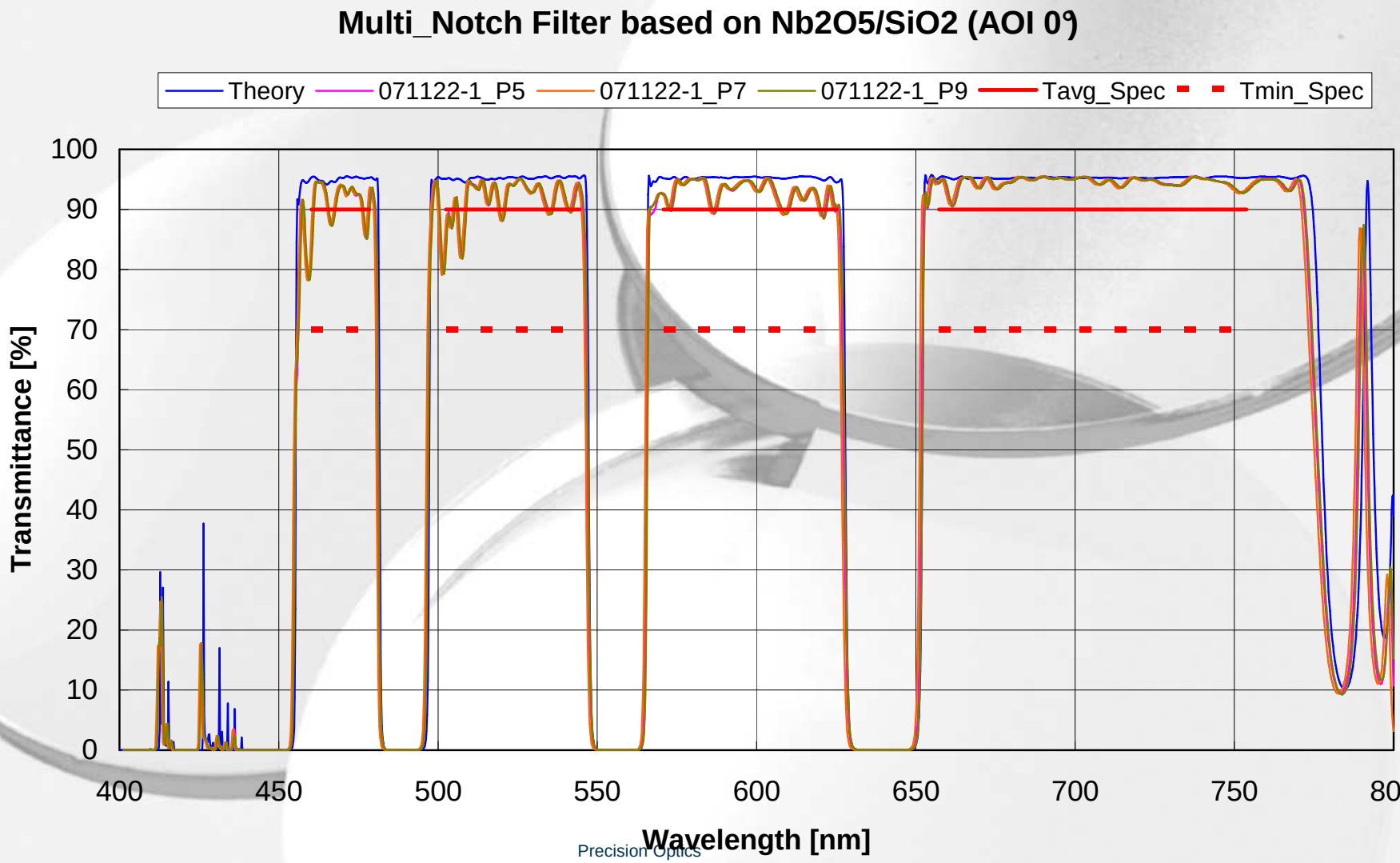
- Multi_Notch Filter (AOI 0°),

Development done in co-operation with MSO, Jena



Notch Filter Results

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Multi_Notch Filter (AOI 0°)

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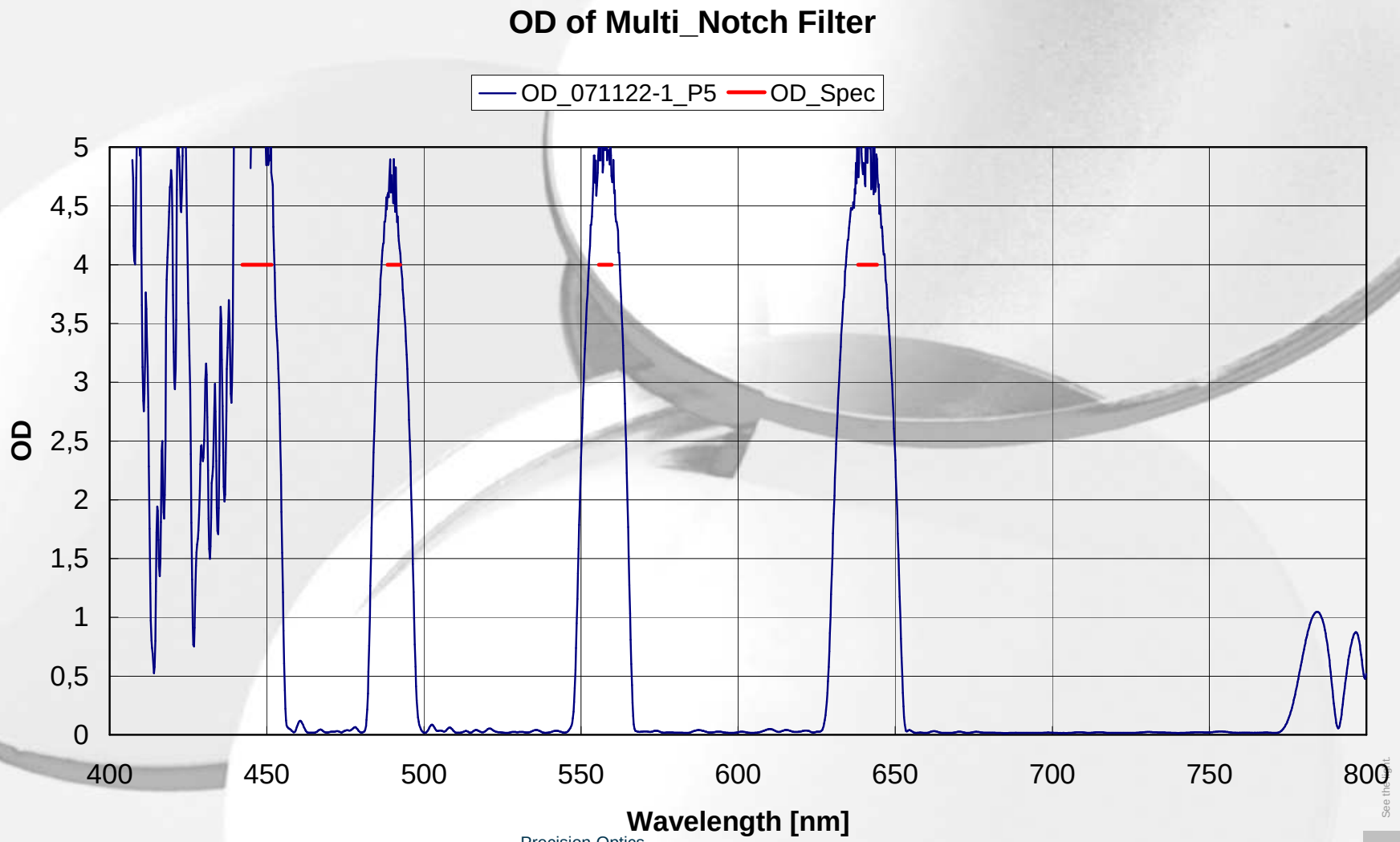

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Summary Helios

- High quality coatings for classical filter designs by PARMS (Plasma Assisted Reactive Magnetron Sputtering)
- Excellent reproducibility by in-situ direct on-substrate optical monitoring
- Fully automated and clean room compatible production solution with low particle/defect level
- High productivity compared to IBS
- Precise preparation of complex interference filter demonstrated at various notch filter designs

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Complete Solutions for the production of high end optical coatings

- LO is providing coating systems for applications from DUV to VIS, NIR to IR
- We have developed our own components, optimized for the process requirements
- Our coatings systems are modular, the standard components are selected according to the process requirements
- LO is providing the coating system and the process according to customer's requirements. The function of the machine and the process will be set up and demonstrated, also at customer's site
- After the process installation finished, you can start with production

Thank you very much

for your attention !

More Questions, interested ?

Please visit us on our booth

F 38 in Hall 3.0

Dr. Karl Matl

Leybold Optics GmbH