PRECISION LENS MOLDING OF CHALCOGENIDE OPTICS

Jayson J. Nelson

22 Apr 2015

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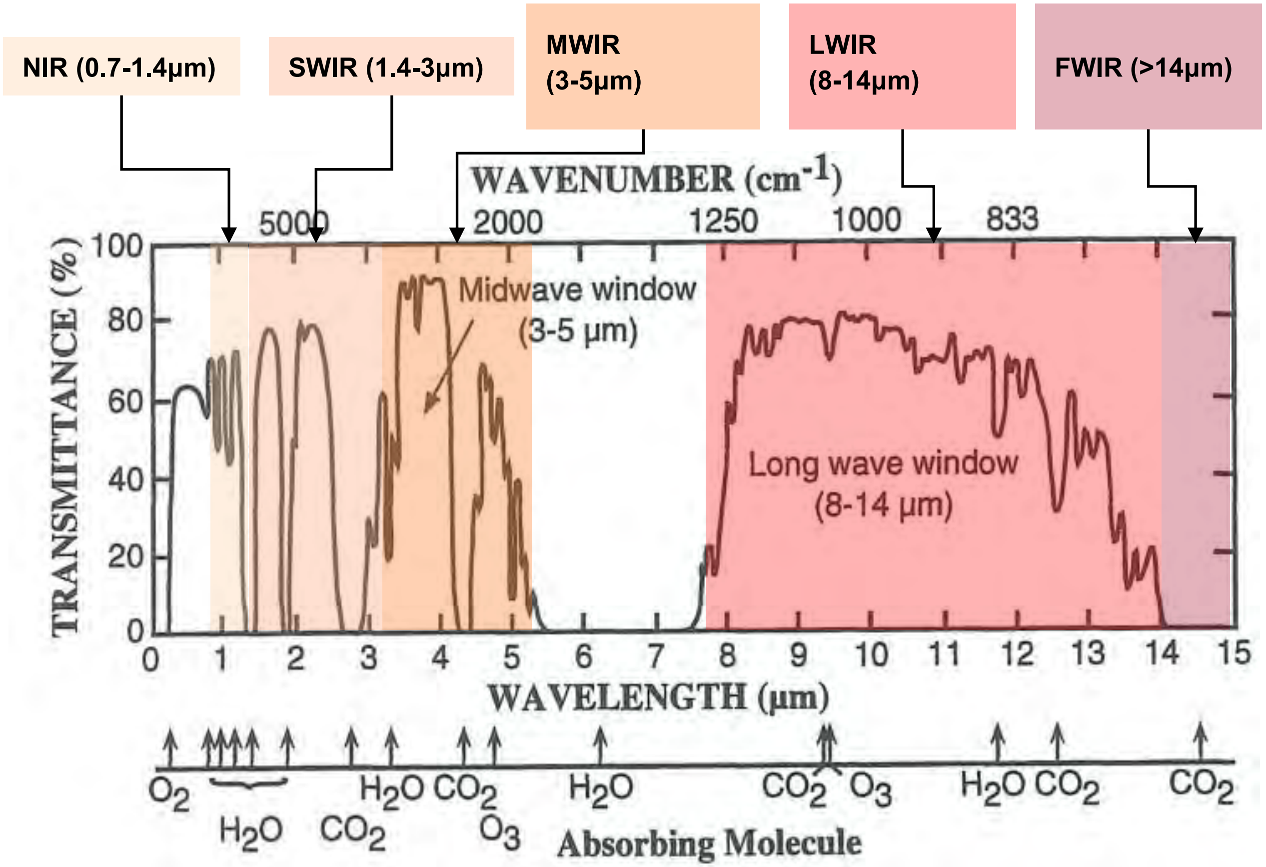
PRECISION LENS MOLDING OF CHALCOGENIDE OPTICS

- ✓ Global markets are looking for low cost materials that satisfy infrared imaging requirements and can be manufactured in commercial quantities (IR equipment sales up, prices coming down).

- ✓ Chalcogenide materials offer a clear path for new product development and high tech applications due to their unique properties and ability to be tailored to specific customer needs.

- ✓ Recent developments in low cost preforms and molding technology enable rapid changes in the market.

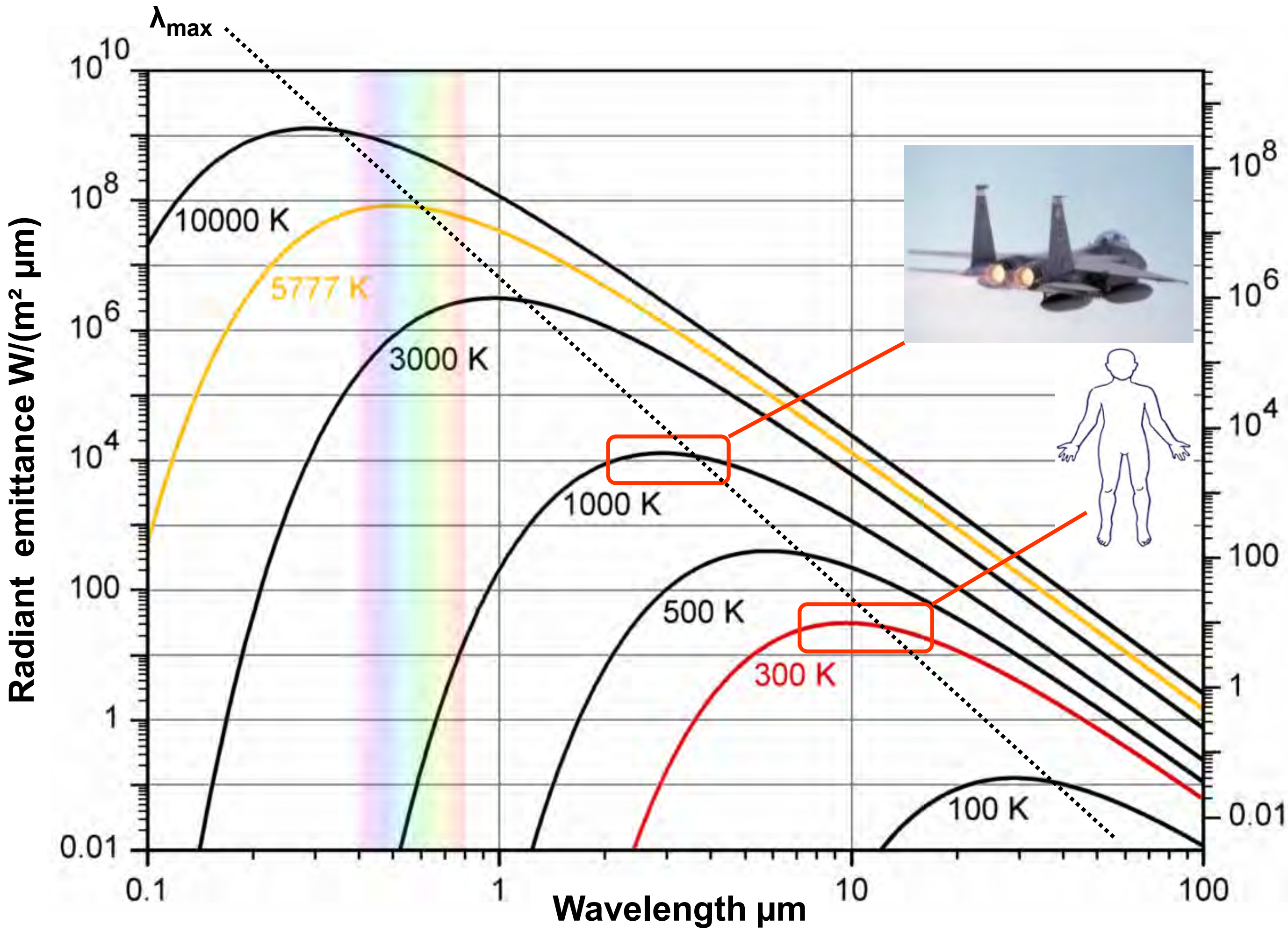
INFRARED TRANSMISSION



Infrared Atmospheric Transmission Spectrum

for a 1.8 km horizontal path at sea level with 40% relative humidity

THERMAL IMAGING SPECTRA



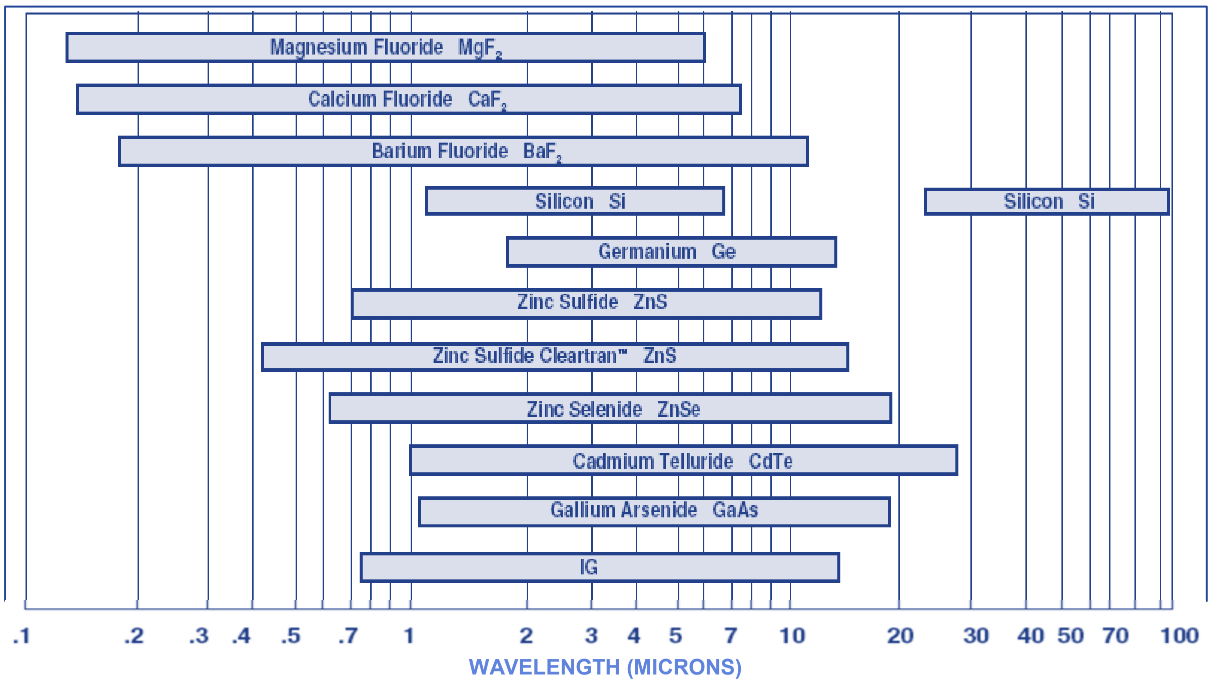
IR windows for thermal imaging

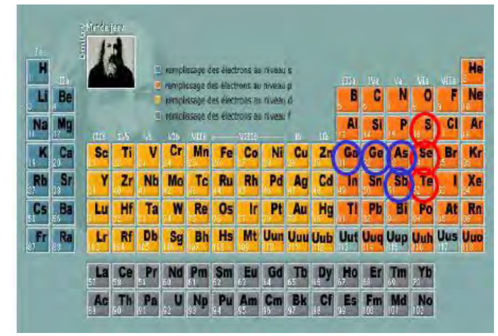
8~12 µm covers max. radiation for e.g. human bodies

3~5 µm covers max. radiation for e.g. fighter exhaust

Source of Images: Wikipedia

WHY CHALCOGENIDES?





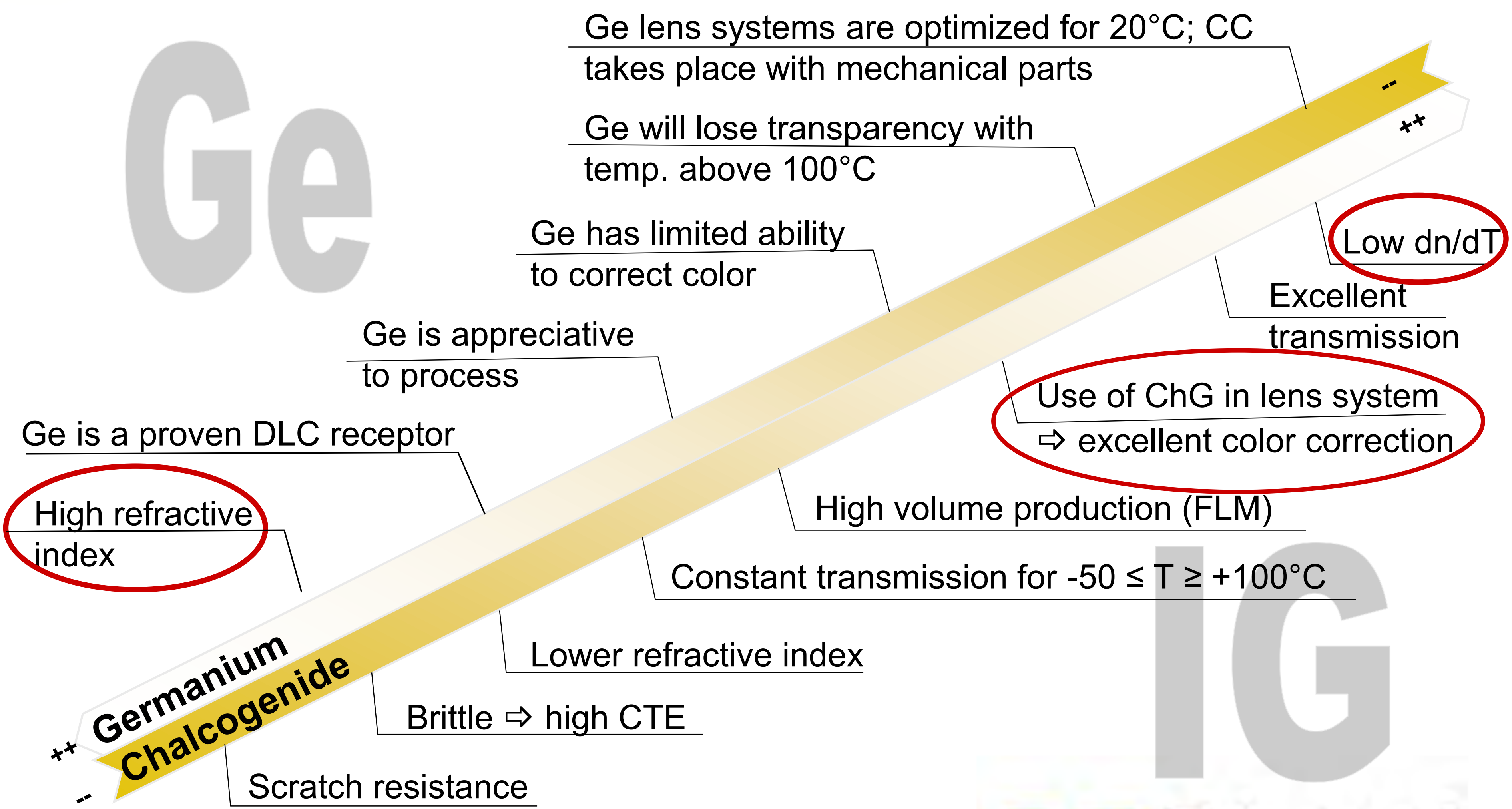
All IR materials have trade-offs

- Alkali Halides: ideal transmission, low dispersion, extremely hygroscopic, very soft
- Silver/Thallium Halides: good transmission, extremely soft, HIGHLY toxic
- Alkaline earth fluorides: slightly hygroscopic, poor LWIR transmission, unique n, v and dn/dT
- Ge: high index, near zero LWIR dispersion, opaque when heated and huge dn/dT (0.0004/K)
- ZnSe, ZnS (clear): Good transmission, moderate dn/dT, but high dispersion and scatter
- GaAs, CdTe: Unique combination of n and v, but expensive and hard to get in large aperture
- Chalcogenide (IRG) glasses: Good transmission (can include visible), scalable, moldable, tunable properties, sensitive to thermal effects

Source of data: SCHOTT NA

MATERIAL COMPARISONS

Chalcogenides have their strength in dn/dT and color correction of optical systems



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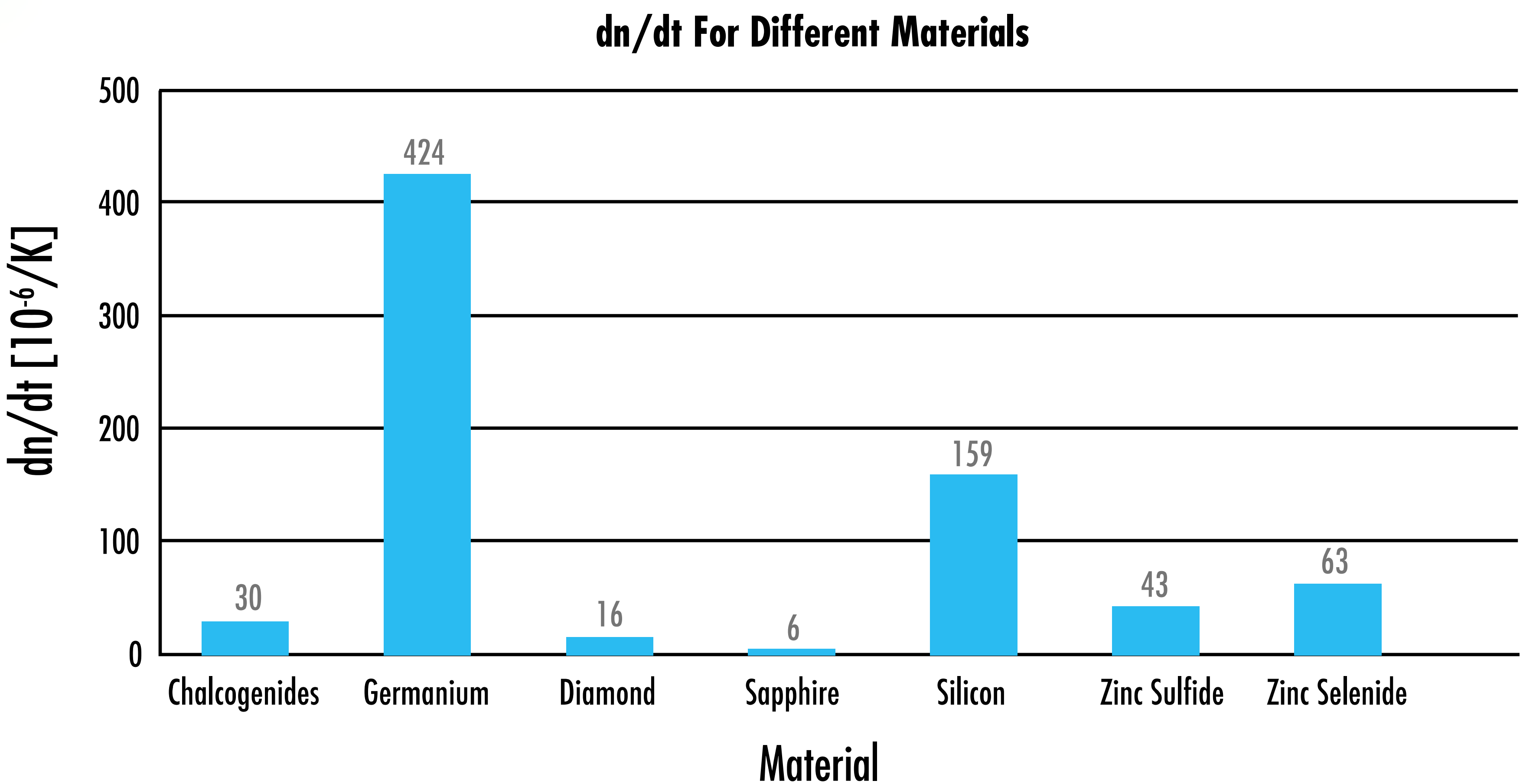
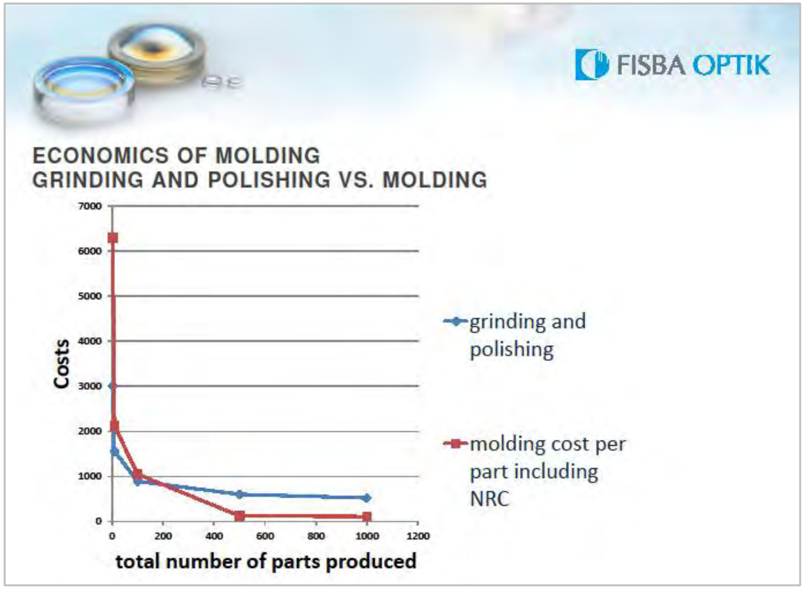
OPTICAL PROPERTIES

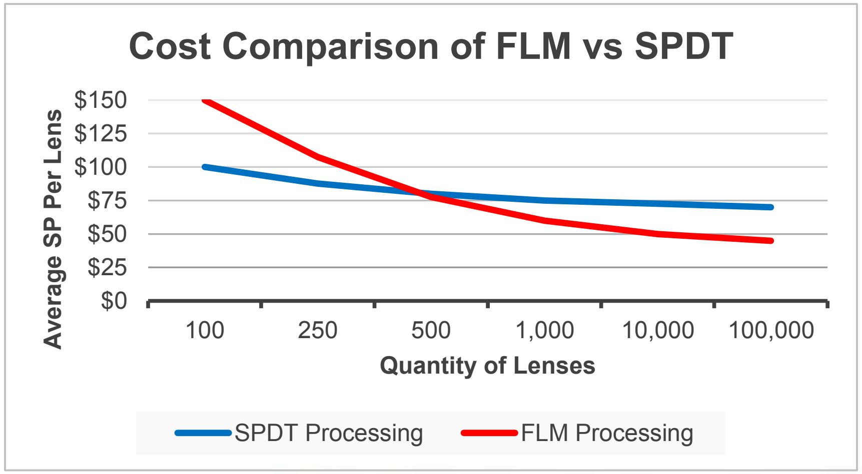


WHY MOLDING?

Precision Lens Molding Benefits

- Manufacture of complex shapes not possible with conventional grinding & polishing
- Lower ramp up costs for high volume applications than single point diamond turn or conventional polishing
- Lower unit manufacturing cost than single point diamond turn for low rate initial production through high volume
- High fidelity reproduction

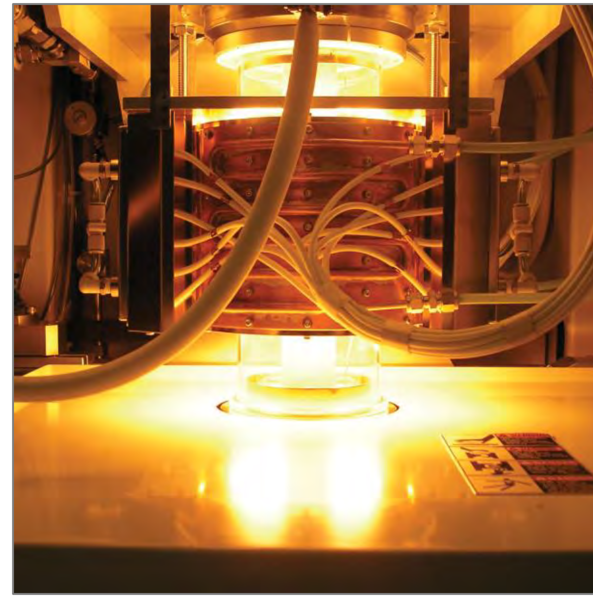


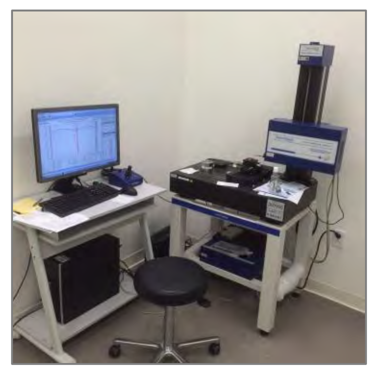


** 15mm Meniscus Chalcogenide Lens, Uncoated*

NEW IR MOLDING CAPABILITIES

- Joint development program between Edmund Optics® and Fisba Optik AG
- Focused on development of Precision Lens Molding (PLM) and Finished Lens Molding (FLM) competencies for IR products
- Completely new facility in Tucson, AZ
- Class 1000 clean facility, localized class 100
- Toshiba GMP-311 PLM machines with Scara robot and tray handler





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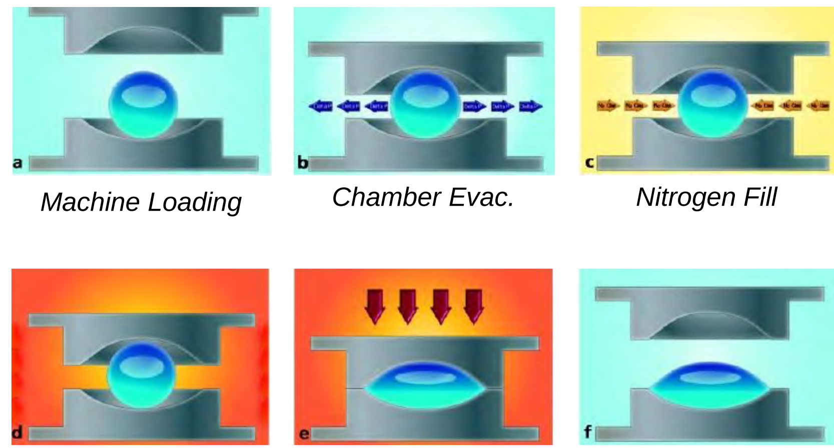
IR MOLDING CAPABILITIES

Equipment Capabilities

- Toshiba GMP 311V
- Vacuum molding capability
- Auto loader and tray handler enables efficient mid to high volume production
- Single cavity and multi cavity tooling
- Non conventional approach for tool development empowers manufacture of diffractives and special features



Machine Loading | Chamber Evac. | Nitrogen Fill

Heating | Molding | Machine Unload

Image Source: FISBA

IR MOLDING CAPABILITIES

Manufacturing Capabilities

- Planar, spherical, aspheric surfaces
- Positive, negative, or meniscus lens designs
- Flow modelling and tool compensation programs
- Manual (low volume) or automated (mid – high volume)
- Precision equal to or better than industry standard

Surface Description	Manufacturing Cost	Comments
Planar - Convex (sphere or apshere)	++	Rotationally symmetric
Bi-convex; spherical - aspheric	++	
Bi-convex; aspheric - aspheric	++	Only slightly more expensive than sph - asph
Meniscus (spherical or aspheric)	+	
Bi-concave; spherical - aspheric	-	Post processing may be required
Bi-concave; aspheric	--	Very high risk

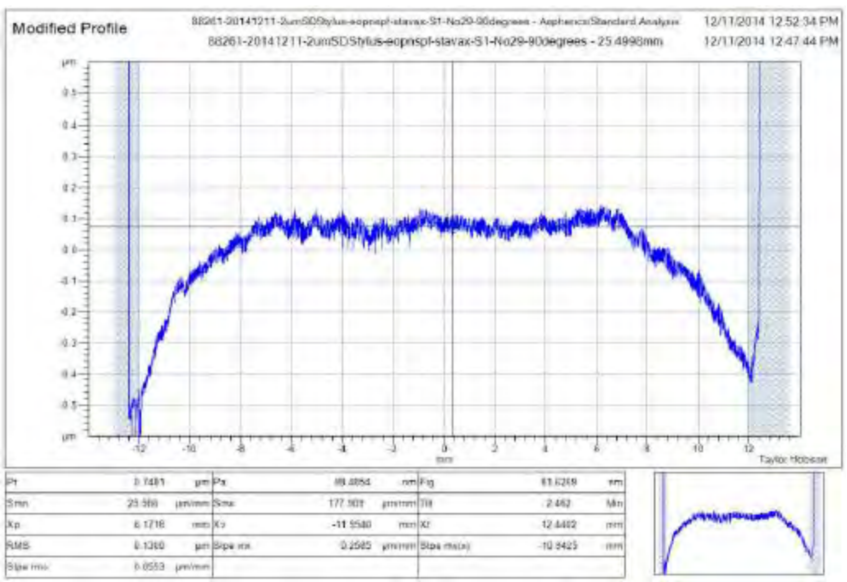
	Standard Quality	Precision Quality
Diameter	3 - 30mm	3 - 30mm
Aspheric Figure Error (fringes @ 633nm)	5	2
Irregularity (fringes @ 633nm)	2	1
Vertex Radius	+/- 1%	+/- 0.1%
Decenter (mm)	±0.015	±0.005
Wedge (arcmin)	5	2
Center Thickness Tolerance (mm)	±0.030	±0.015
Diameter Tolerance(mm)	±0.025	±0.010
Surface Quality	60-40	20-10

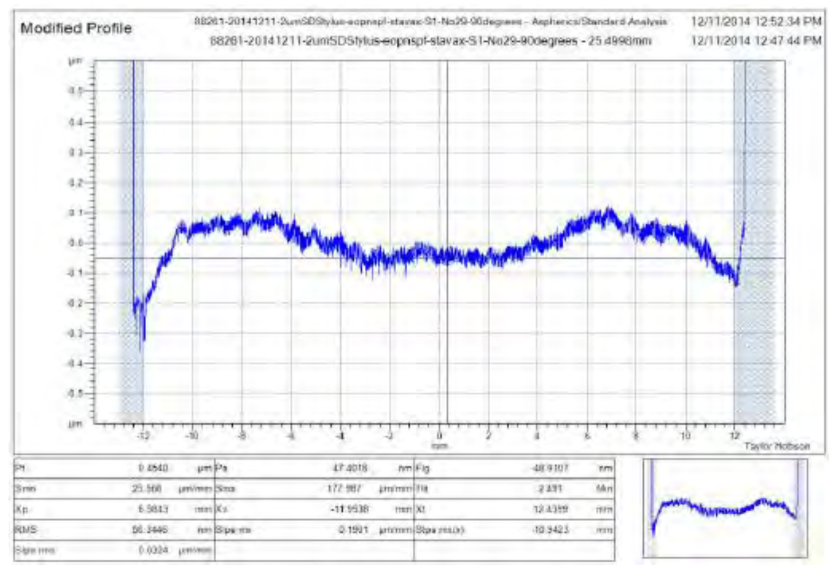
IR MOLDING RESULTS

First Pressings Results

- 25mm meniscus lens
- CX asphere, CC sphere
- Uncorrected tool surfaces

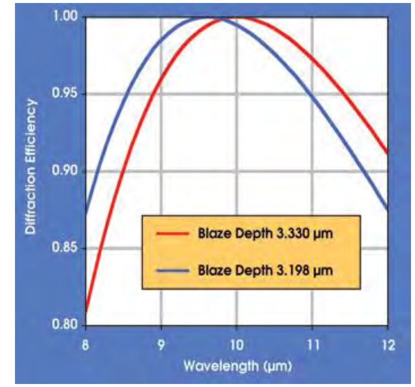
- Tool – 0.67λ power, 0.20 λ Irregularity
- Lens – 0.52λ Power
- Lens – 0.33λ Irregularity





IR MOLDING DEVELOPMENT TO MEET YOUR APPLICATION NEEDS

- Ball preforms and net shape preforms
- Simple geometries – planar, spherical, aspheric
- Complex shapes under development – diffractives
- Free form shapes in development plan – arrays



Lens Geometry	Preform Type			
	Ball Preform	Plano Plano	Lenslet (Plano - Convex)	Lenslet (Bi-Convex)
Bi-Convex	✓			✓
Equal Meniscus	✓		✓	
Positive Meniscus	✓		✓	
Negative Meniscus	✓		✓	
Bi-Concave		✓		

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FLM VS. PLM

Finished Lens Molding (FLM)

Precision Lens Molding (PLM)

FLM Considerations

- Lower process costs than precision lens molding (no post processing)
- Higher yields (less handling)
- Higher preform costs

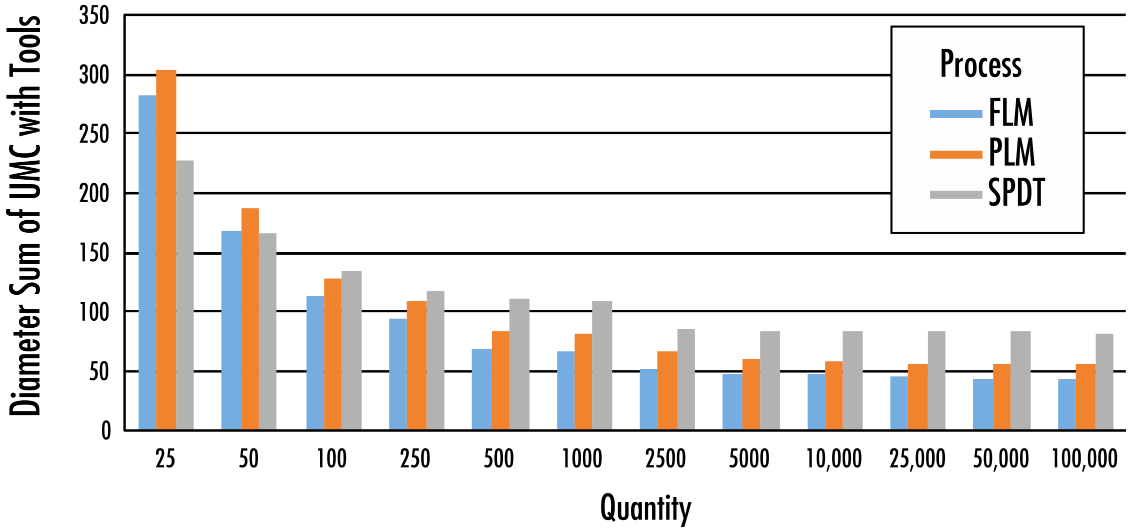
PLM Considerations

- Large clear aperture requirements
- Tight diameter tolerances
- Special features (datums, fiducials, segmenting)

COMPETITIVE COSTING ANALYSIS

Results Matrix

- ✓ Provides comparison between SPDT, FLM, and PLM processing
- ✓ Compared 5 different lens volumes – 7.5mm to 25mm diameter
- ✓ Compared 12 different quantities – 25 pieces to 100,000 AU
- ✓ Analyzed with NRE separate & amortized over order quantity
- ✓ Crossover point is highly dependent on lens volume & order quantity



Assumes 25 mm diameter x 8 mm OAL meniscus optic

Lens Diameter (mm)	Crossover Quantity (AU)
7.5	5,000
10	1,000
15	350
20	90
25	75

** Approximate values shown, reference only*

** Assumes Amortized Tooling NRE*

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Summary

✓ Global markets are looking ……….

The Opportunity Exists

✓ Chalcogenide materials … for new product development ….

The Opportunity Is Real

✓ Recent developments in low cost preforms ….

The Opportunity Is Now

Applications

Energy Conservation

Automotive

Security / Sensing

Medical Monitoring

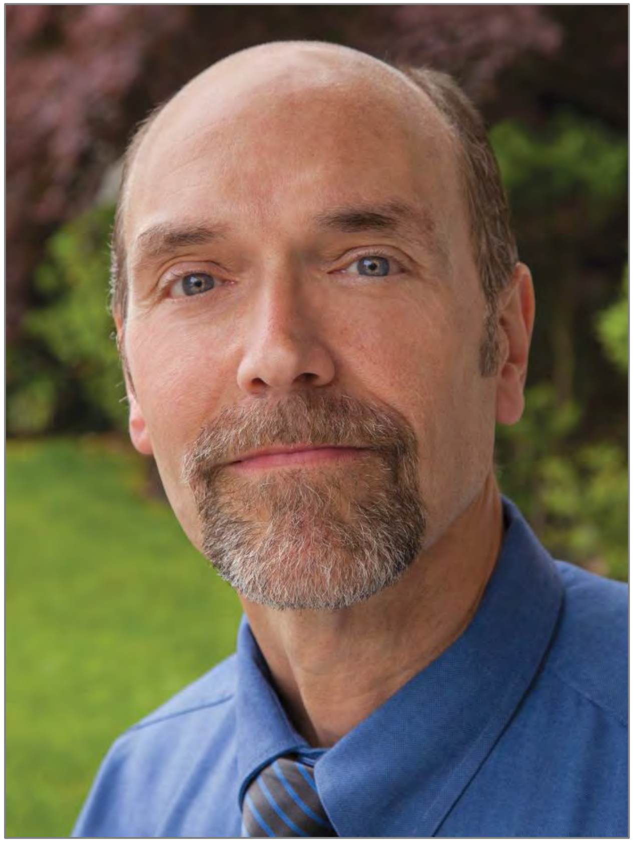
Firefighting

Industrial

Defense

Select Images: sofradir-ec.com

HOW CAN I HELP YOU?



Jayson Nelson

Manufacturing Technology Manager

jnelson@edmundoptics.com

+1-856-547-3488