Course Notes

SPIE Education Services

SC1086
Optical Materials, Fabrication and Testing for the Optical Engineer

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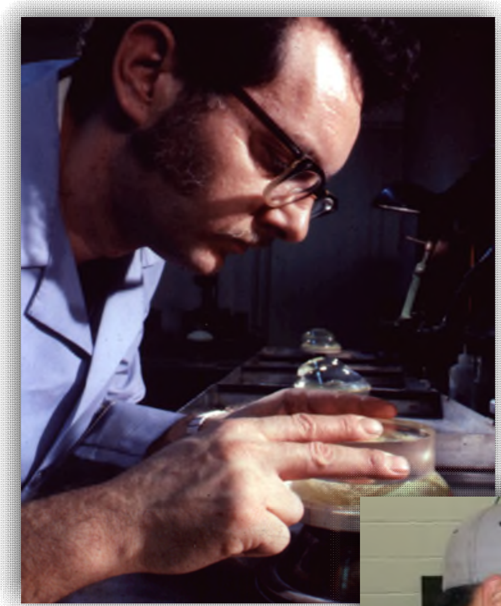
Conventional grinding processes require skilled application of relative motion, pressure and chemistry



Circa 1970

Circa 2015

Goals of grinding:

- Rapidly remove material
- Achieve the desired form
- Prepare the surface for polishing (minimal damage)

Surfaces are ground using cast iron or glass tools and loose abrasive (ex. aluminum oxide) in water

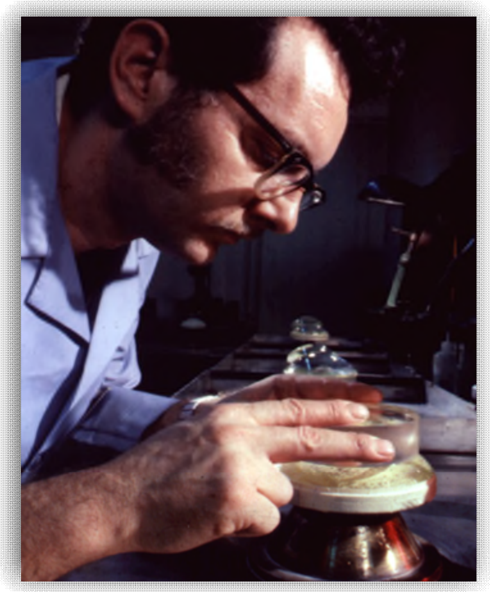
Each radius requires unique and dedicated tooling

In use, tools continuously change and require periodic reconditioning

Traditional processing methods are still very cost-effective for producing spherical optics

Traditional Optical Pitch Polishing

Polishing is a chemo-mechanical process



Goals of polishing:

- Converge to final specifications (surface form and mechanical dimensions simultaneously)
- Remove all trace of damage
- Smooth, defect-free surfaces

Surfaces are polished using pitch or polyurethane pads with polishing abrasive (ex. cerium oxide) and water slurry

Multiple lenses with the same radius can be run on the same tool (multi-block) or run as singles

Traditional processing methods are still very cost-effective for producing spherical optics, especially with multiple spindles running simultaneously

Deterministic sub-aperture polishing

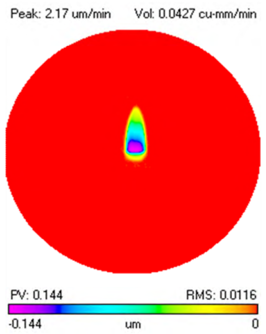
Small tool locally removing material

Dwell-based algorithms remove material based on initial surface metrology and tool influence function

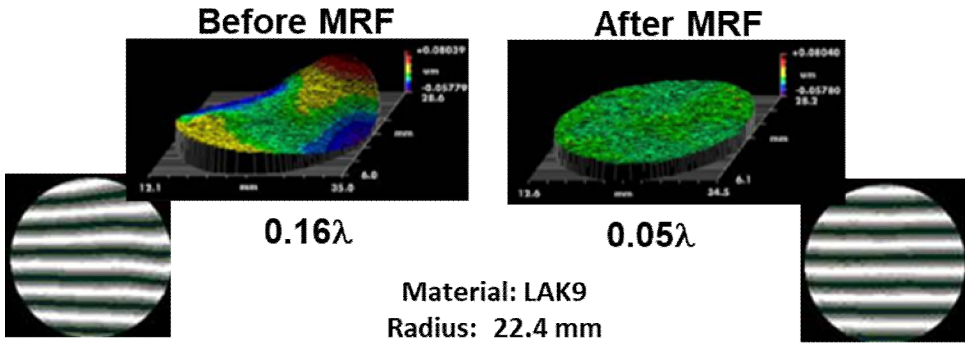
More predictable surface form convergence

May require post smoothing to minimize mid-spatial frequency errors

Complex surfaces, like **aspheres** are **freeforms** possible



Magnetorheological Finishing (MRF) Example



Material: LAK9
Radius: 22.4 mm
Clear aperture: 21.06 mm
Total surfaces: 9
Average run time: 4.5 min

Several other sub-aperture technologies exist

Example images from: QED Technologies www.qedmrf.com; and OptiPro Systems, Inc. www.optipro.com

Optical Manufacturing Tolerances

Why Tolerance?

- Tolerancing constrains the amount of Optical Path Difference (OPD) fabrication introduces to the system
  - Communication tool with optical fabricators

Performance

- Tolerances influence the cost to manufacture an optic, some tolerance types more than others

Cost

Mechanical Dimensions

Tolerancing considerations

Tight thickness tolerances are more difficult when combined with:

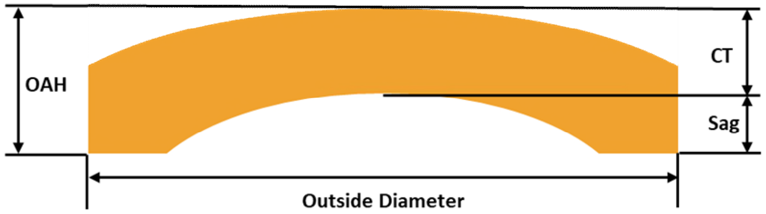
- Very stringent cosmetics, fractional wavelength irregularity, or soft optical materials

Thin edges (< 1mm thick) should be avoided if possible

- Prone to chipping which can result surface defects or catastrophic failure
- Difficult to hold during processing and measurement

Try to avoid compounding or conflicting dimensions

- Example: Overall height depends on center thickness and sag



Aspect ratio is relationship between diameter and center thickness

- High aspect ratios may result in glass bending/flexing during processes
- Ideal aspect ratios at least 6:1 for precision optics

Involve opto-mechanical design early in the process to identify mounting surfaces or establish lens spacing