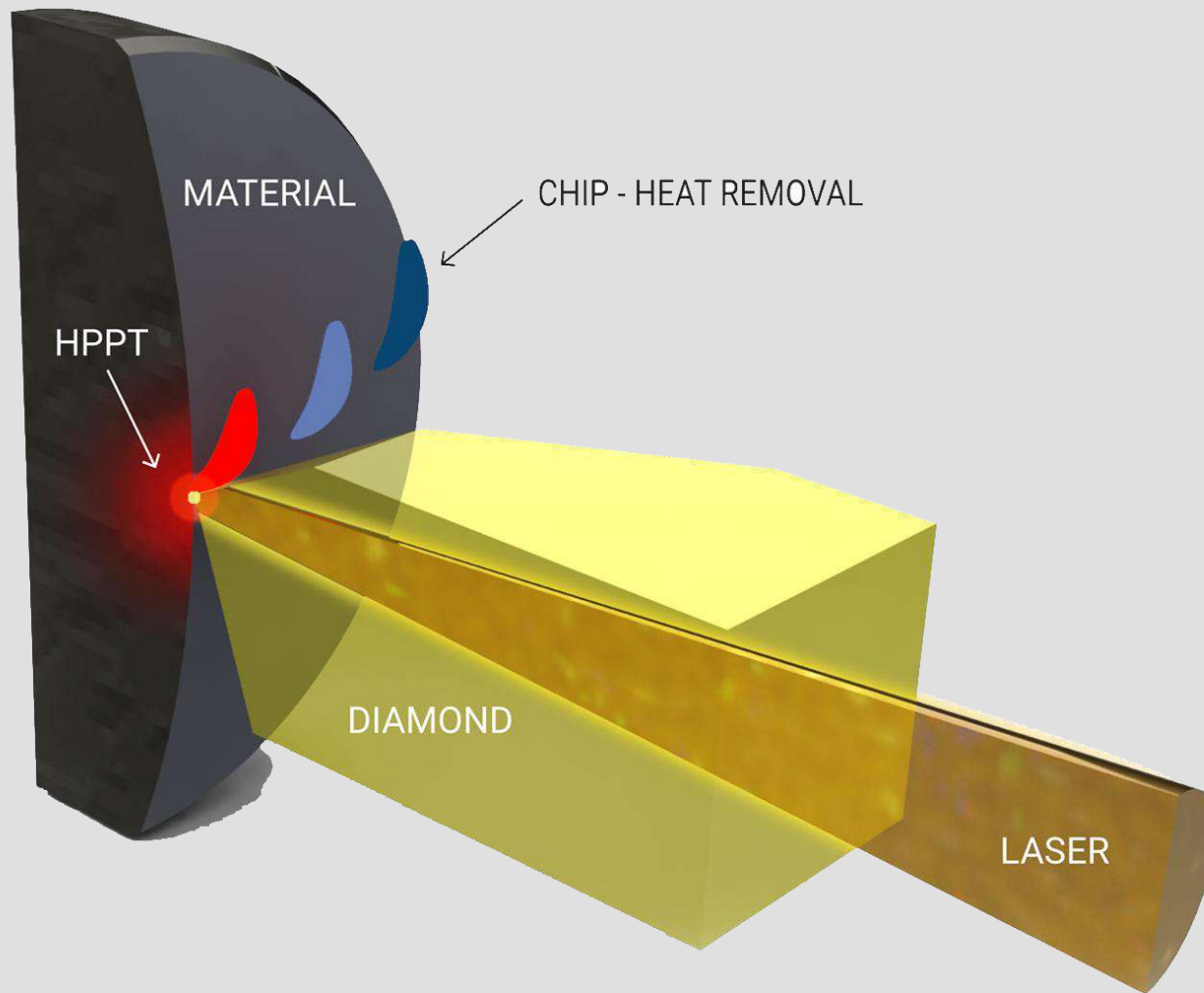




Current Development:
**Laser-Assisted Diamond Turning of
Glass**

THE PATENTED SOLUTION



- Worldwide Patent Coverage.
- Proprietary Opto-Mechanical Diamond Tool (OMDT).
- Flexible Tool Geometries.
- Micro-LAM is the exclusive & only authorized supplier of the OMDT.

Laser Assisted Machining

Optimus Material Capability

Current & Ongoing Development

Infrared

- ✓ Silicon
- ✓ CaF2
- ✓ BaF2
- ✓ ZnS
- ✓ ZnSe
- ✓ Ge (high-speed)

Tungsten Carbide

- ✓ Glass Molding Applications*
- ✓ IR Molding

**2020 Licensing Agreement*



Glass Aspheres

- ✓ Fused Silica
- ✓ BK-7

Reduce polishing time vs. grinding.

In Development (2021-22)

- Glass Aspheres
- Freeform Glass
- Silicon Carbide
- Others (market demand)

KEY VALUE PROPOSITIONS FOR DT GLASS

- Advantages of Diamond Turning over CNC Aspheric Grinding:
 - Improved figure control (form P-V).
 - Improved surface roughness (pre-polish or better quality).
 - Significantly less sub-surface damage.
 - Minimizes polishing time.
- Rapid prototyping for glass elements.
- Ability to add mechanical features with diamond tool.
- Complex aspheric & freeform capability.
- Deterministic manufacturing.

MINIMIZE SUB-SURFACE DAMAGE WITH LAM

Grinding



- $>25\ \mu\text{m}$ sub-surface damage
- Average roughness $>1\ \mu\text{m Sa}$
- Average P-V $>2\ \mu\text{m}$
- Long corrective polishing time



Ø 25mm Fused Silica

Laser-Assisted



- $<3\ \mu\text{m}$ sub-surface damage
- Average roughness $<100\text{nm Sa}$
- Average P-V $<0.5\ \mu\text{m}$
- Short polishing time



Ø 25mm Fused Silica

Diamond Turning Glass

Reduce Polishing Time

Typical Diamond Turning Parameters

(Fused Silica & BK-7)

Spindle Speed: 1000 – 4000 rpm

Feed: 1 – 3 $\mu\text{m}/\text{rev}$

Depth of Cut: 2 - 20 μm

Tool Radius: 0.5 – 2 mm

Part Diameter: 1 – 50mm

Typical Machining Results

Roughness (Ra): 50- 150 nm

Form (P-V): 300 – 600 nm

Sub-Surface Damage Depth: 0.5 - 2 μm

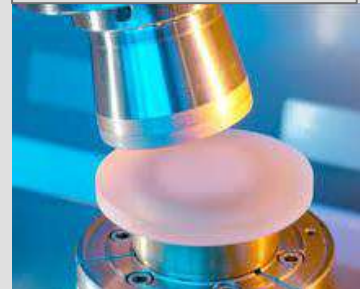


The results vary depending on machining parameters, glass type and part size.



Reduced Polishing Time: 40 – 70 %

CASE STUDY: 50MM FUSED SILICA ASPHERE

<p>Spherical Generator For Best Fit Sphere</p>	<p>CNC Aspheric Grinding. 3μm P/V, 25μm Subsurface</p>	<p>CNC Aspheric Polishing. 1μm P/V Remove 25-30μm</p>	<p>CNC Finish Polishing 0.15μm P/V Remove < 2μm</p>	<p>CNC Optical Centering.</p>
<p>15 mins</p>	<p>30 mins</p>	<p>50 mins</p>	<p>20 mins</p>	<p>10 mins</p>

<p>15 mins</p>	<p>30 mins</p>	<p>10 mins</p>
<p>Spherical Generator For Best Fit Sphere</p>	<p>LAM Diamond Turning & Optical Centering 0.50μm P/V, <2μm Subsurface</p>	<p>CNC Finish Polishing 0.15μm P/V Remove < 4μm</p>
		

125 mins
vs.
55 mins

55% Savings on
machining time

75% savings on
metrology time

Emerging Markets: Automotive, Consumer Electronics & Medical

Luxury Car – 15-25 lenses/car



Driverless Car – 45-55 lenses/car

