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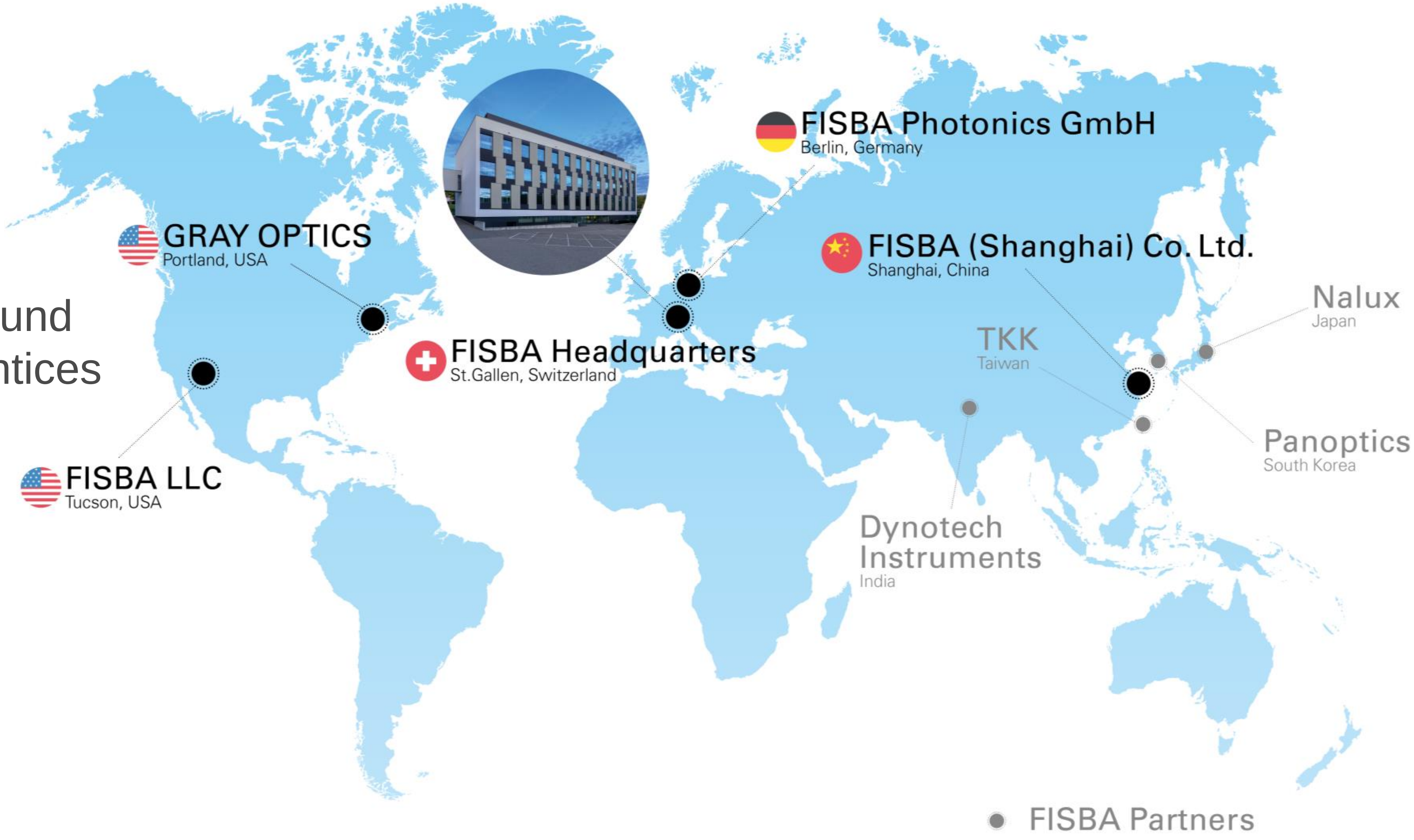
FISBA Innovators in Photonics

High Refractive Power Micro Optics

EPIC Meeting on Micro Optics

Our company

- Founded in 1957
- Privately owned
- Approx. 360 employees around the world, thereof 30 apprentices
- Revenue > CHF 65 Mio.
- 4 owned subsidiaries
- 4 Distributors



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Overview

- What is different for «micro» rather than «macro»?
- What is different for «high refractive» rather than «low refractive» power?
- Process consequences
- Possible shapes

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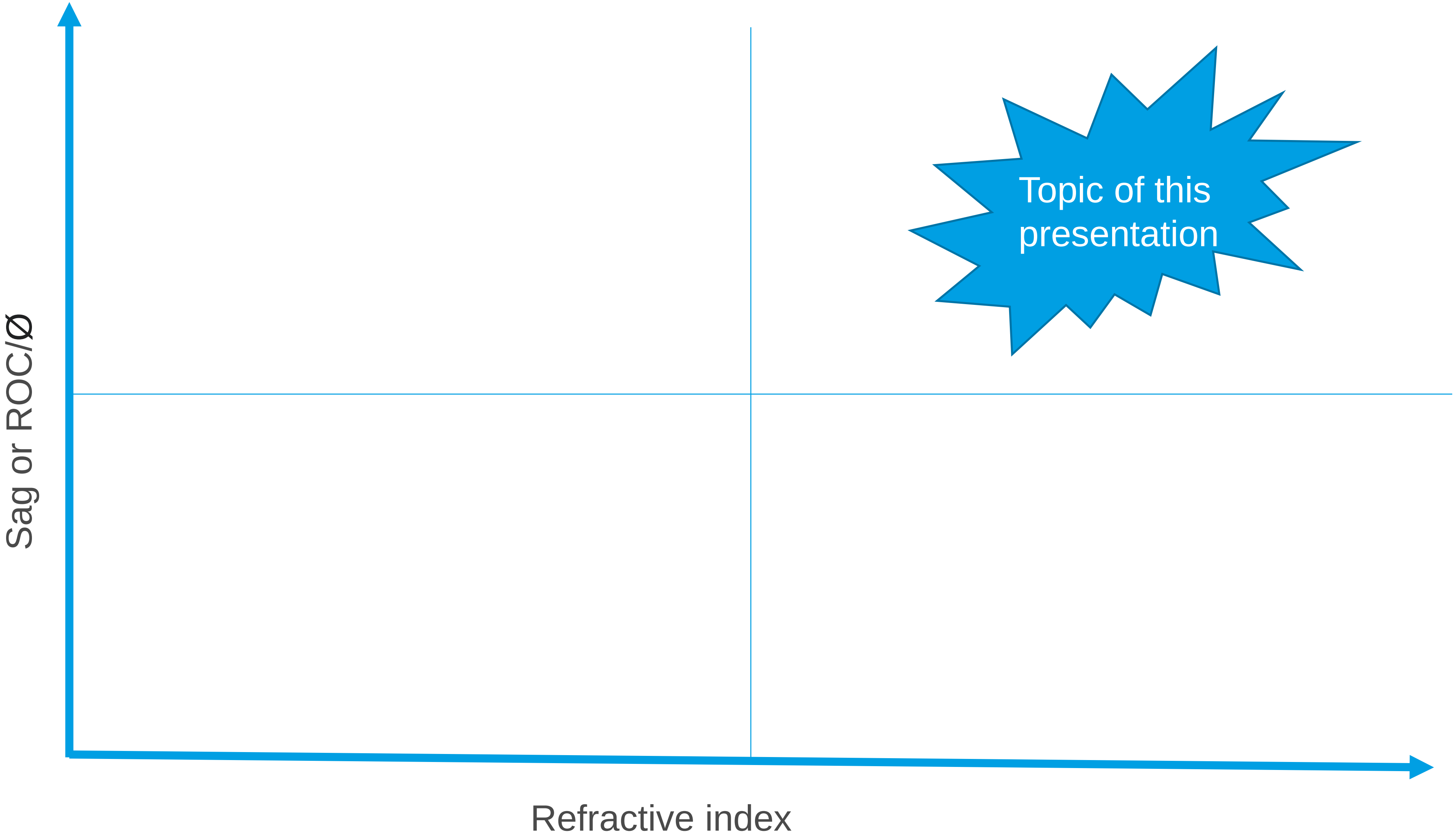
Difference macro / micro: some examples

Characteristic	Macro	Micro
Surface imperfections: allowable size of defects	Less sensitive regarding maximum size of defect but usually similar with regerads to defect area compared to complete CA	More sensitve, if defect occur randomly on only a few lenses, 100% inspection can solve the problem
Birefringence	Sensitive, even if light is not polarized because of wavefront destortion	Less sensitive
Homogeneity of refractive index in raw material	More sensitive	Less sensitive
Transmission of material	More sensitive	Less sensitive, unless it is a high power application
Slope error	Less sensitive, depending on ray bundles (can still be sensitive in some cases)	More sensitive at same spacial frequency

High refractive power



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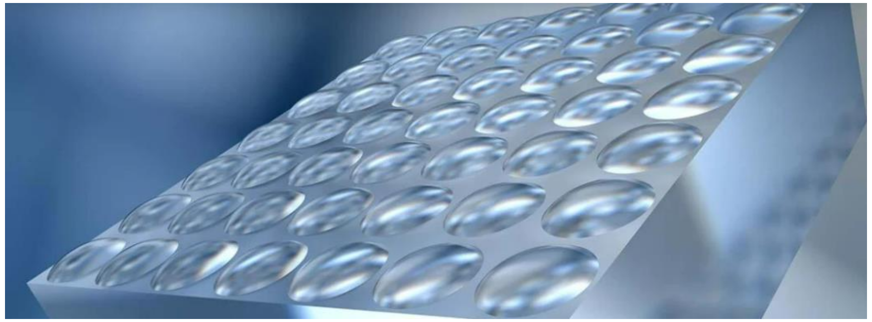
Examples micro optics processes

Well known or new – well working – covering many applications



Courtesy of SUSS MicroOptics SA

- **Lithography:** limited sag / in the visible often limited to fused silica (low refractive index)
- **Laser processing (ablation / polishing):** limited sag / well established only for fused silica (low refractive index)
- **Plastic injection molding and plastic based imprinting technologies**: limited in temperature stability, durability, selection of materials and higher power laser applications.
- **Additive manufacturing:** various methods, limitations if glass-like and limited surface quality

What we want is: highly precise processing of high refractive index glasses with «steep» surfaces

(low ROC compared to diameter)

Processes: where we came from

Conventinal grinding and polishing: we still do it!

Micro means:

- Make everything smaller
- More precise and stable
- Cleaner
- Better metrology

Thermal processes / replication in glass

Glass Molding

- Aspherical, cylincrical and (with limitations) free form shapes possible
- The higher the sag, the more important is a correction of spherical aberrations

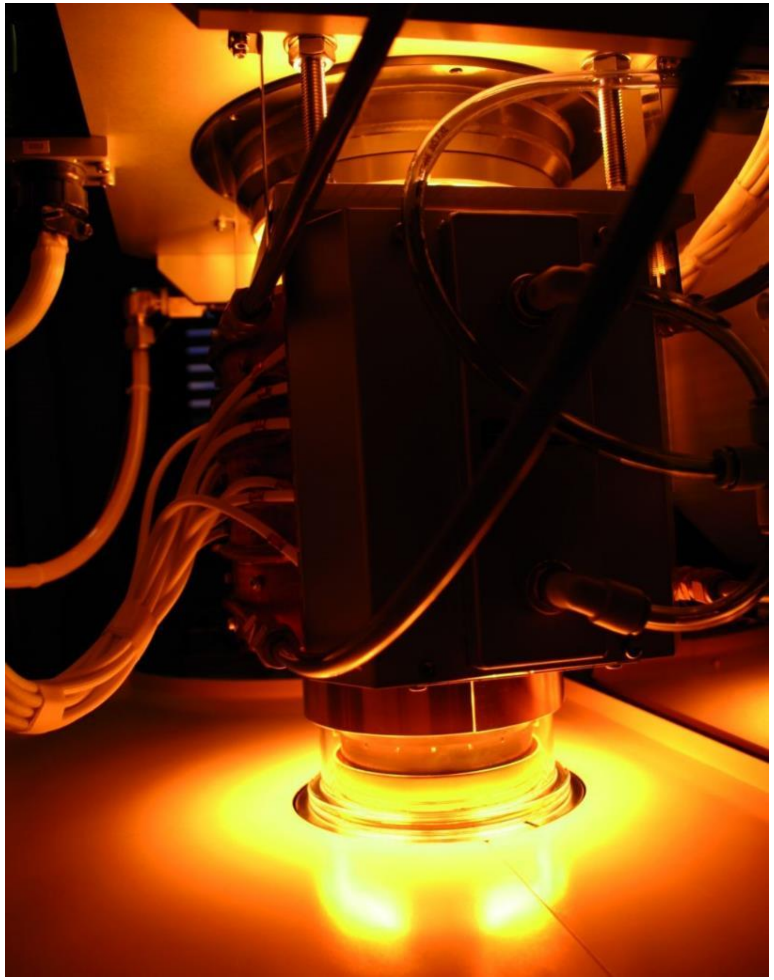
Non isothermal molding

- Glass heated and cooled outside mold: low precision, fast cycle time
- Typically used in illumination or sensor applications

Isothermal molding

- Mold and glass at same temperature during forming and cooling
- Typically used in imaging or laser beam shaping applications

What FISBA does



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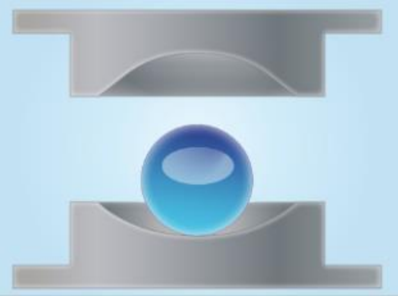
Precision Glass Molding (isothermal Molding)

Process

Step 1
Preform

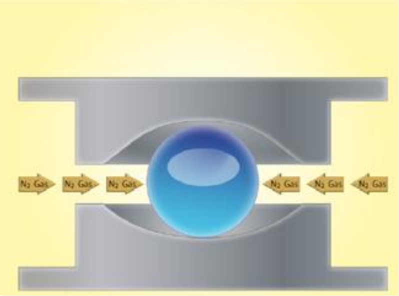
- Polished preform
- Near-shape, ball or disk
- Advanced cleaning

Step 2
Loading



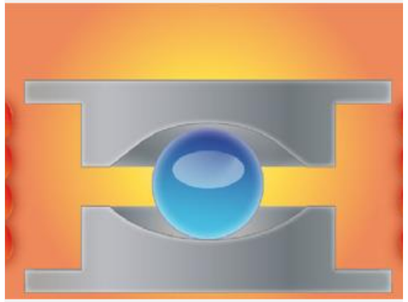
- Upper and lower cores
- Preform
- Protective tool coating

Step 3
Inert gas atmosphere



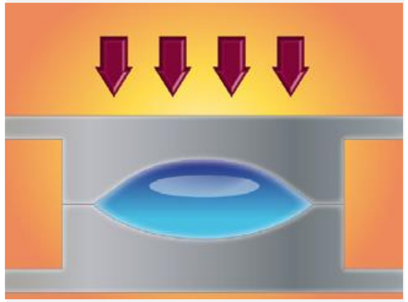
- Evaporation
- Purging with nitrogen

Step 4
Heating



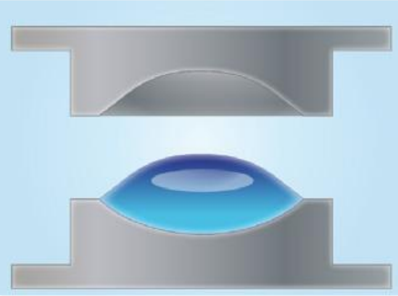
- Infrared heater
- Homogeneous temperature

Step 5
Molding



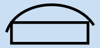
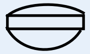
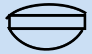
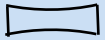
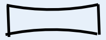
- Precise force control
- Varying force depending on process phase

Step 6
Decompress



- Precise control of cooling rate
- Removal
- Inspection

Precision glass molding process (isothermal molding)

Form	Feasibility	Comment
Planar Convex 	+	If rotational symmetric: no major advantage to biconvex
Biconvex, one side aspherical 	++	
Biconvex double asphere 	++	Only slightly more expensive compared to one sided aspheric
Meniscus (spheres or aspheres) 	+	
Biconcave and spherical on steeper side 	-	Conventional post polishing possible if necessary
Biconcave aspherical 	--	Risk very high, only worth a try if steepness is very low

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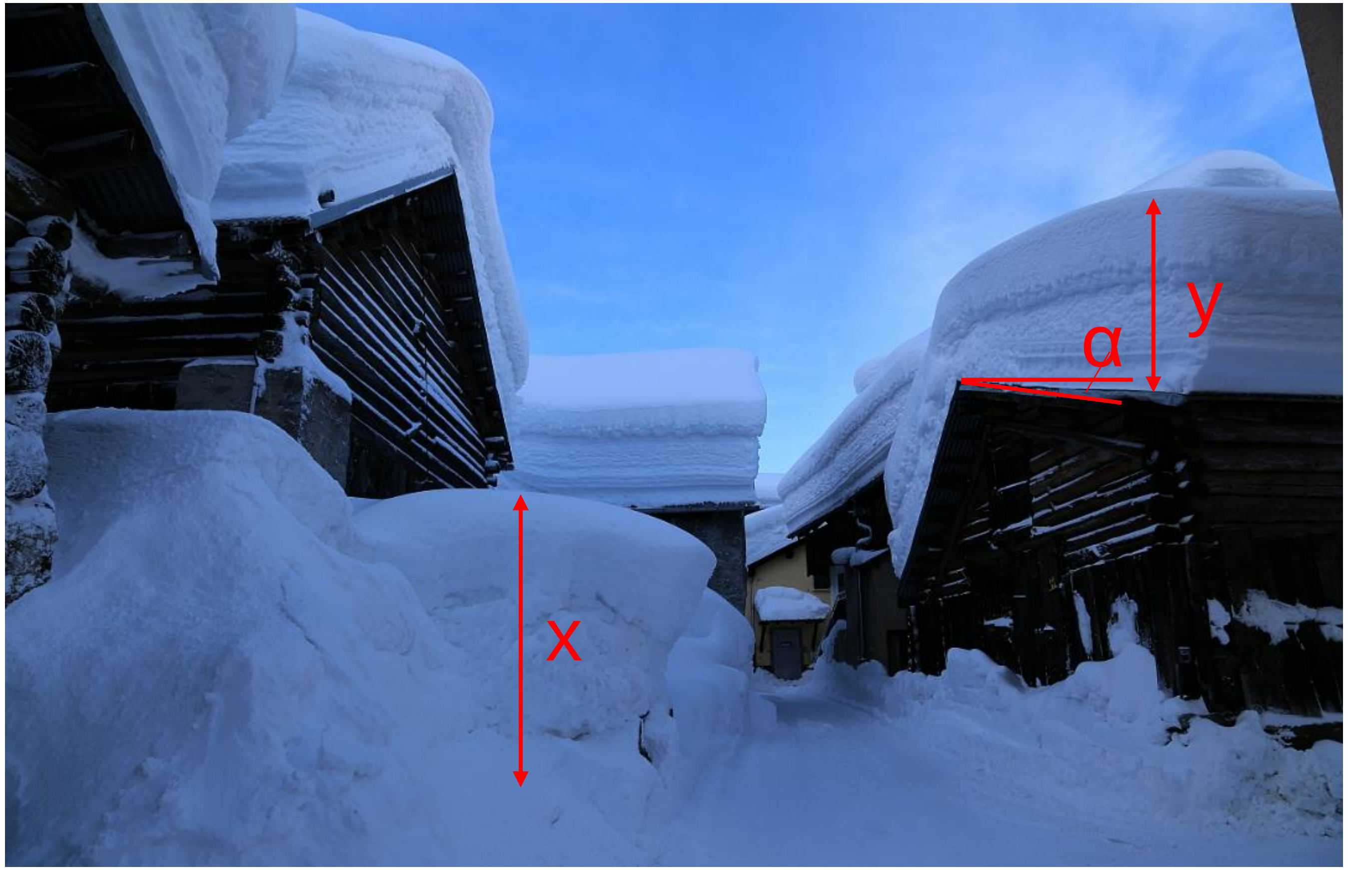
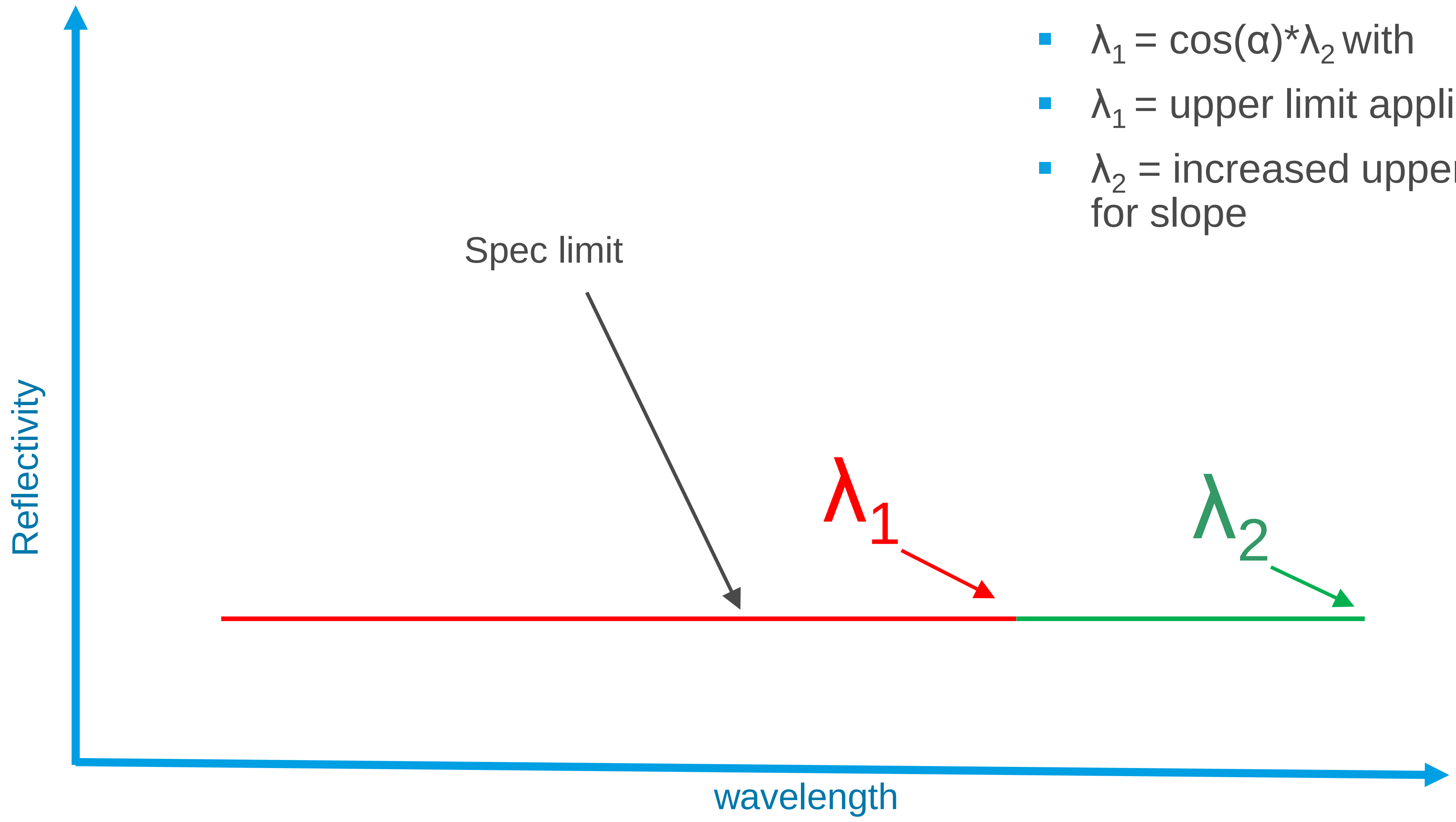
Coating Challenges



- x > y
- y=cos(α)*y
- Good coating performance requires higher upper limit of the covered wavelength range
- Pay attention to shadowing effects when doing high sag micro optics on wafers

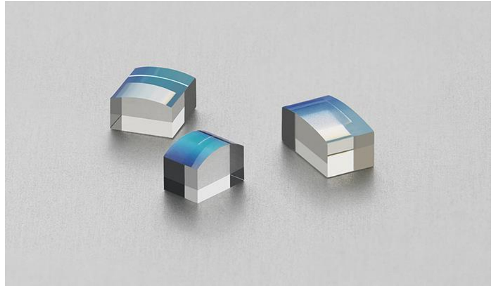
Coating: compensation of steep surfaces



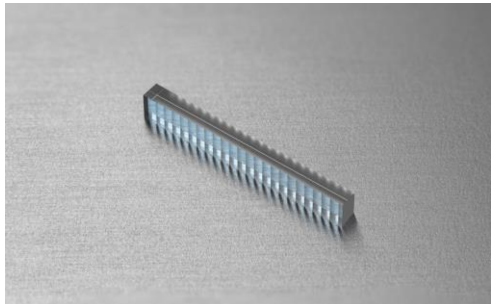
- $\lambda_1 = \cos(\alpha) * \lambda_2$ with
- λ_1 = upper limit application wavelength
- λ_2 = increased upper limit to account for slope

Possible shapes

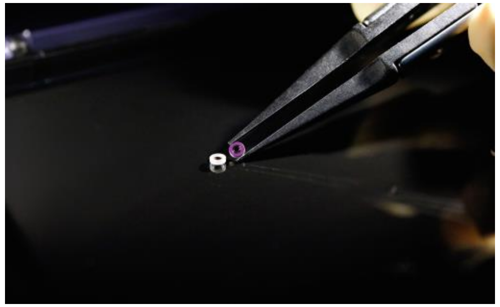
And how we can handel them

Acircular cylinders (often called «acylinders»



Cylinder arrays



Aspherical lenses

Spherical lenses (optionally cemented)

FAC on tab

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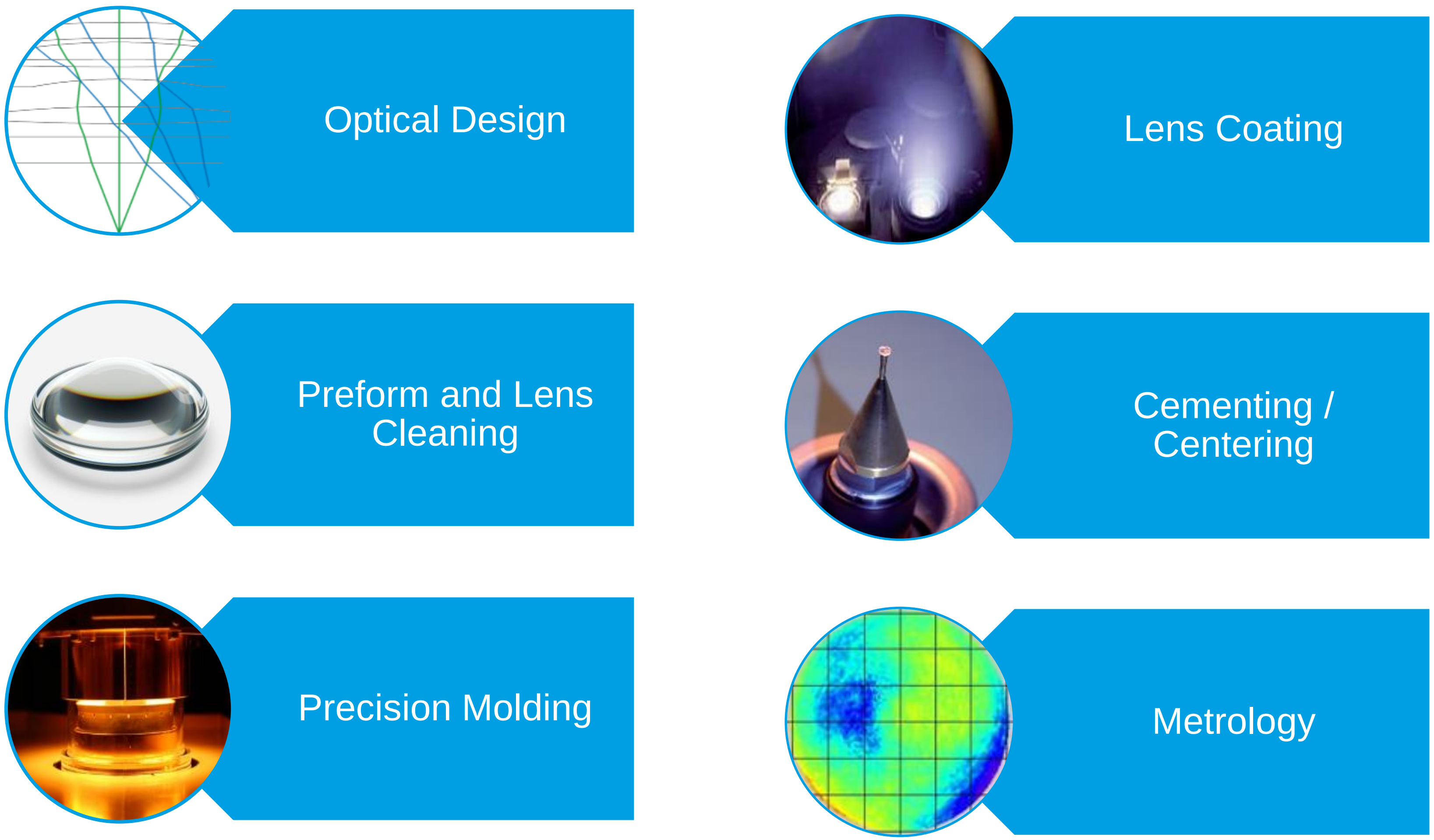
All under one roof is almost a must



- Any transport packaging and handling of micro optics adds more costs in relative terms compared to macro optics
- Large interdependencies between process steps: can only be optimized as one chain
- Strong collaboration of lens designers and process specialists leads to best possible solution

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THANK YOU