E. Hofbauer, R. Kometer, HOFBAUER OPTIK Mess- & Prüftechnik

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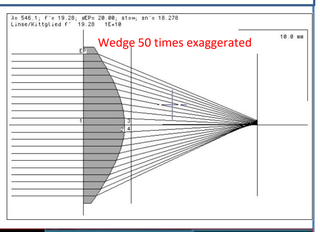
Optimized Blocking on Mandrel
No Centering Error, Polishing Error and 'slope error' on Aspheres

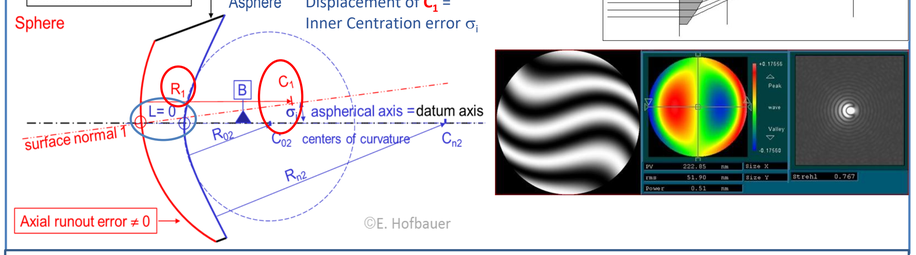
Motivation: Problems with and on Aspheres

- Partly high scrap rates in **Asphere production** -> 'Inner Centration'
- **Mounting of semi-finished asphere on mandrel** as a challenge
- No fast, easy and precise measurement process for Centration Error
- Decenter on mounted lens leads to Polishing and Slope Errors

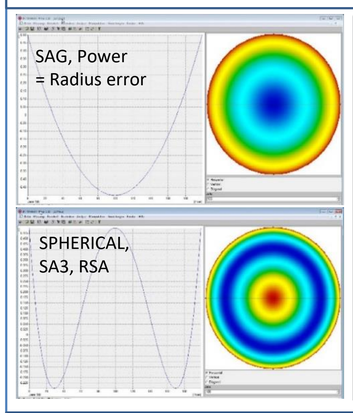
Laser Beam Error on High NA-Lens (0,5) with Centration Error 0,3'

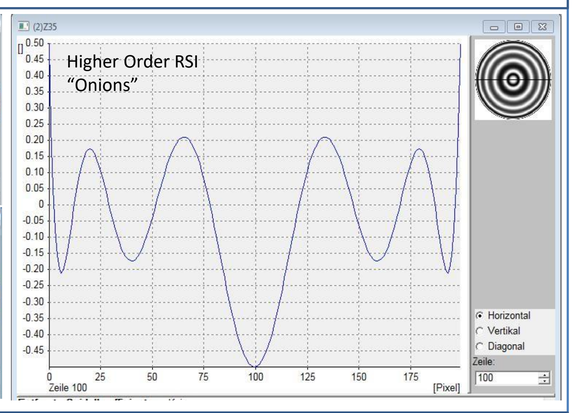
- A small wedge of **0.3 arcmin** causes significant **COMA**
- First order COMA 0.32 lambda PV@633 nm (223 nm) or 0.08 lambda rms (52 nm)
- **Airy disk is influenced -> Strehl Ratio S = 0,77**





Gobal form Errors SAG, ASTI, COMA, RSI

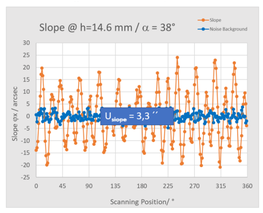




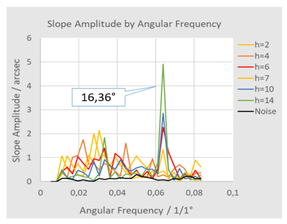
Local form Errors as Mid-Spatial-Frequency Errors (MSFE)

The slope measurement in sagittal direction in the outer zone of the aspheric lens is showing a periodic structure.

The Sample#3 Part 1 – Glass Optic
The remaining residual shows a periodic structure



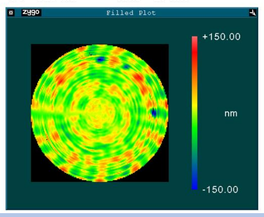
The Sample#3 Part 1 – Glass Optic
The periodic structure (MSFE) appears at 16.36° (f=22)



The Fourier-Transform reveals a significant periodic structure at 16,36°.

After integration and interpolation we are able to derive a 2D-Surface plot of the SUT. The clearly visible *„spokes"* are a typical´remain of the grinding process (**)

The Sample#3 Part 1 – Glass Optic
PV = 313 nm RMS = 27 nm



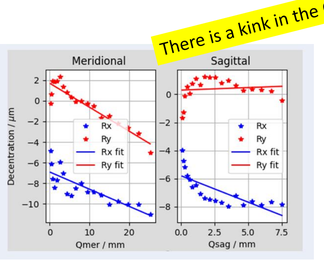
- The results of the Measurements were shown at the IWXM (2022)

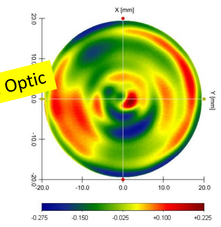
** Olga Kukso et al., "On the metrology of MSF errors after grinding," Proc. SPIE 10742, Optical Manufacturing and Testing XII, 107420X (14 Sept. 2018)

Effect of Local Irregularities (f.e. local Coma) on Centration Results *

The point-wise measurement of the decentration along the asphere axis can not be fitted by one straight line. This indicates a change in tilt depending on the zone of measurement. This effect is called a ***„Kink in the Optic".***

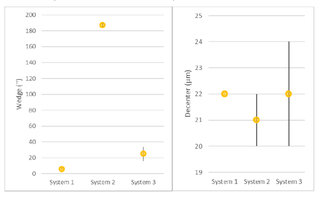
There is a kink in the Optic





The detailed surface measurement shows a strong asymmetric center artifact – i.e. local coma.

This local coma is described as falling in between classical form and decenter specifications, which becomes evident when comparing different measurement techniques, that show strong differences in reported wedge angle, depending on the number of measurement points.



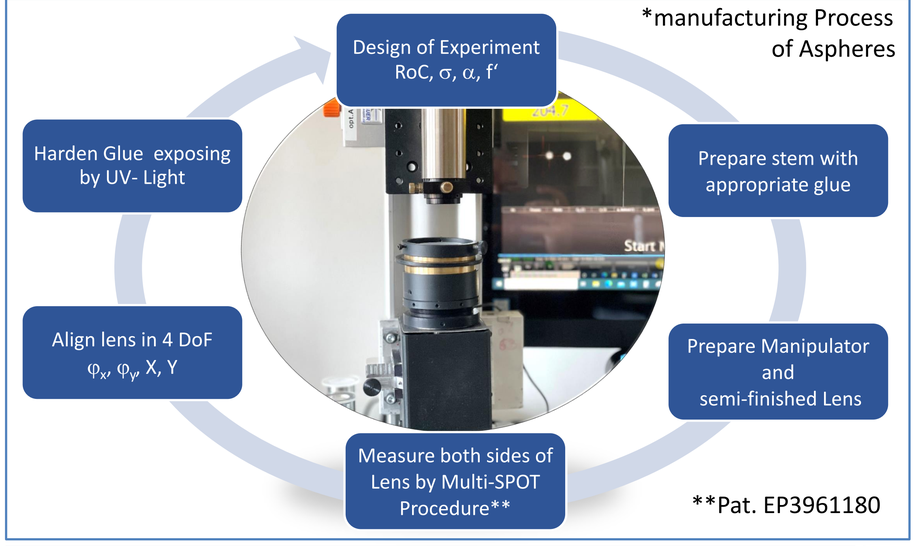
T8423	Asph. Axis 1 vs. Asph. Axis 2			
	Wedge (")	Uncertainty	Decenter (µm)	Uncertainty
System 1	6		22	
System 2	187	3	21	1
System 3	25	9	22	2

* M. Knobl, J. DeGroote Nelson, et al. Edmund Optics Inc.: High Order Surface Artifacts on Aspheres and their Interpretation in Metrology and Tolerancing, EOSAM 2024

Mounting Process Step d)*

Pat. Pending ...

*manufacturing Process of Aspheres

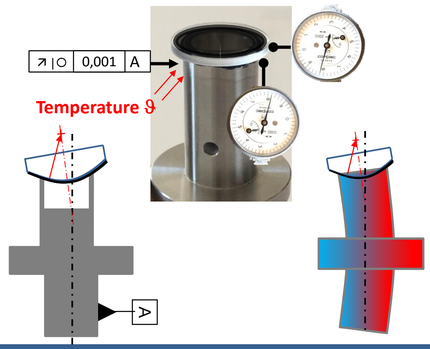


**Pat. EP3961180

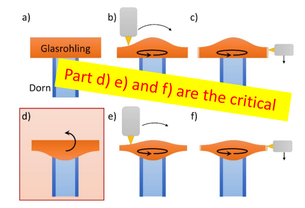
Problems at Manufacturing Process of Aspheres

- Inner decentration results during grinding and polishing process
- No good equipment is reliable for cementing Aspheres
- Vertex of lower side is not measureable by dial gauge
- Axial and circular runout of mandrel has to be < 1 µm
- Painting/ Purple tape has to have an even thickness < 1 µm
- Dial gauges on rough cylinder barrel is imprecise > 1 µm
- Blocking lens by temperature may cause decentration
- **NEW: HD-Chuck on Machine Spindle Axis C is a great Problem** circular runout: up **to 4 µm**, tilt angle runout up to **30 arcsec**

5 errors - to be avoided



Manufacturing Aspheres on stem:
Because it is the best way -> Accuracy

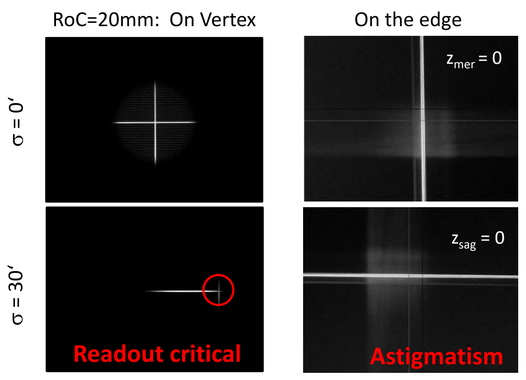


a) Bocking is uncritical
b) Grinding first Surface
c) Polishing first surface and Centering
d) Unmounting semi-finished lens
e) Grinding
f) Polishing w. final centering

Vignetting Field Stop VFS and Measurement Process on Aspheres

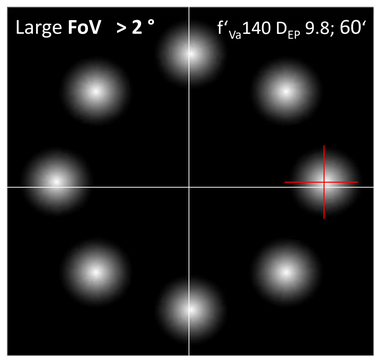
Problems @Auto Collimator AC:

Different Apertures, Focussing lens or RoC

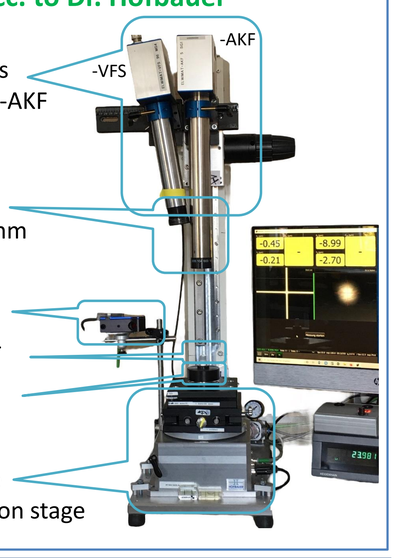


- Small Aperture ↓ -> small **FoV** ↓ -> Only one direction of image is measurable
- Small WD ↓ ---> Vignetting ↑
- -> small DoFocus: 0,1 … 1 mm ↓ -> critical Depth of Focus ↓

The Solution @Vignetting Field STOP Proc. VFS acc. to Dr. Hofbauer



- Small Aperture -> large **FoV** ↑ **up to 10°**
- Large Working distance **WD** ↑ **up to 0,5m**
- High depth of Fokus f' 140 F#11: **± 100mm**



Angle Meas. Sensors ELWIMAT-VFS &/or -AKF f' 35#4 … f'200#8

Focussing Optics
Lens f' = 30 … 500 mm
Iris ∅ 2 - 20 mm

Lateral edge sensor

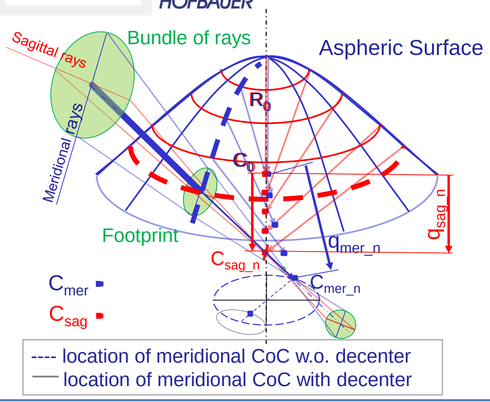
Aspherical lens DUT

Ring edge for DUT with vacuum

Friction wheel drive or air bearing rotation stage

Model and Design of Experiment on Aspheres

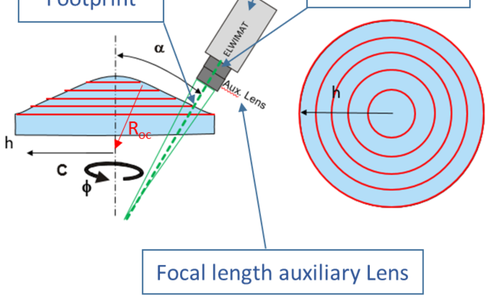
ZIM Zentrales Innovationsprogramm Mittelstand
HOFBAUER
TECHNISCHE HOCHSCHULE DEGGENDORF THD
OPC OPTICS OPTICAL PRECISION COMPONENTS
INGENERIC



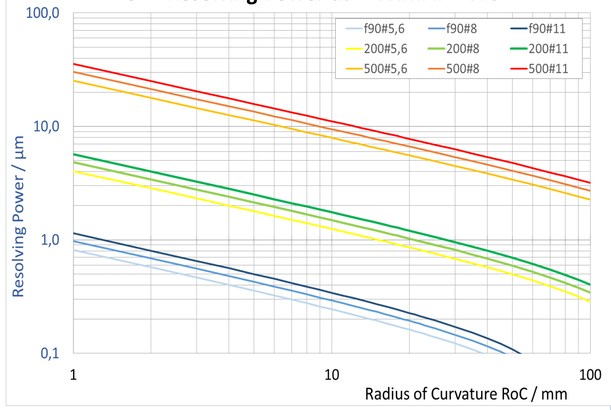
Focal length V-SPOT Sensor

Footprint

Lens Aperture



Focal length auxiliary Lens



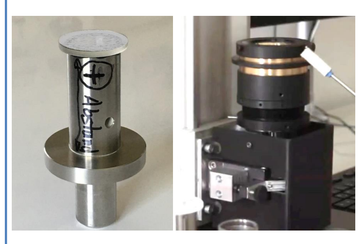
Our Test Models and lenses to be blocked: grinded plane Surface on top

A) Developing a Manipulator

- Mounting and glueing independent from the accuracy of stem
- Sensitivity < 1 µm and 5 arcsec

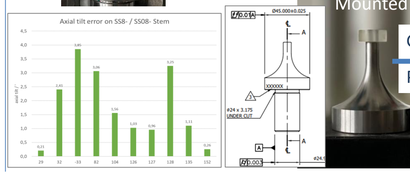
B) Develope a direct drive HD-25

- Circular Runout << 1µm



C) Customer inspired Plane-Asphere 1: R_0=7,8
Raw Material: Plane - Plane

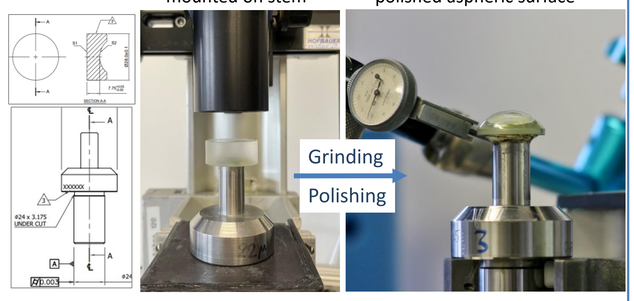
Quality of the stem:
Measurement of axial runout



D) Customer inspired Sphere – Asphere: R_0=13 mm
Raw Material: Plane - Spheric

1.Semi-finished Lens mounted on stem

2.After grinded and polished aspheric surface



Centration Measurement Results by NEW controlled Blocking on Stem Process

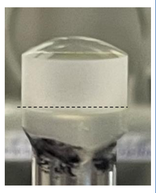
- ✓All lenses were successfully measured On and Off Stem
- ✓Spheric lens was measured with MCM friction wheel drive
- ✓ Single Aspheric lenses were measured with new ACM
- ✓ Grinding Chuck seems to have axial runout ≈ 3.5 µm

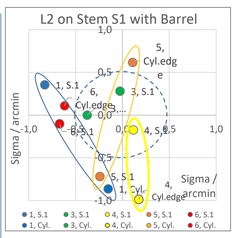
Measure circular runouts of finished Asphere on stem and inner Centration Error ICE

No.	After Mounting		After Processing - On Stem			- Off Stem
	Wedge*	S2	S2= plane	S1= Asphere CoC_0		ICE Inner Centration
1	0,6'	0,04'	n.A.**	4,0 µm	1,7'	1,79'
3	0,77'	0,15'	0,21'	3,7 µm	1,6'	1,82'
4	0,82'	0,14'	0,07'	0,8 µm	0,35'	0,83'
5	0,68'	0,6'	0,60'	1,9 µm	0,8'	1,28'
6	0,71'	0,23'	0,22	2,8 µm	1,2'	3,06'

- 5 lenses processed
- Lower Surface of mounted lens < 0,6'
- Decenter of CoC_0 up to 1,7' => 4 µm @R_0 = 7,8
- HD-Chucks on Manufacturing Spindles seems to be ‚Out of Order'
- Despite poor processing spindles, good result of ICE

* Measured on Semi finished Lens
** not measurable because full of glue on back side

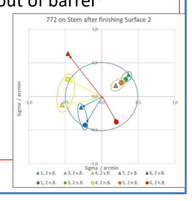




No	After Mount	After Processing - On Stem		- Off Stem
	S2 R=12	S2 R 12	Asph. CoC_0	ICE
1	0,3'	0,48'	0,9'	1,34'
3	0,48'	0,45'	0,28'	0,56'
4	0,55'	0,52'	0,21'	1,03'
5	0,2'	0,3'	0,76'	1,10'
6	0,3'	0,22	0,68'	1,04'

- 5 lenses processed: Lower Surface S2 of mounted lens were < 0,55'
- Azimuth changes between decenter of CoC_0 and runout of barrel*
- No significant change in lower Surface tilt after processing (except of the marker on stem)
- Decenter of CoC_{Vertex} S1: 0,9' => 3,5 µm @R_0=13
- Despite poor processing spindles, good result of ICE
- ICE is influenced by decenter and tilt of HD-Chuck

* The clamping changes during manufacturing process



Summary

The Vignetting Field STOP-Procedure

- Large field of view (FoV) and large working distance (WD)
- Manipulator allows high precision in independent DoF:
- 0,1 µm < dx, dy < 1 µm and 0,05 < sigma < 0,5'
- Fast Process time to process < a few minutes
- ICE is influenced by decenter and tilt of HD-Chuck on C-axis

Outlook

Following Activities are in progress

- Completing and optimize Software evaluation
- Integration of DoE-Calculation in Software Module
- Further Customers Trials for best Quality even Spherical Surface on Top: Spheric – Spheric
- Next Grinding and Polishing with better HD Chuck

References and Acknowledgement

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