



Background

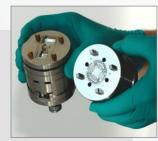


- Metal product surface finishing is important
 - Mechanical properties
 - Optical properties
 - Corrosion resistance
 - Visual impression
- Mechanical polishing process takes up 30% to 50% of the production cycle time









- A need of high precision micro-polishing due to the demand on minimization and complex parts to consumer product
- Particularly for the mould and die industry, high value-added product



Limitations of Conventional Polishing



- Mechanical polishing process is labour-intensive and time-consuming
- Lack of skillful technicians, poor repeatability & reproducibility
- Challenging to polish micro-sized feature, even with robotic arm and CNC machine integration
- Even tiny error or defect can make irreversible damage

 Suspended particulate generated in the process leading to health issue

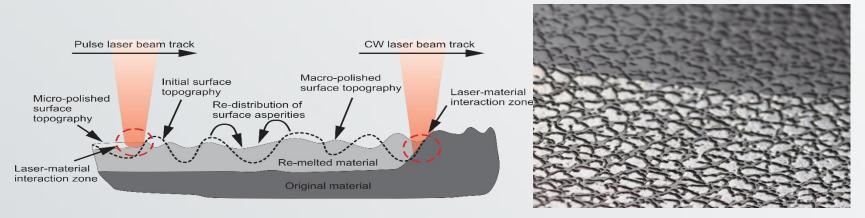




What is Laser Polishing



- Automated laser process, operator independent
- Non-contact polishing with employed two types of laser, CW and pulsed
- High reproducibility, high process speeds, especially when compared to manual polishing
- No grinding and polishing particulate generated



Selectively polished surface



2-step Laser Polishing Process



	Macro-polishing	Micro-polishing
Laser radiation	Continuous Wave Laser	Pulse Laser
	laser polished remetted layer liquid heat effected zone cw laser radiation y z laser power constant initial surface roughness remetted layer liquid solid	laser radiation V _s laser polished initial surface roughness remelted layer melt pool heat affected zone solid
Remelting depth	20 - 100 μm	< 5 μm
Process time	7 - 60 s/cm²	1 - 10 s/cm²
Initial roughness	 milled, turned, EDM Ra = 0.4 - 10 μm 	 ground, fine milled Ra = 0.2 - 0.8 μm Adjust glossy
Achievable roughness	Depending on material, material quality and initial roughness Ra = 0.1 - 0.50 μm	



Laser Polishing Process



Process video on tool (24s)





Laser Polishing System



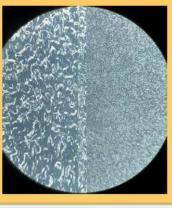


- CW + pulsed fiber laser source
- 3-axis galvo scanner and 5-axis portal machine with XYZ-AC kinematics
- Designed for parts with up to 100 kg
- Protective gas process chamber

Innovative Polishing Process

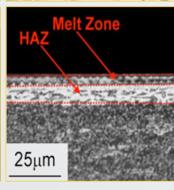






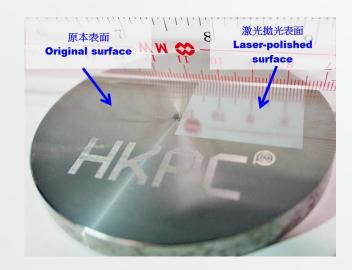






- HKPC developed patented laser polishing process
- Optimal processing parameter on materials:

Tooling steel
Stainless steel
Titanium & Ti alloy





Comparison of Polishing Surface Microstructure



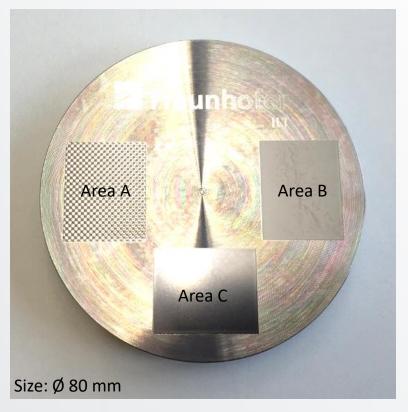
Conventional Polishing	CW Laser	Pulsed Laser
Steel	TiAl6V4 Steel	TiAl6V4 Steel
 Sharp-edged scratches Flat surface Risk of loosing dimensional accuracy Correction of errors 	 No sharp-edged scratches Nearly no change in dimensional accuracy Slightly wavy surface No error-correction 	 No sharp-edged scratches Nearly no change in dimensional accuracy Finer surface No error-correction



Solution and Technical Advantages Materials Study



- Sample materials: 1.2343 Tool steel (H11)
- Initial turned surface Ra ≈ 1.5μm
- A: Laser structured surface, micro-laser polished
- B: Macro-laser polished Ra ≈ 0.12μm
- C: Macro- and micro-laser polished Ra \approx 0.09 μ m
- The optimal surface Ra ≈ 0.1µm will be possible with laser polishing

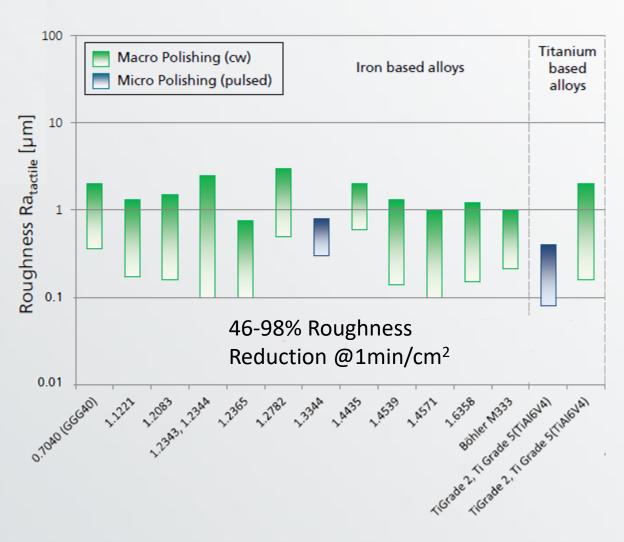


Remarks: Laser polishing parameter database developed



Materials Database



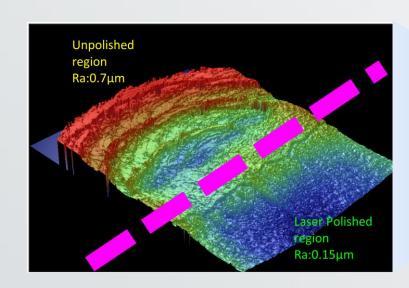


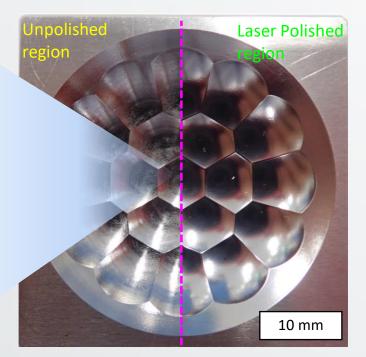


Solution and Technical Advantages Tool of Patterned Lens



- Materials: 1.2083 Stainless steel
- Reduction of 50% manual polishing processing time
- Initial surface roughness: Ra ≈ 0.7μm
- Polished cavity surface roughness Ra: ≈ 0.15 μm (B1)



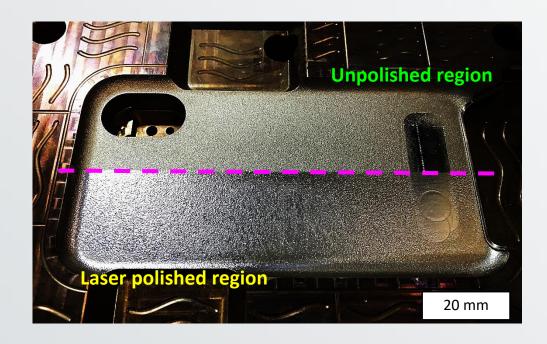




Solution and Technical Advantages Tool of Textured Phone Cover



- Materials: 1.2344 Tool steel
- Chemical etched pattern with high initial surface roughness
- Processing time: 15 minutes (selectively polished area)
- Glossy surface is formed by laser polishing on etched pattern surface





Solution and Technical Advantages Tool of Glass Bottle



- Materials : GGG40
- Ductile iron is difficult to polish due to carbon nodular
- State of the art for manual polishing with a roughness Ra $\approx 0.4 \mu m$
- Initial roughness (as milled): Ra ≈ 1-2μm
- Laser polished roughness: Ra ≈ 0.35-0.40μm
- Homogeneous roughness over the complete surface achieved



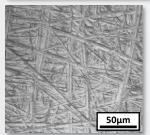


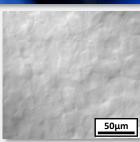
Solution and Technical Advantages Medical device (VAD) parts



- Materials : Titanium grade 5
- Processing time:
 - Manual polishing: 3 hours
 - Laser polishing: approx. 5 minutes
- No chemical contamination by polishing process
- Less sharp-edged scratches
- Precision dimensional control
- No correction of errors from previous manufacturing steps









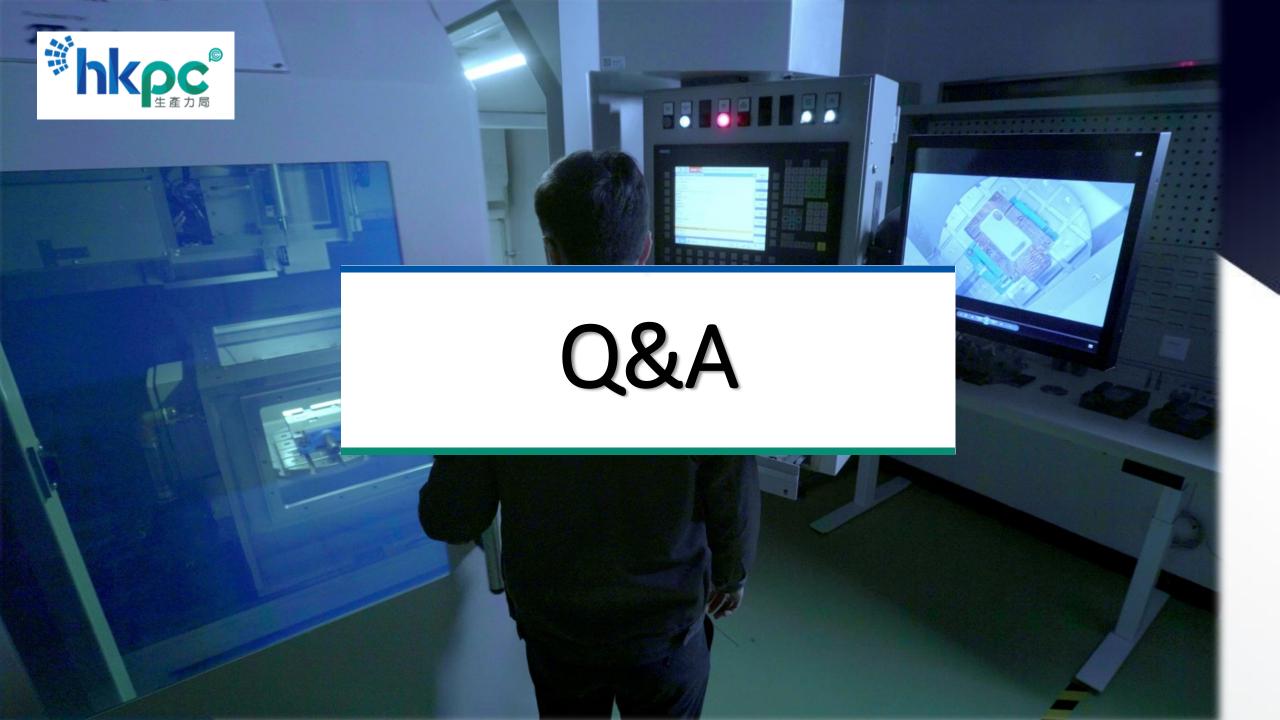
Summary





- Innovative
 - Feasible for 3D geometries
 - Automated laser process
 - Fast speed (5-12x)
 - Excellent dimensional accuracy

- Challenging issue
 - Complicated geometries, sharp ends
 - Fine texture patterned & selective polishing region
 - Chemical-free polished surface
 - Improve tool lifetime







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