



The Synergy of Water and Fire

‘Advanced Micro Machining Applications from Watch Gears to Turbine Blades’



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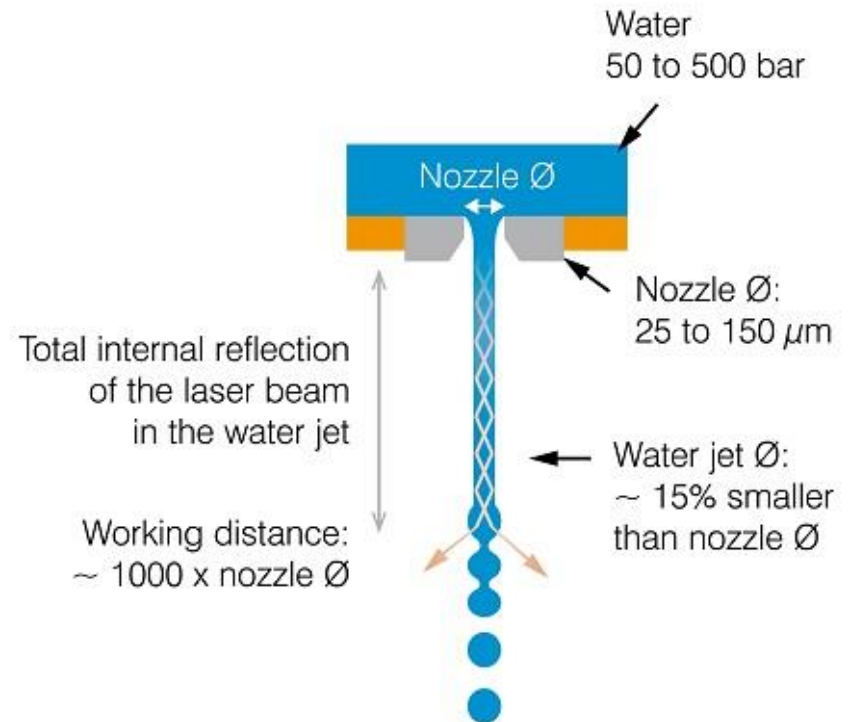
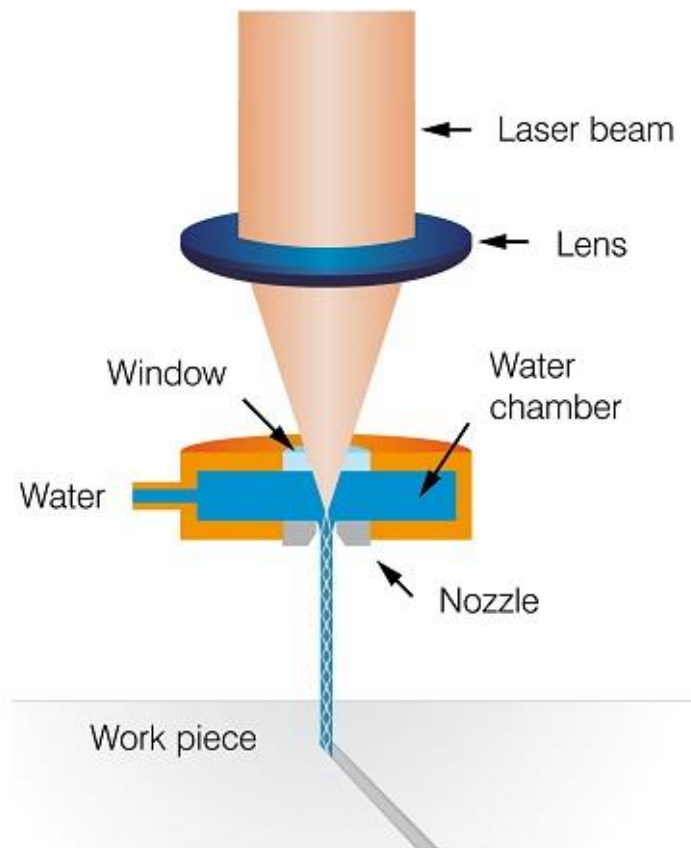
Synova Confidential

Research - Oriented Manufacturing Operation

- Established: 1997
- Product Focus: Laser MicroJet applications
- Location: Duillier, Switzerland
- Number of employees: 75
- Capacity: 100 machines per year
- 4 subsidiaries with demo centres in the USA, Japan, Korea and India

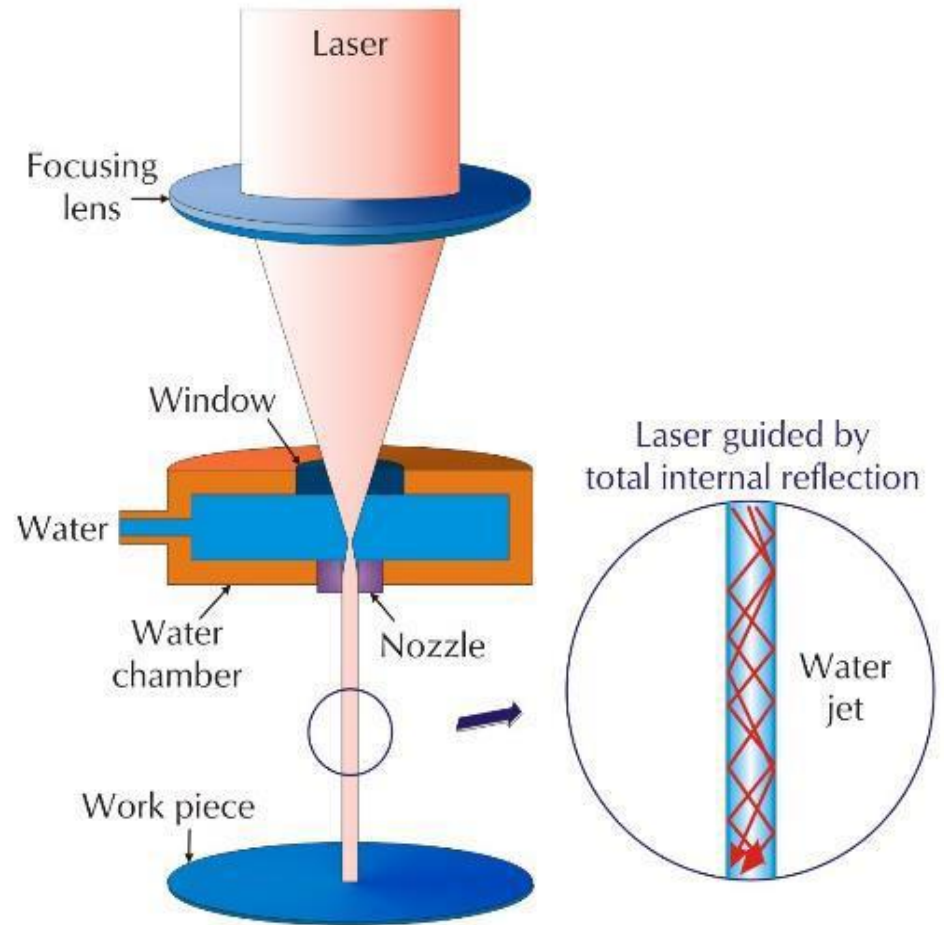


Laser MicroJet Principle



Laser MicroJet Technology

- Using the differences in the refractive indices between air and water, the technology creates a laser beam that is completely reflected at the air-water interface
- The laser is entirely contained within the water jet as a parallel beam similar in principle to an optical fiber



Technology Benefits

Conventional Laser

Requires precise focus adjustment



Conical laser beam leaves non-parallel kerf walls



Limitations in cutting aspect ratio



Heat affected zone



Particle deposition



Inefficient material removal leaves burrs



Laser MicroJet



No focus adjustment required, non-flat surfaces are not an issue, 3D cutting possible, variable cutting depth of up to several cm



Cylindrical beam results in parallel kerf walls, consistent high quality cutting



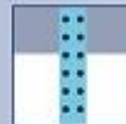
High aspect ratio, very small kerf width ($>20\text{ }\mu\text{m}$), minimal material loss, with simultaneous deep cuts possible



Water-cooling process avoids thermal damage and material change, high fracture strength is maintained



A thin water film eliminates particle deposition and contamination, no surface protection layer required



High kinetic energy of the water jet expels molten material, no burrs form



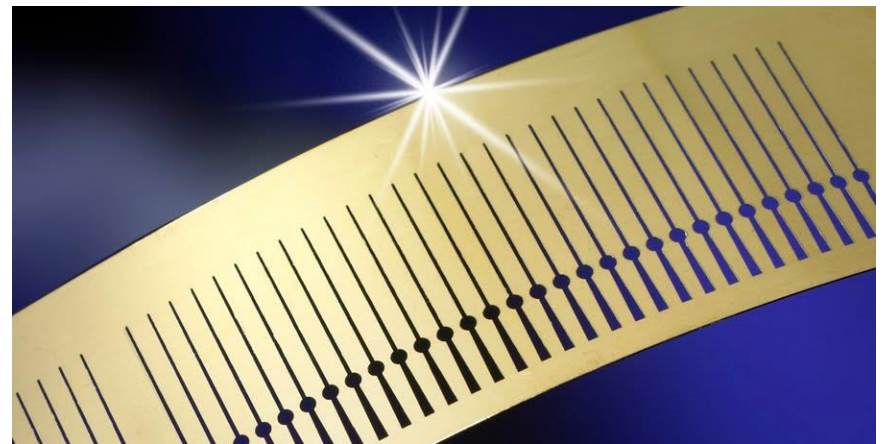
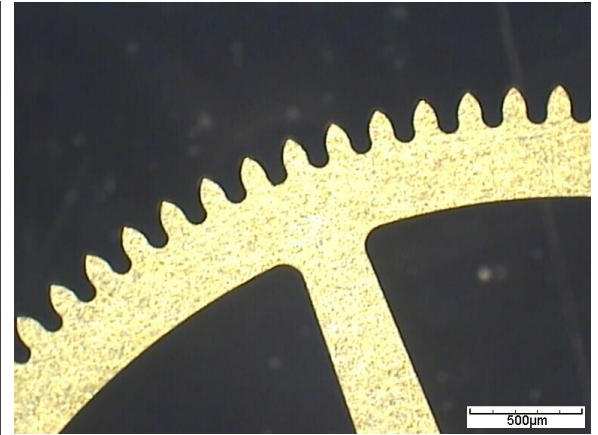
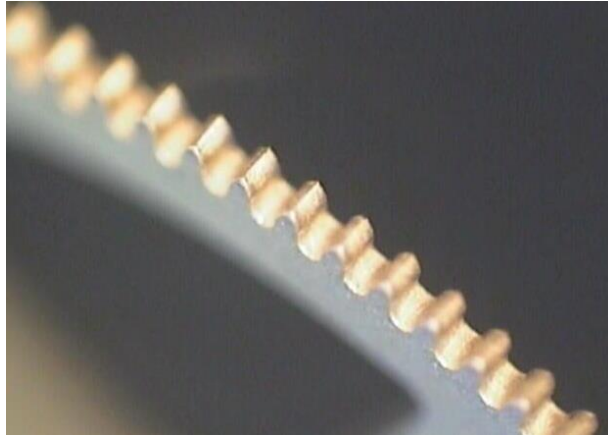
Application: Watchmaking

Synova's advanced Laser MicroJet (LMJ) systems with 3 or 5 axes are ideally suited for cutting watch movement components and decorative parts with high precision and quality as needed for the watch industry.

- Excellent cutting quality with smooth surfaces and sharp edges
- Parallel kerf walls due to cylindrical laser beam
- Narrow kerf widths of 25 μm to 60 μm , depending on nozzle size
- Thickness from 0.05 mm to 4 mm (up to 10 mm)
- Low roughness (R_a) of the cutting wall from 0.15 μm to 0.7 μm , depending on the laser source
- No or very limited heat affected zone (HAZ), no burrs due to water cooling and cleaning capabilities
- Very flexible, new designs quickly prepared under CAD control



Application: Watchmaking Examples



Application: Tooling Manufacturing

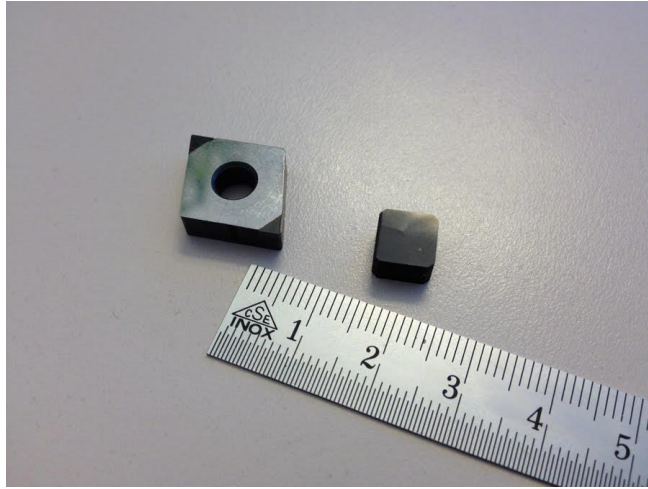
Synova offers fast and accurate laser machining solutions for the tool manufacturing industry.

- Materials: PCD, SCD, natural diamond, PcBN, carbide
- Maximum thickness: 20 mm (PCD/ WC drill bits)
- Average thickness:
 - 1.6 mm for PCD/ WC inserts
 - up to 2 mm for SCD
 - up to 4.7 mm for PcBN
- Operations: Roughing, finishing, clearance shaping (with evolving clearance angle, if needed)
- High speed 2D & 3D cuttings
- Low roughness on PCD: ($R_a < 0.3$ micron)

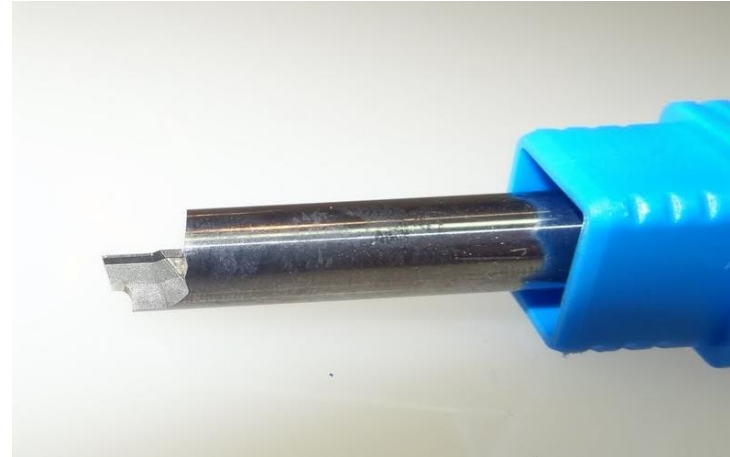


Application: Tool Manufacturing Examples

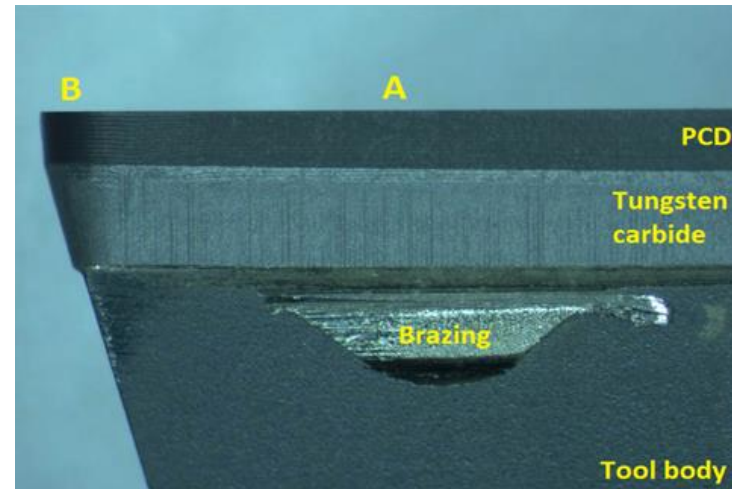
PCD tool inserts



PCD Drilling tool inserts



MCD tool insert



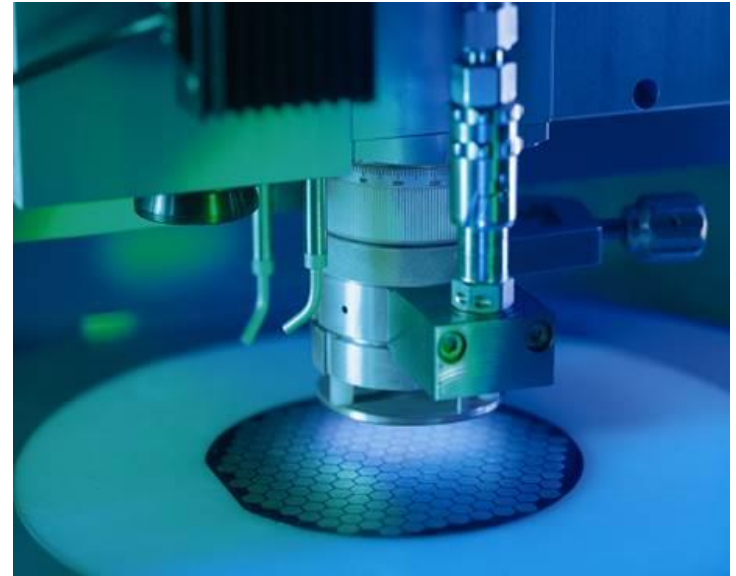
Surface and edge quality by LMJ



Application: Semiconductors

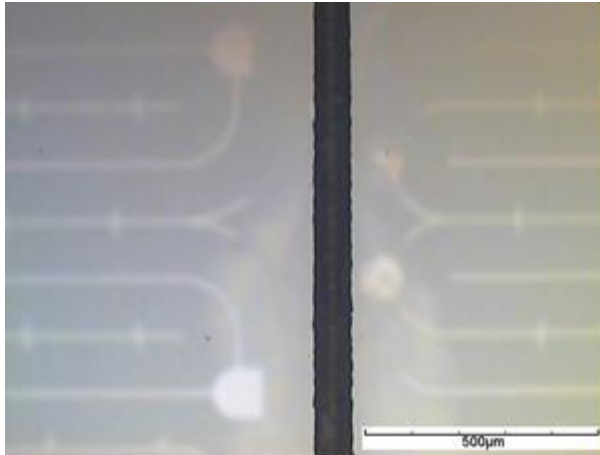
Synova's unique water jet guided laser systems offer many advantages for applications in the semiconductor industry compared to conventional diamond blade saws or laser systems.

- High precision with a tolerance of $\pm 3 \mu\text{m}$
- Cutting of any shapes (2D) possible
- High cutting speed: up to 200 mm/ s
- Wafer thickness from 50 μm to 2 mm
- Maximum axis velocity 1000 mm/ s

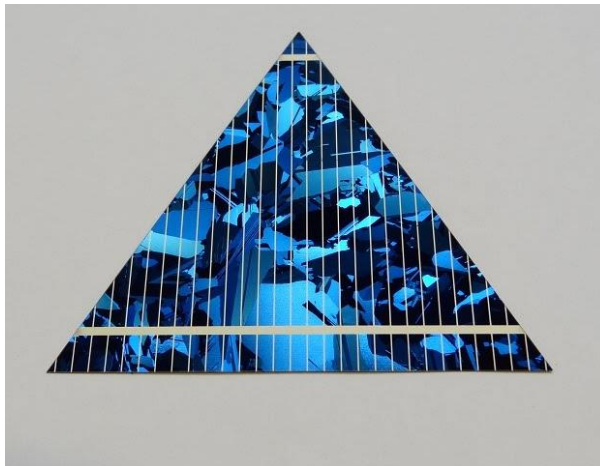
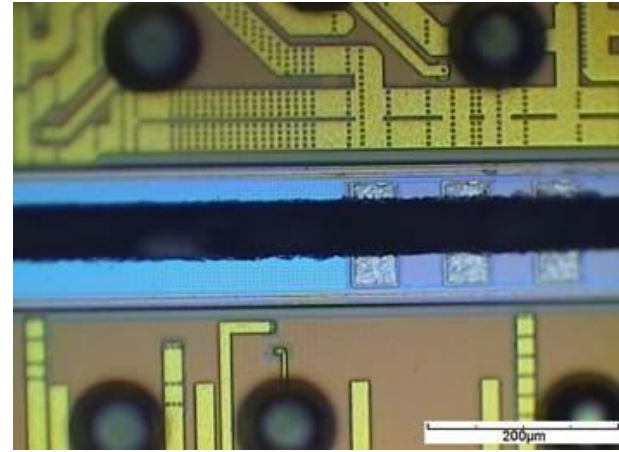


Application: Semiconductor Examples

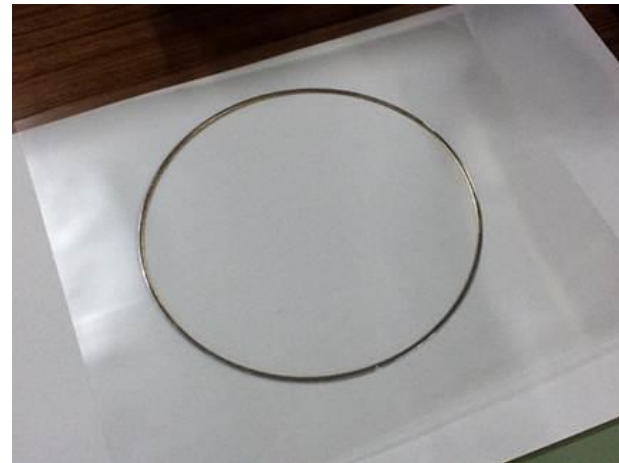
Grooving on Sapphire



Thin Low-k wafer



Solar Cells



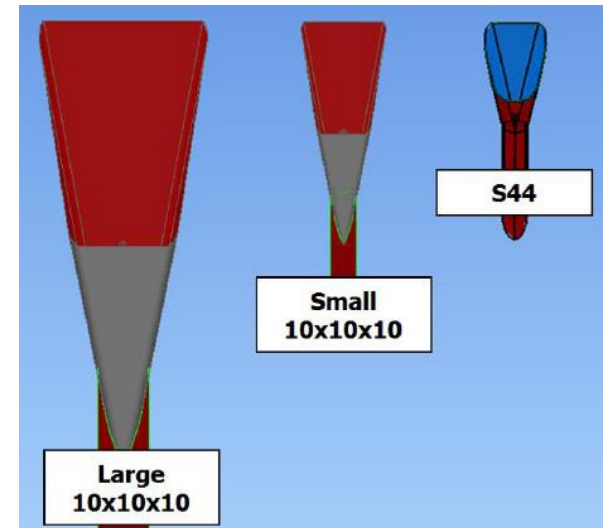
Wafer edge after removal

Application: Energy & Aviation

Synova's advanced Laser MicroJet (LMJ) systems with 3 or 5 axes are perfectly suited for machining high-precision parts in the energy and aviation industry.

Typical Shaped Holes

- IGT Turbine Parts: Large 10x10x10
- Aerospace Turbine Vanes: Small 10x10x10
- Aerospace Turbine Blades: S44



Compared Processes:

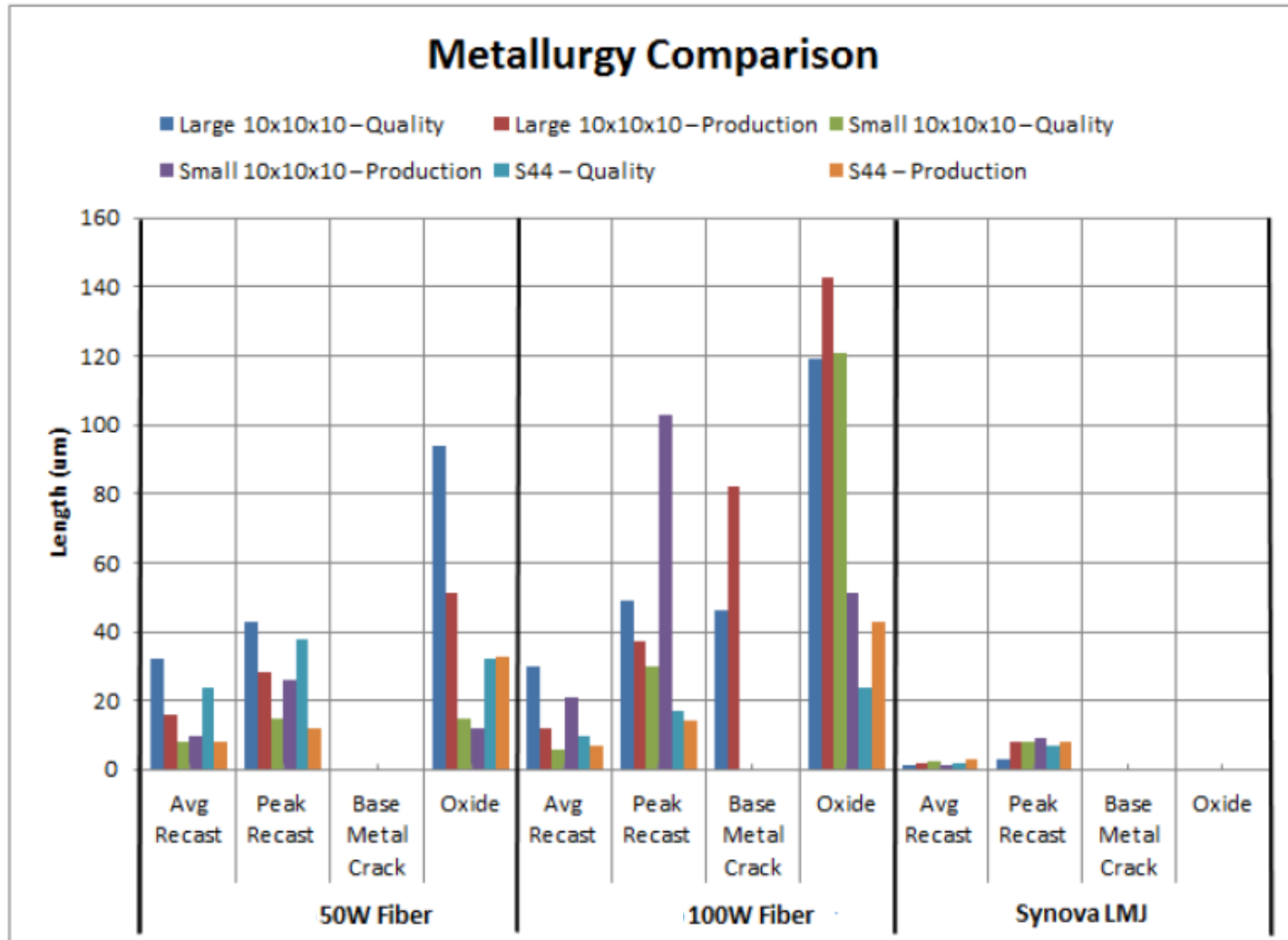
- Laser MicroJet
- 50 W Fiber Laser
- 100 W Fiber Laser

- Each of the three shapes was produced using two different methods, «Production» (balance between quality and speed) and «Quality» (ideal shape with best quality)

- Material: Inconel 718 plates, 2 mm thick

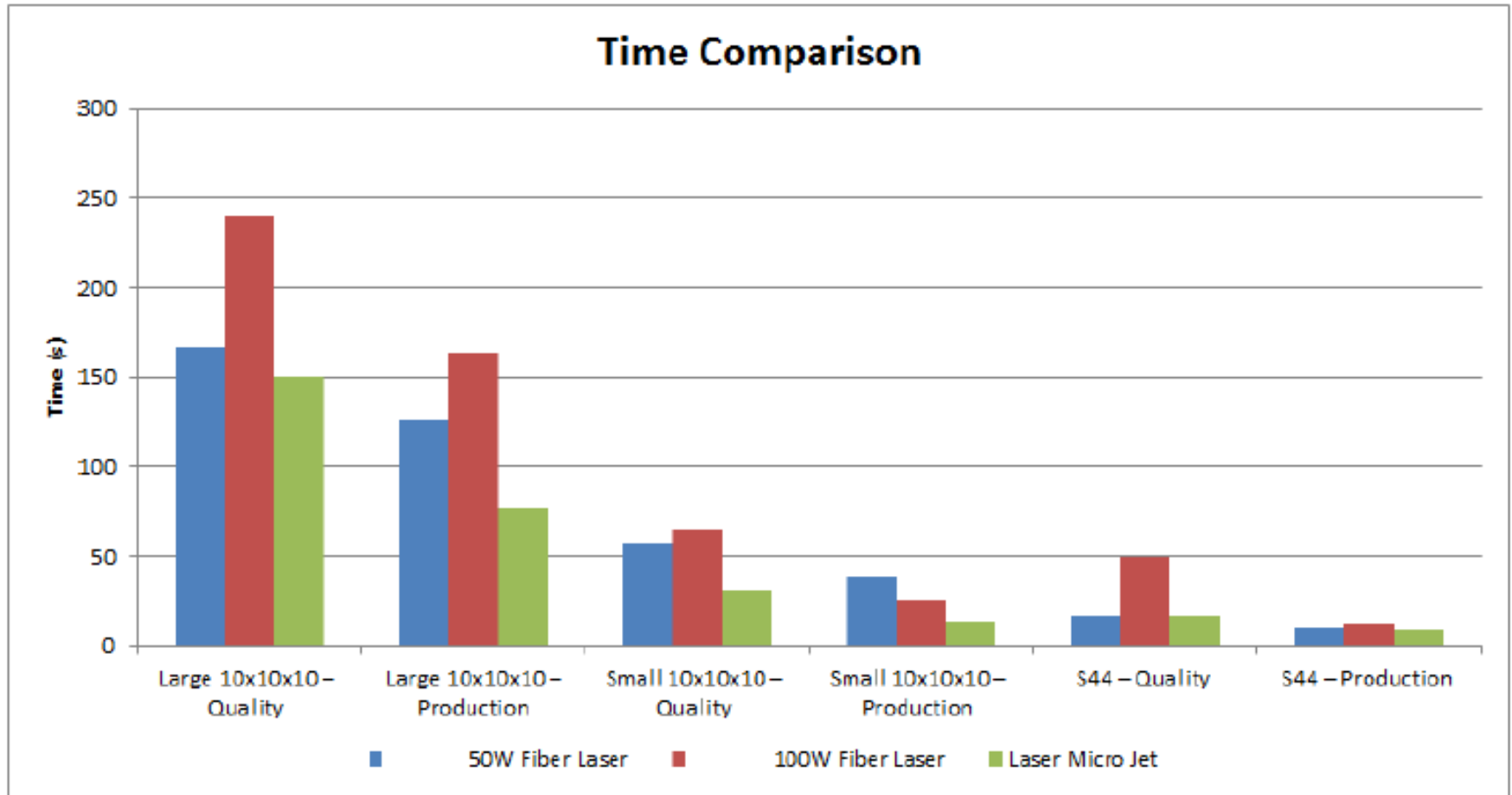


Application: Energy & Aviation

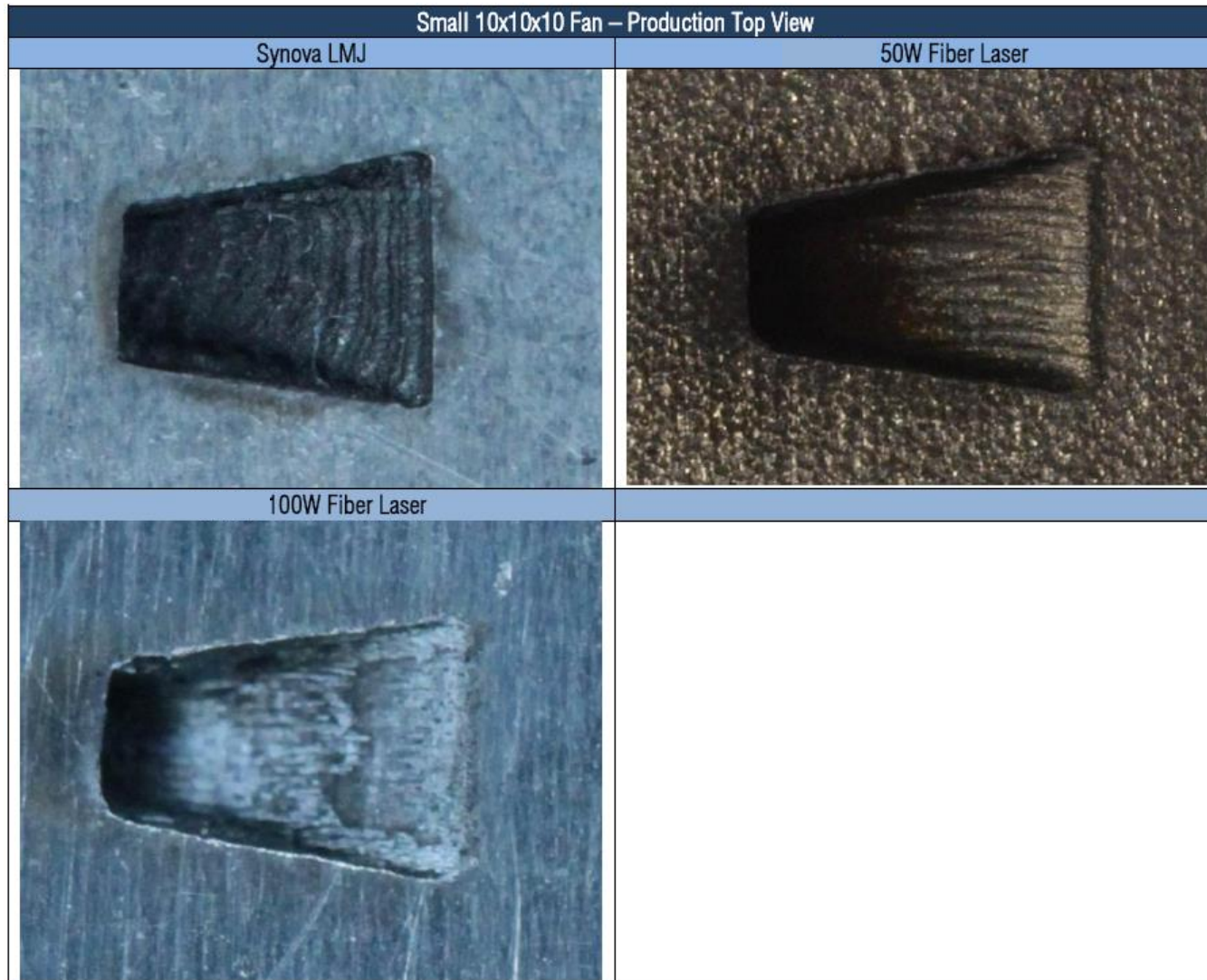


Application: Energy & Aviation

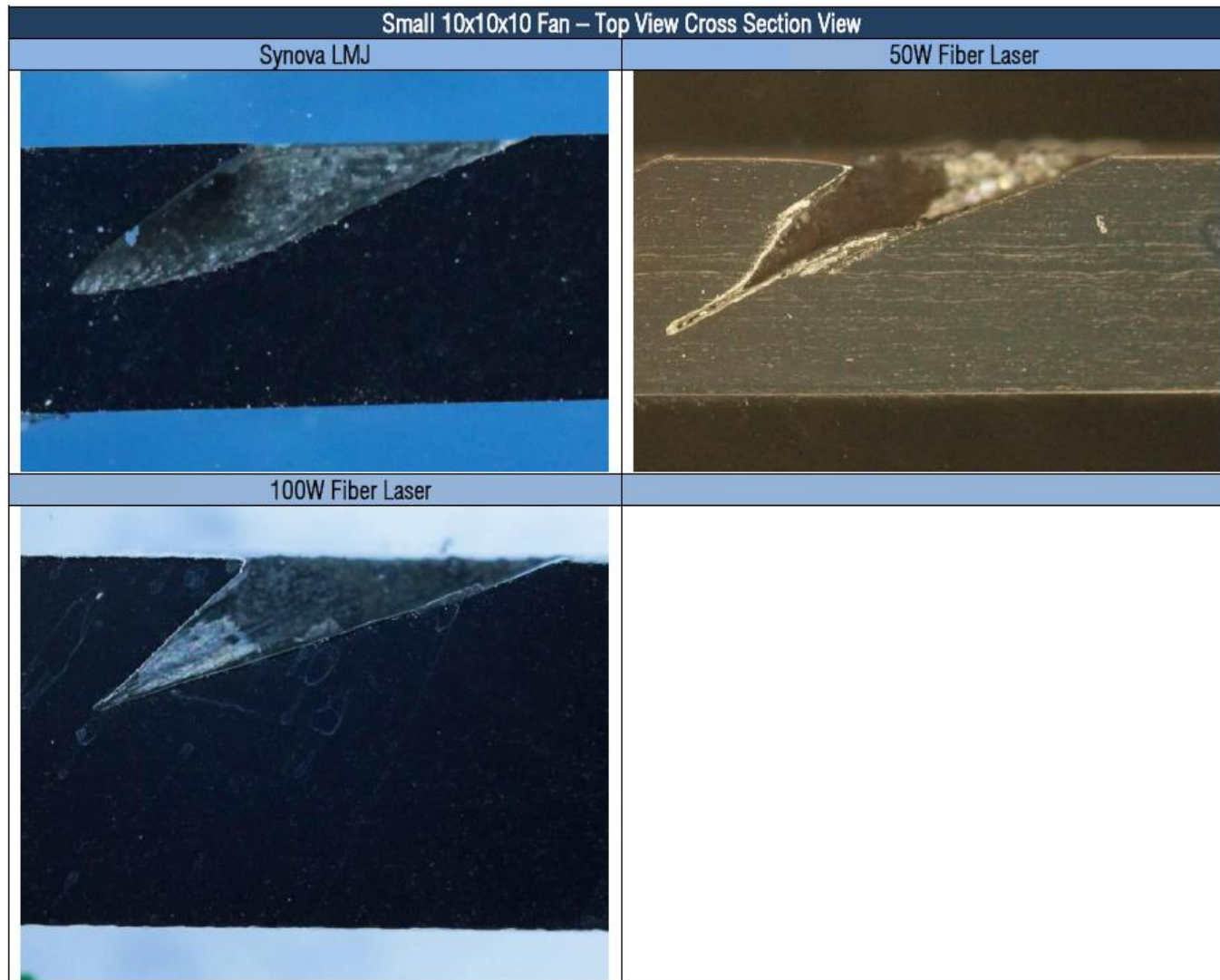
Speed Results



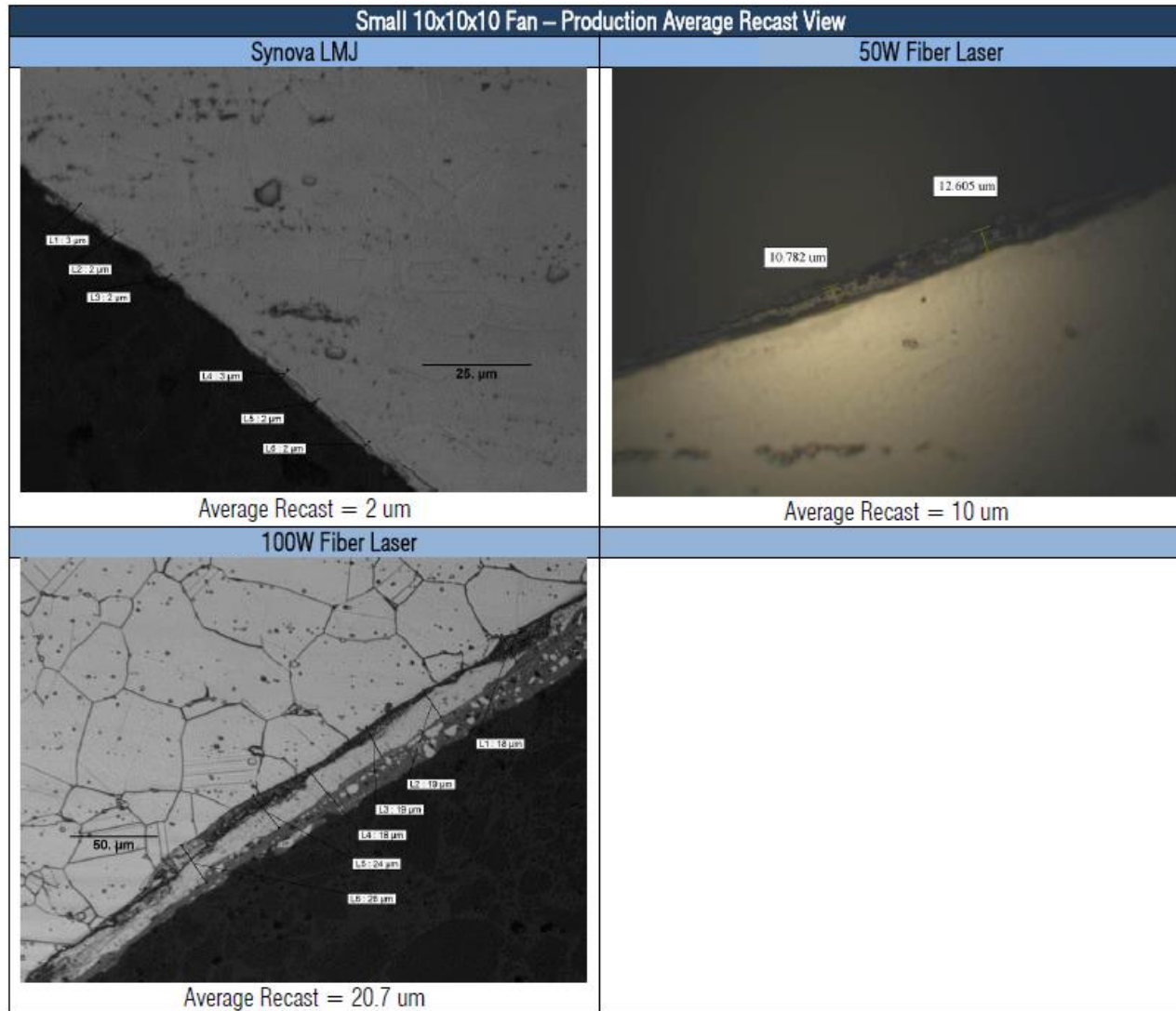
Pictures – Small Holes



Pictures of Cross Section – Small Holes



Pictures of Recast – Small Holes



MCS Series - Metal Cutting System

- Synova Laser MicroJet
- Makino-based platform
- 3-axis MCS 300
- 5-axis MCS 500
- Hole-drilling in super-alloys (8mm thick, 0.76 dia. in 70 seconds)
- 30µm kerf width
- Precision: $\pm 1.5\mu\text{m}$
- High aspect ratio in hole-drilling (up to 1:20)



Materials

- Metals: Super-alloys, stainless steel, aluminium, copper, nickel, titanium
- Hard Materials: Ceramics, PcBN, PCD, MCD, CVD diamonds, tungsten carbide
- Ceramic-matrix composites (CMCs): Carbon, alumina, silicon carbide



Operations

- MCS 300: Cutting, grooving, drilling, shaping in 3 axes, trenching, milling, dicing, engraving, profiling
- MCS 500: Cutting, grooving, shaping in 3 and 5 axes, trenching, milling, dicing, engraving, profiling



General Specifications

		MCS 300	MCS 500
Working volume	mm (W x D x H)	400 x 300 x 200	500 x 400 x 500
B-axis		360°	- 100°to 50°
C-axis			360°
Max. stroke	mm (X, Y, Z)	480 x 310 x 210	760 x 400 x 500
Accuracy	μm	± 1	± 1.5
Repeatability	μm	± 1	± 1
Max XY speed	m/min	60	60



Hybrid Diffuser Machining



Hybrid Diffuser Machining

Machine Technologies

- Unique water jet guided Laser MicroJet by Synova
- High Performance EDM hole-drilling by Makino
- Work piece position data is transferred between machines



The whole is truly greater than the sum of its parts!



Turbine Engine Market Demands

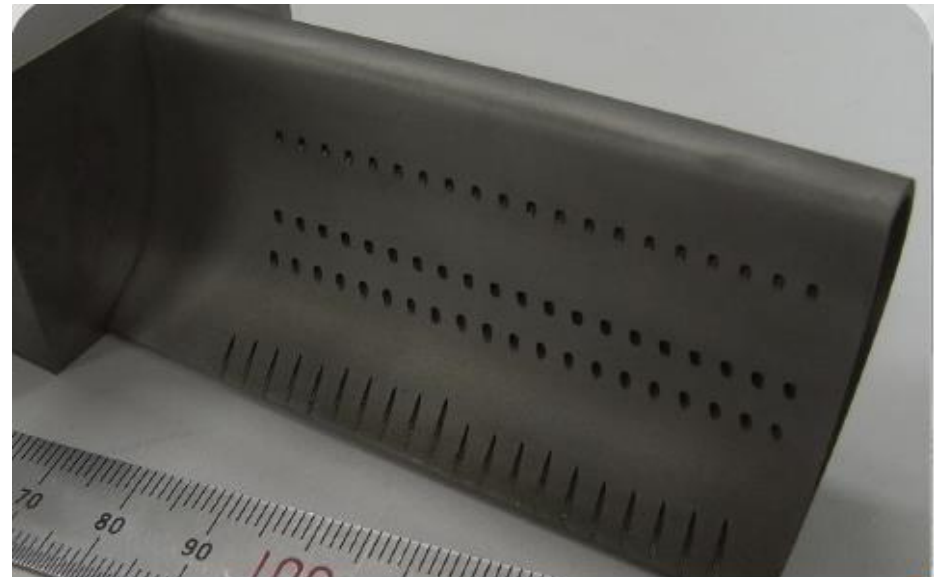
- Increased number of holes in airfoils with more complex geometries
- Increased use of thermal barrier coatings
- Desire to pre-coat and drill components
- Higher performance requirements drive needs for higher hole-drilling quality



Hybrid Diffuser Machining

Process Capability & Flow

- Single process for parts with Thermal Barrier Coatings (TBC)
- Handles Non-Line-Of Sight holes (NLOS)
- Balanced cell outputs



Laser MicroJet	EDM Drilling
Drills through TBC	Deep Holes
Single Step Diffuser & Hole	NLOS Holes



Hybrid Diffuser Machining

Laser MicroJet Technology

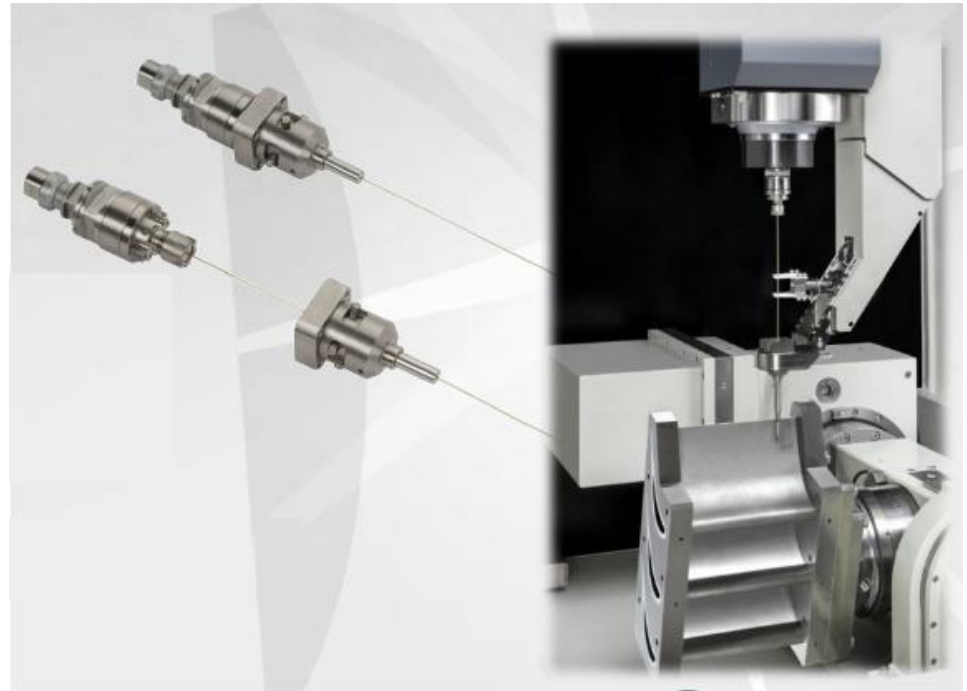
- No recast or damage on exit hole
- Typical Depth-to-Diameter of 10:1 to 20:1
- Angle cutting possibilities down to 25°
- Typical speed: 60s/hole is average
- Smallest holes of 0.4 mm dia. on 3 mm material thickness



Hybrid Diffuser Machining

EDM Drilling Technology

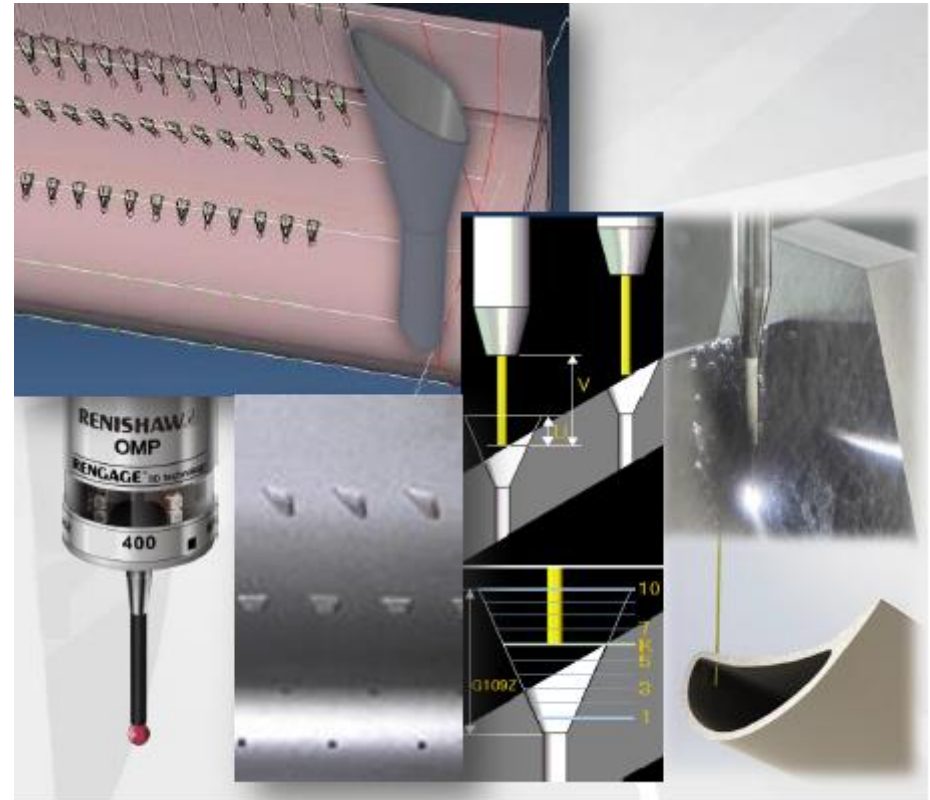
- Fully submerged operation
- Fast & Reliable Break-Thru detection
- Integrated Tool holders
-> Fast ATC
- Vibration Control Finger System
- Optimized for Hole Drilling & Diffuser Shapes



Hybrid Diffuser Machining

EDM Drilling Technology

- Ability to process NLOS features
- Integrated 3D Probing Setup capability
- Generator achieves high speed with required metallurgical quality
- Rise/Fall Work Tank (Ergonomics & Automation)



Hybrid Diffuser Machining

HybridCell Process Summary

- Leverages productive advantages of Laser & EDM Machining
- Processes fully thermal coated turbine engine components
- Eliminates process steps typically associated with TBC coating
- Achieves greater process quality control with potential cost savings



Questions?



Hybrid Diffuser Machining



Thank You!

