INTERTECH 2017

Cutting Diamond Tools
By Laser MicroJet®

New developments in the wet laser machining of industrial diamond tools

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Synova S.A.

SYNOVA
Innovative Laser Systems

Speaker introduction

- Sébastien Kurzen
- Synova S.A. – Switzerland
- Application Engineer
- Diamond tools
- Simultaneous 5-axis machining for diamond tools and CAD/CAM software

Presentation Contents

1. Company
2. Laser MicroJet® technology
3. LCS 50-5
4. State of the art results cutting PCD/WC
5. State of the art results cutting SCD
6. Conclusions

1. Company

- Laser cutting machines (using the Laser-MicroJet principle)
- HQ in Duillier, near Geneva, Switzerland
- Founded in 1997
- 75 employees
- Micro-Machining Centers (MMC’s) in the USA, India, Korea, Japan

2. Laser MicroJet® (LMJ) technology

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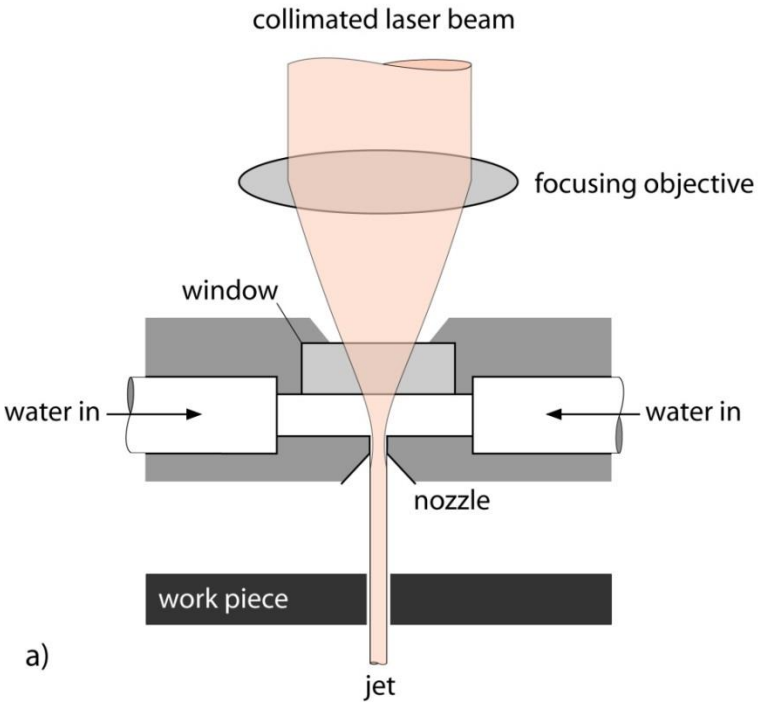
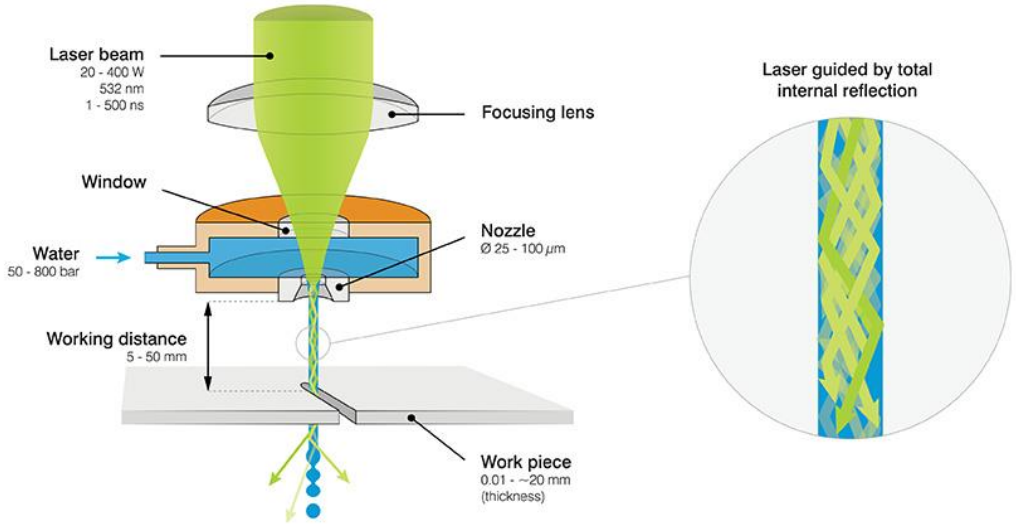
- Laser beam focused into nozzle aperture



2. Laser MicroJet® (LMJ) technology

- Laser beam focused into nozzle aperture
- Laser light guided within water jet by total internal reflection



2. Laser MicroJet® (LMJ) technology

- Laser beam focused into nozzle aperture
- Laser light guided within water jet by total internal reflection
- Laser pulses evaporate material, water cools and cleans between the pulses
- By scanning, a trench is formed which becomes deeper with each pass

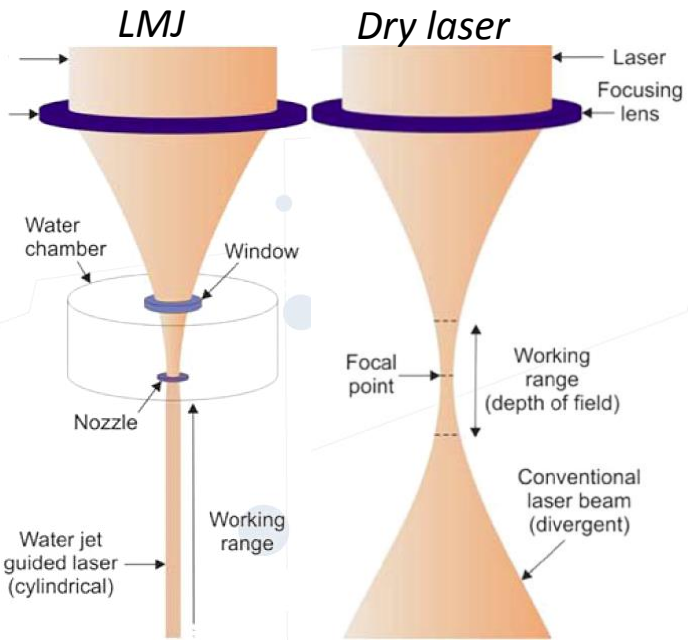
2. Laser MicroJet® (LMJ) technology

https://youtu.be/Q_lRaONosxc?t=54s

2. Laser MicroJet® (LMJ) technology

Advantages are:

- No focus adjustment
- Parallel sided kerf
- Minimal heat affected zone
- High material removal rate
- Debris washed from kerf



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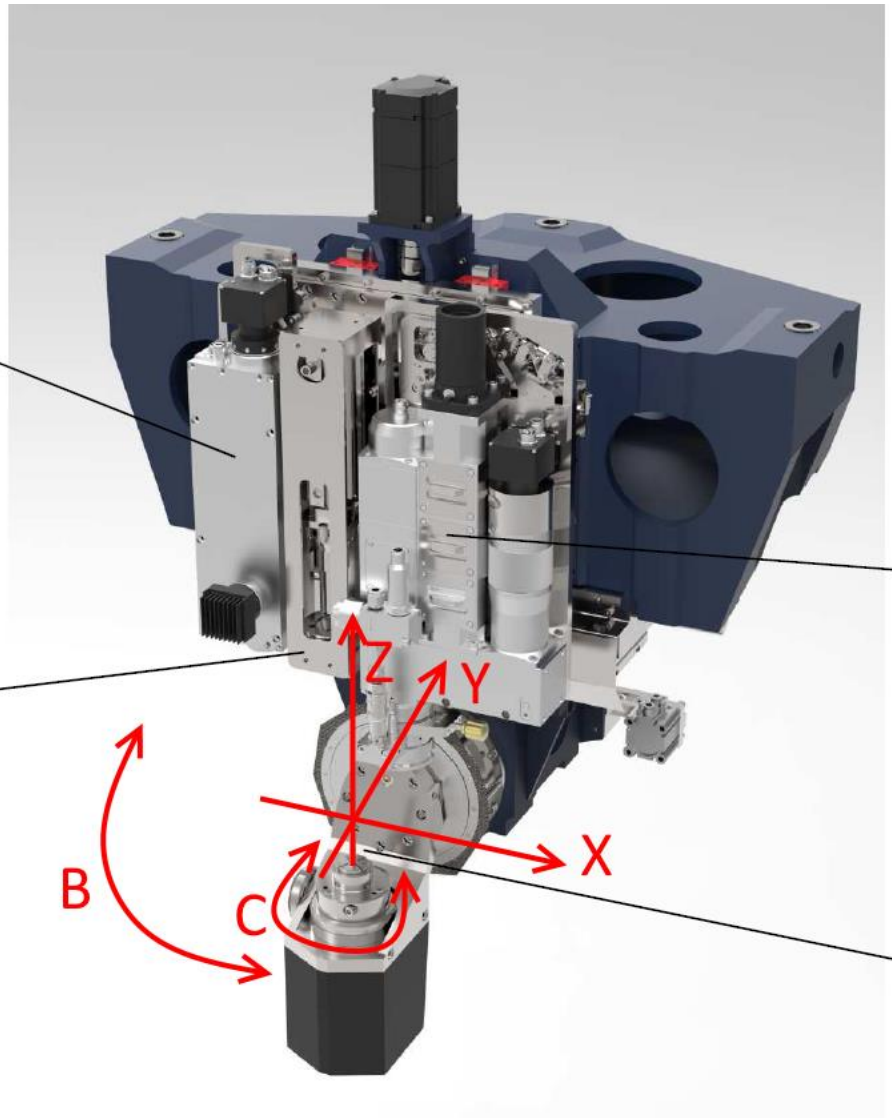
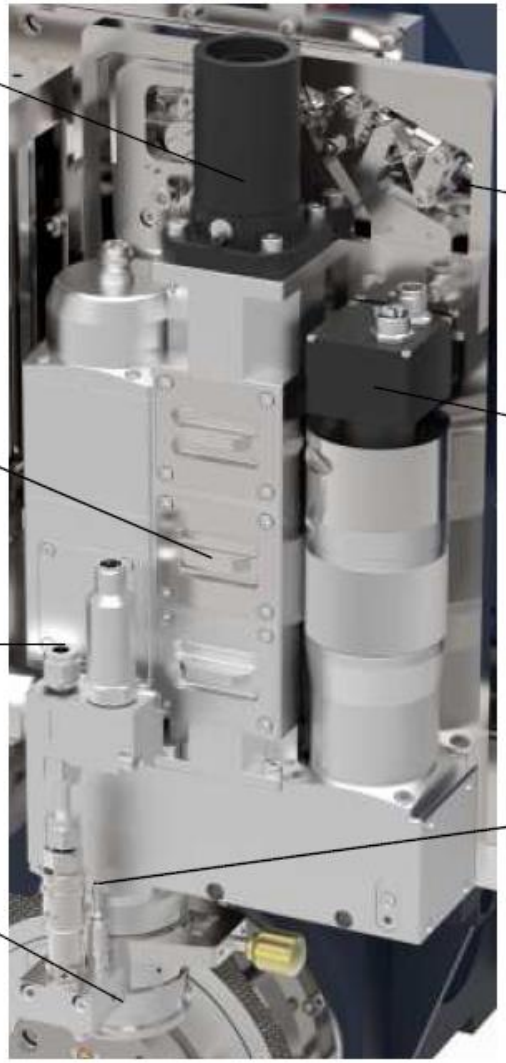

Vision
Camera
Optical
Head
Touch
Probe
Z
Y
X
B
C
Work Piece
Chuck


Fiber Connection
Jet Angle Correction
Optical Head
Nozzle Alignment Camera
Water Connection
Helium Connection
Coupling Unit and Nozzle

3. LCS 50-5

Mainly used to cut:

- Polycrystalline diamond (on WC) & PcBN
- Single crystal diamond (HPHT or CVD)
- Natural diamond
- Ceramics
- Metals

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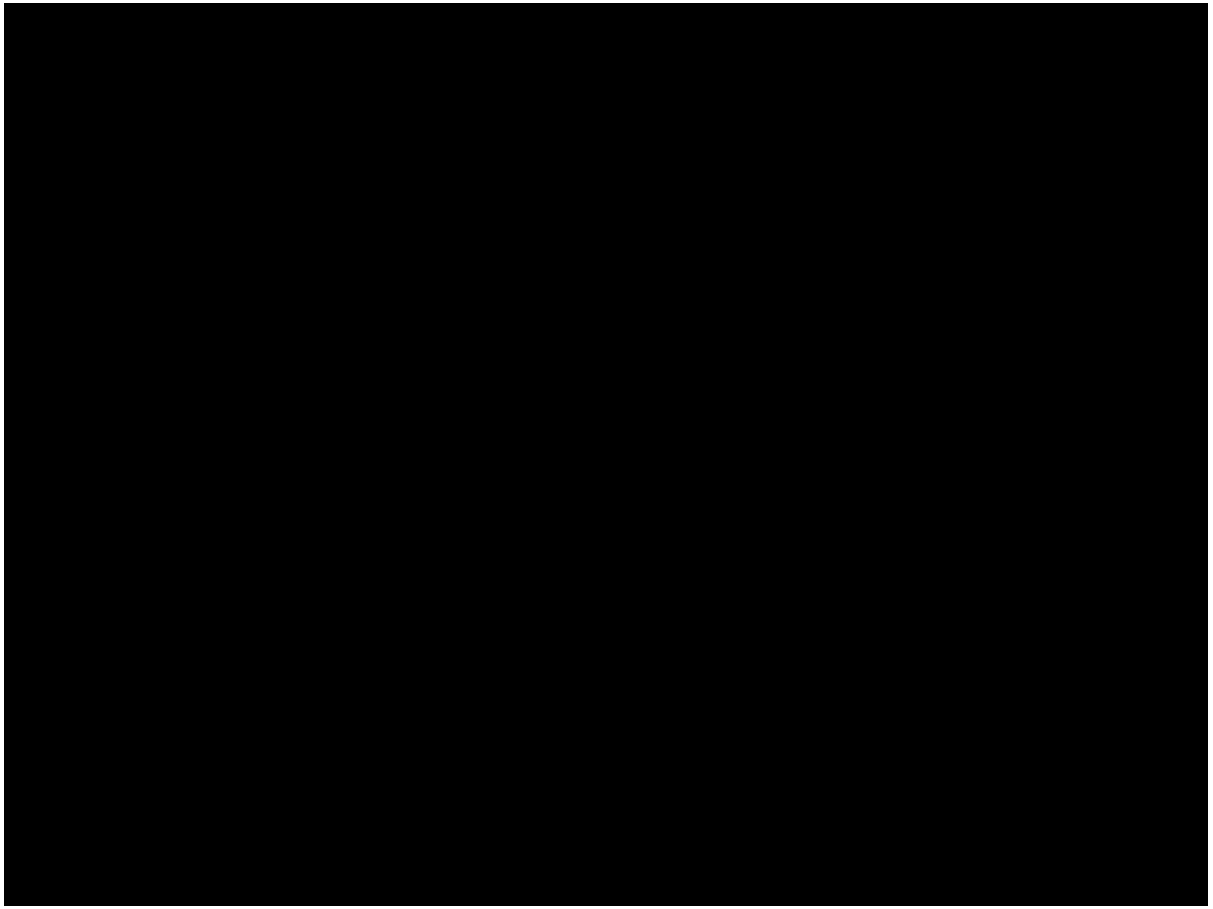
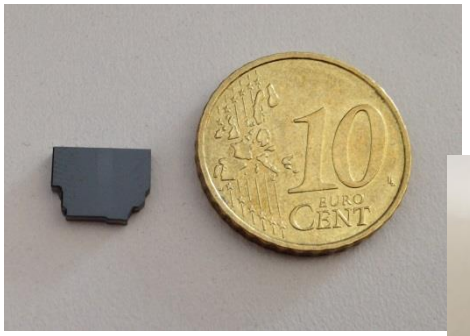
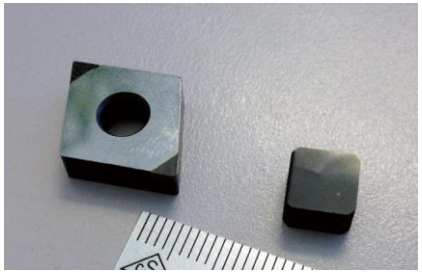
3. LCS 50-5

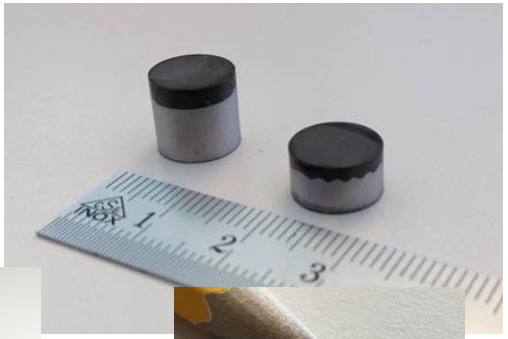


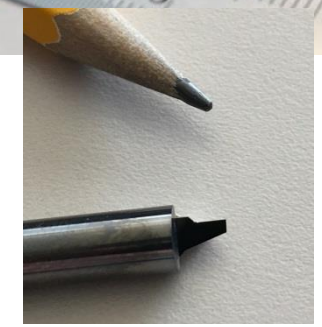
4. State of the art results cutting PCD/WC

- All kinds of tools / geometries can be cut





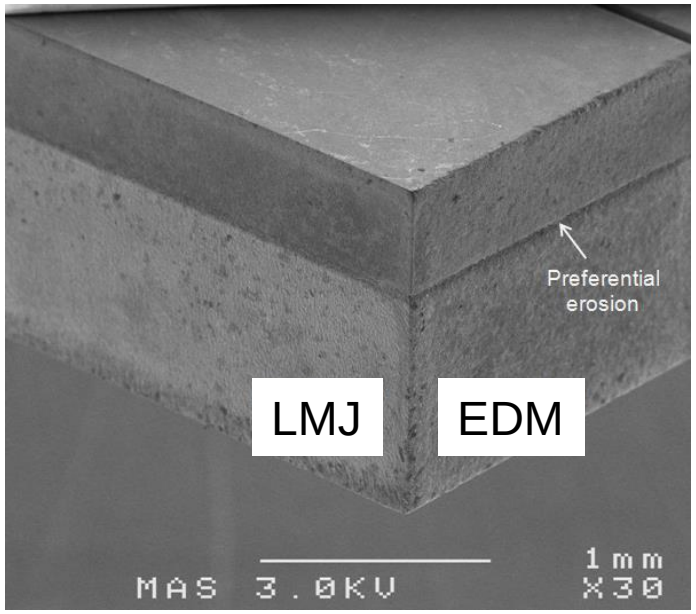




4. State of the art results cutting PCD/WC

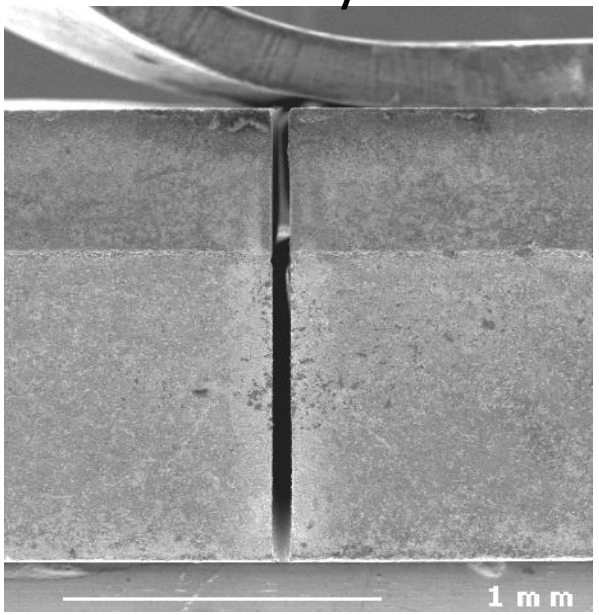
PCD/WC cutting

LMJ vs EDM

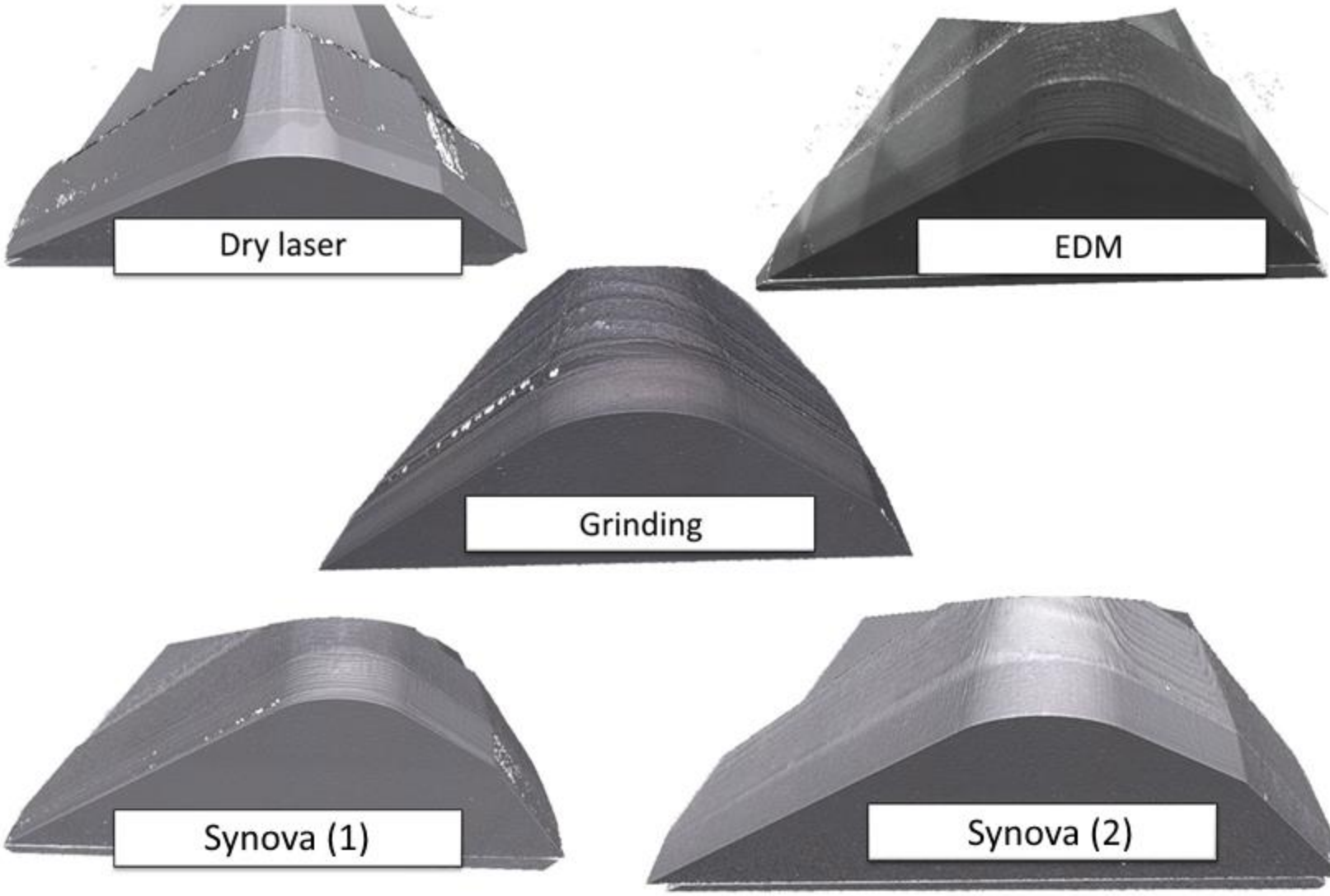


Uniform cut surface profile

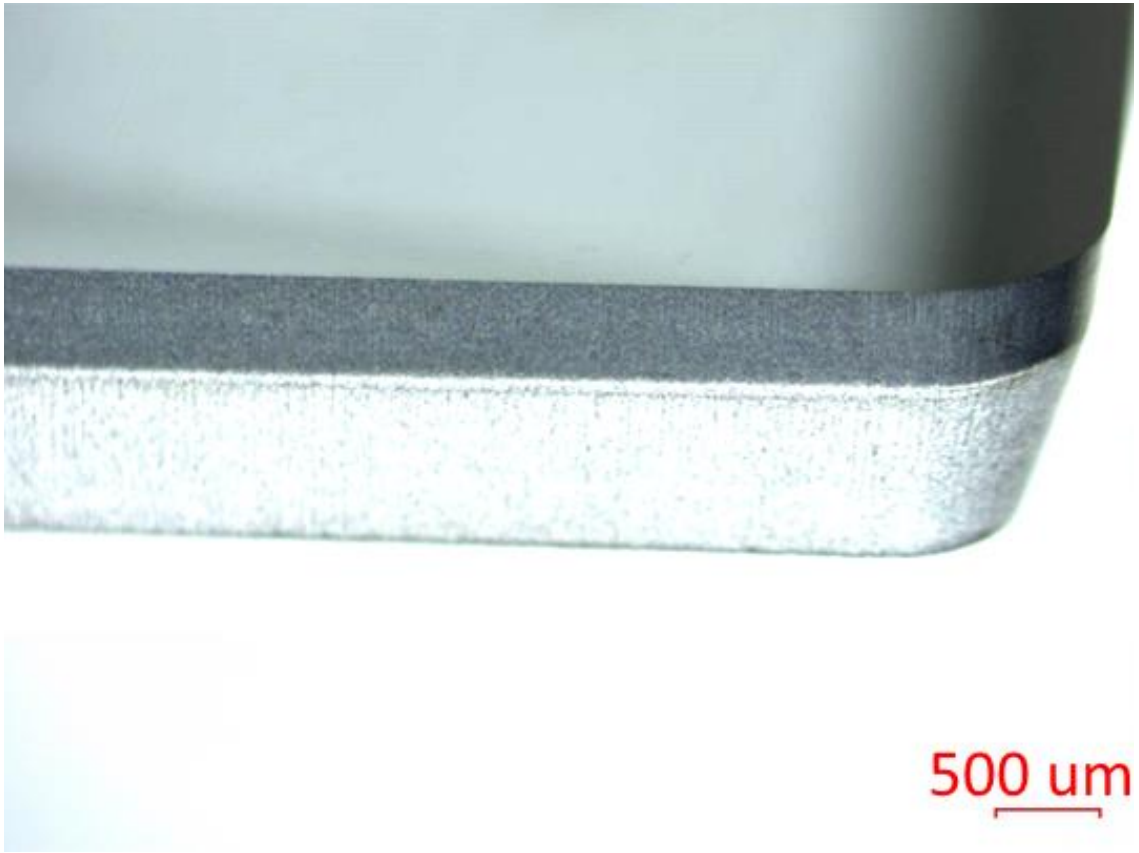
LMJ vs dry laser



Parallel cutting

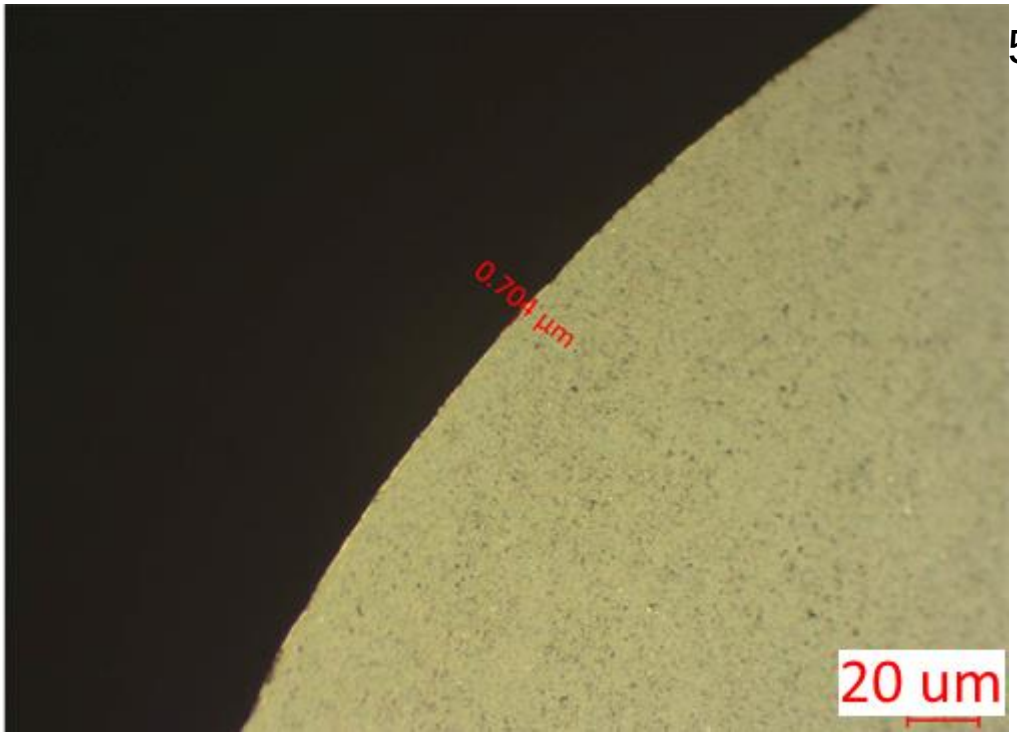

Dry laser
EDM
Grinding
Synova (1)
Synova (2)

4. State of the art results cutting PCD/WC



4. State of the art results cutting PCD/WC

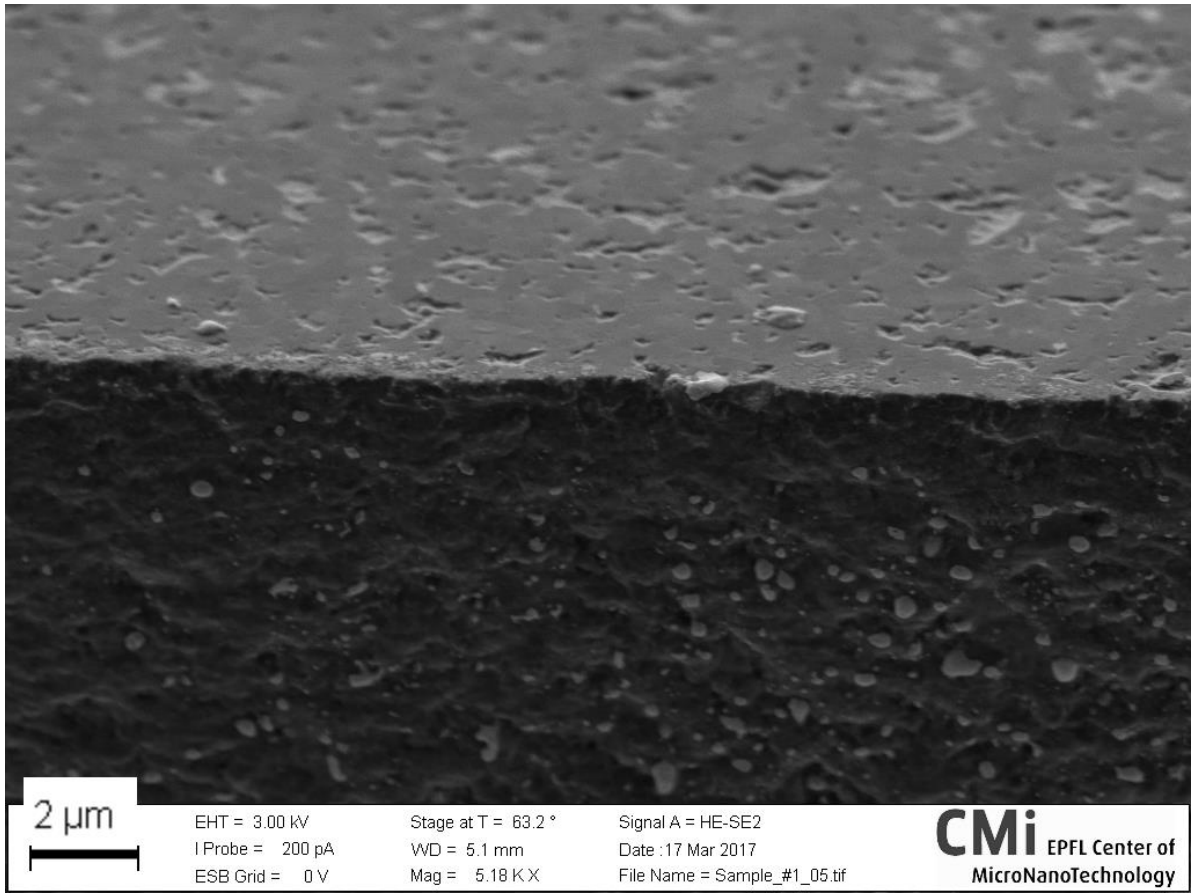
Edge waviness ≤ 1 micron



500x

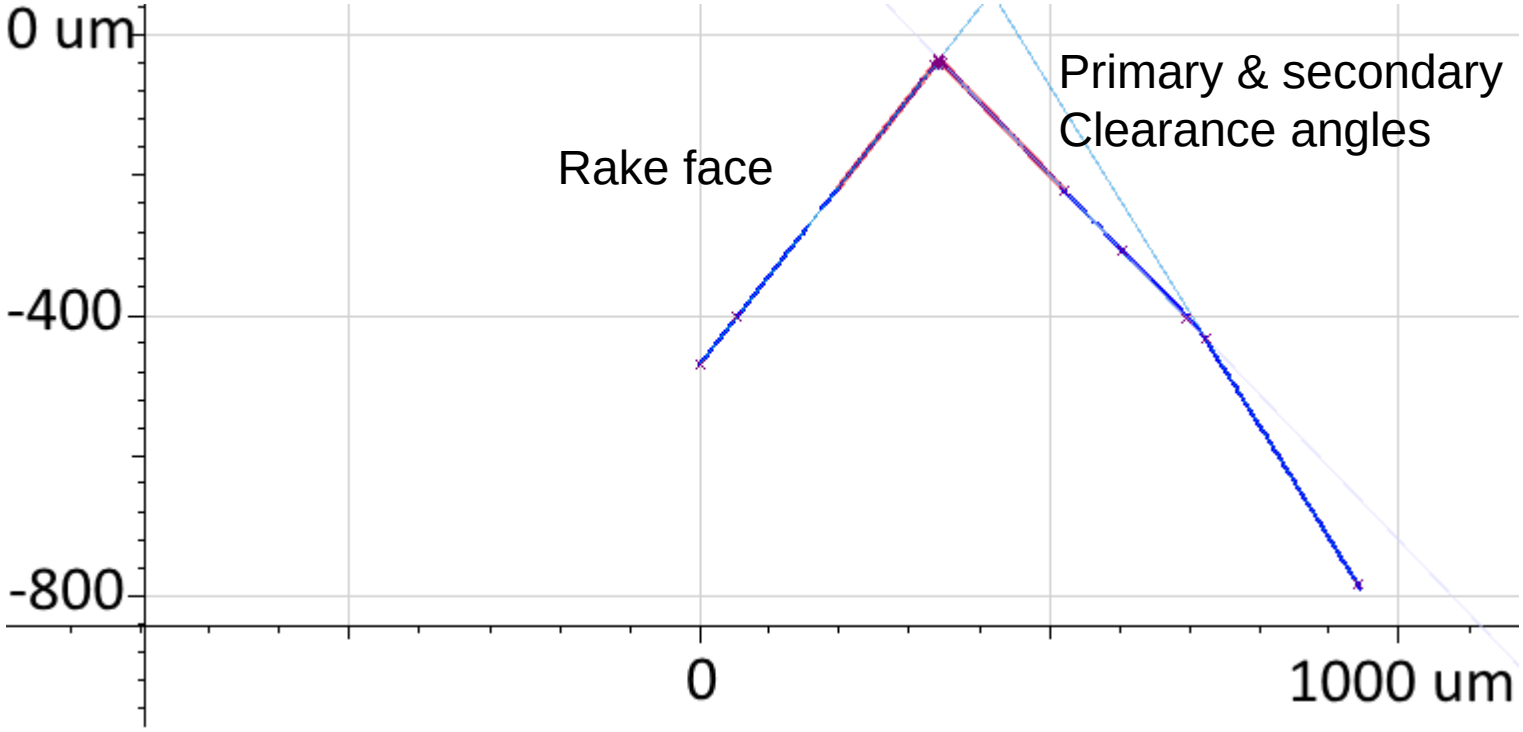
0.5 µm PCD grains

4. State of the art results cutting PCD/WC



5000x

4. State of the art results cutting PCD/WC

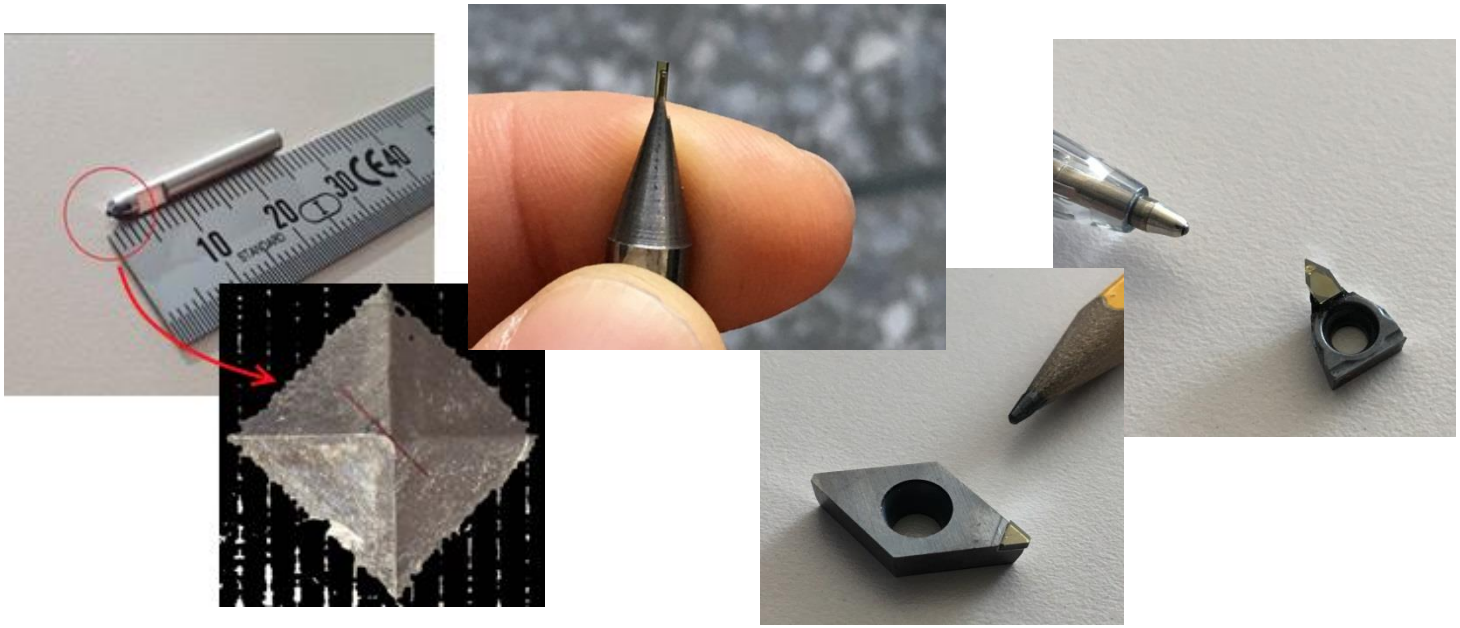


4. State of the art results cutting PCD/WC

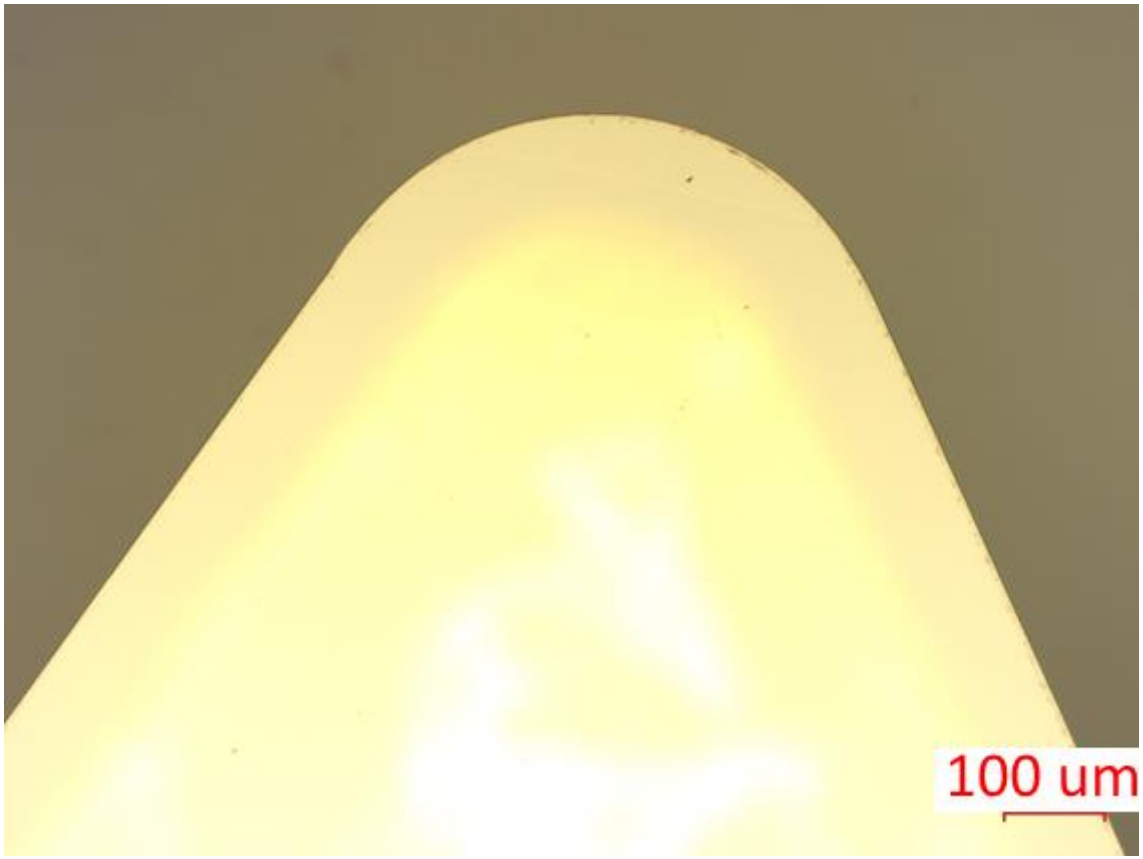
	Programmed	Measured
Primary clearance angle	8.0°	8.2°
Primary clearance depth	500 µm	510 µm
Secondry clearance angle	20.0°	20.1°
Cutting edge radius	-	< 2 µm
Roughness below cutting edge	-	Ra = 0.21 µm, Rz = 1.5 µm
Effective cutting speed	-	1.5 mm/min

5. State of the art results cutting SCD

- All kinds of tools / geometries can be cut



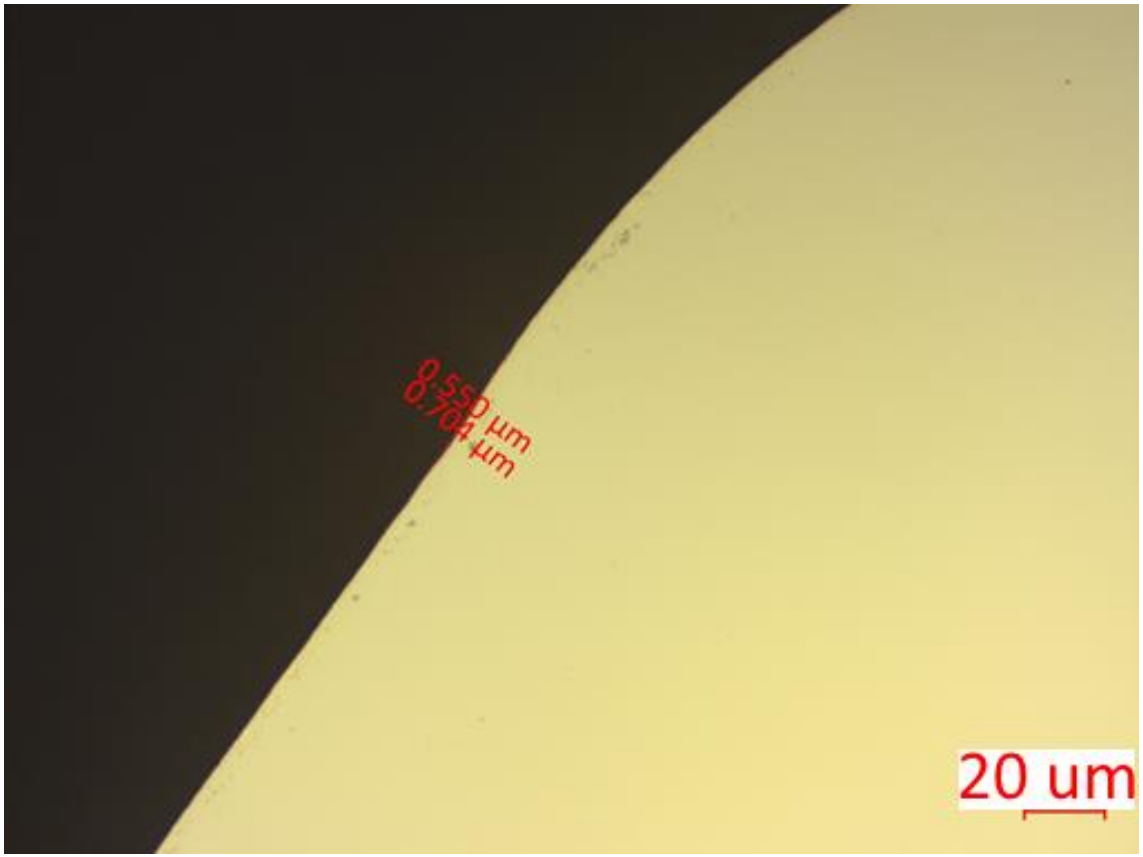
5. State of the art results cutting SCD



100x

5. State of the art results cutting SCD

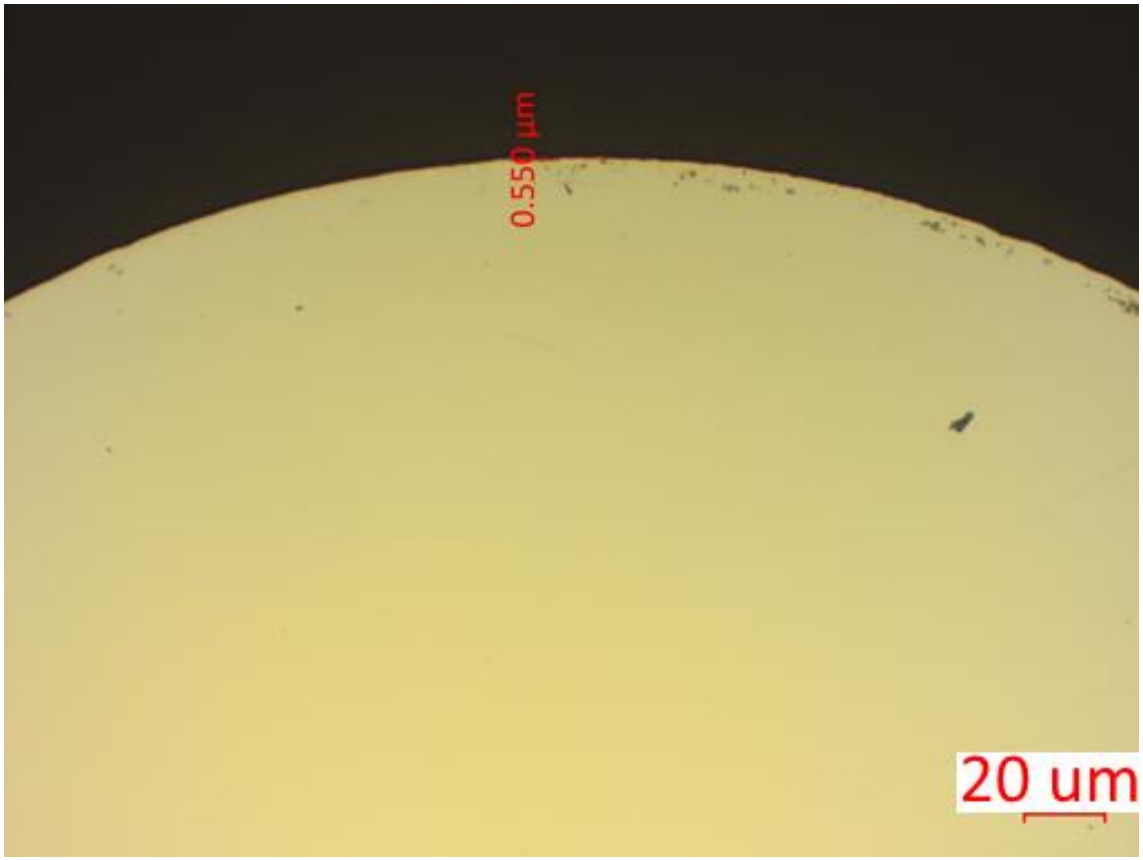
Edge waviness ≤ 0.5 micron



500x

5. State of the art results cutting SCD

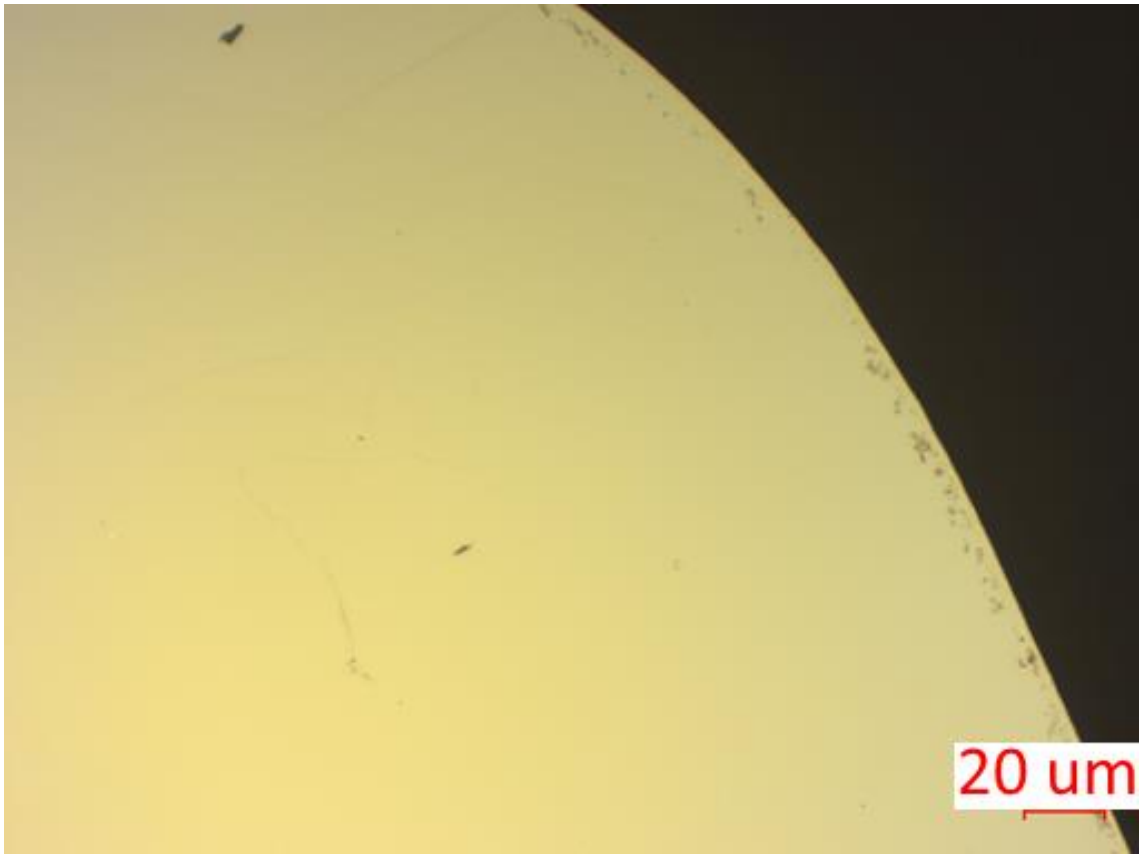
Edge waviness ≤ 0.5 micron



500x

5. State of the art results cutting SCD

Edge waviness ≤ 0.5 micron



500x

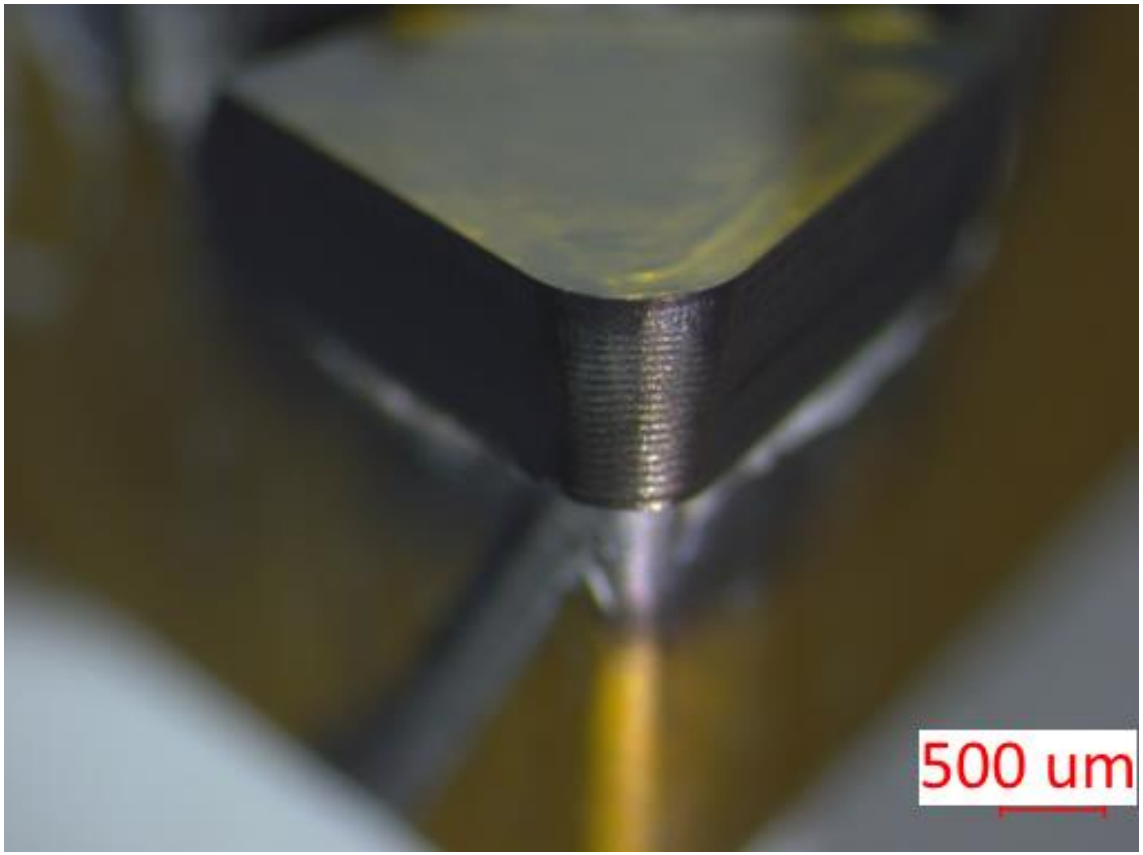
5. State of the art results cutting SCD

Edge waviness ≤ 0.5 micron

1000x

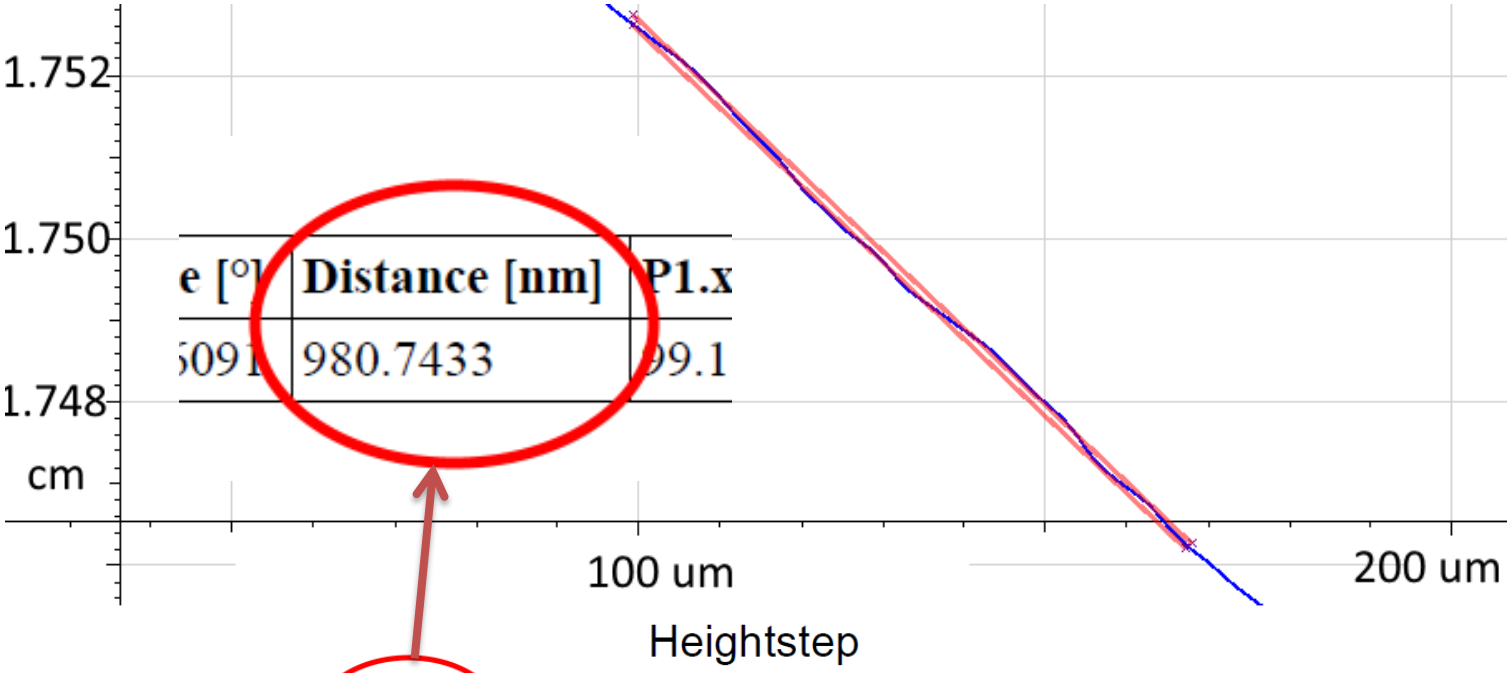
5. State of the art results cutting SCD

Cutting trenches are visible but no impact on roughness



20x

5. State of the art results cutting SCD

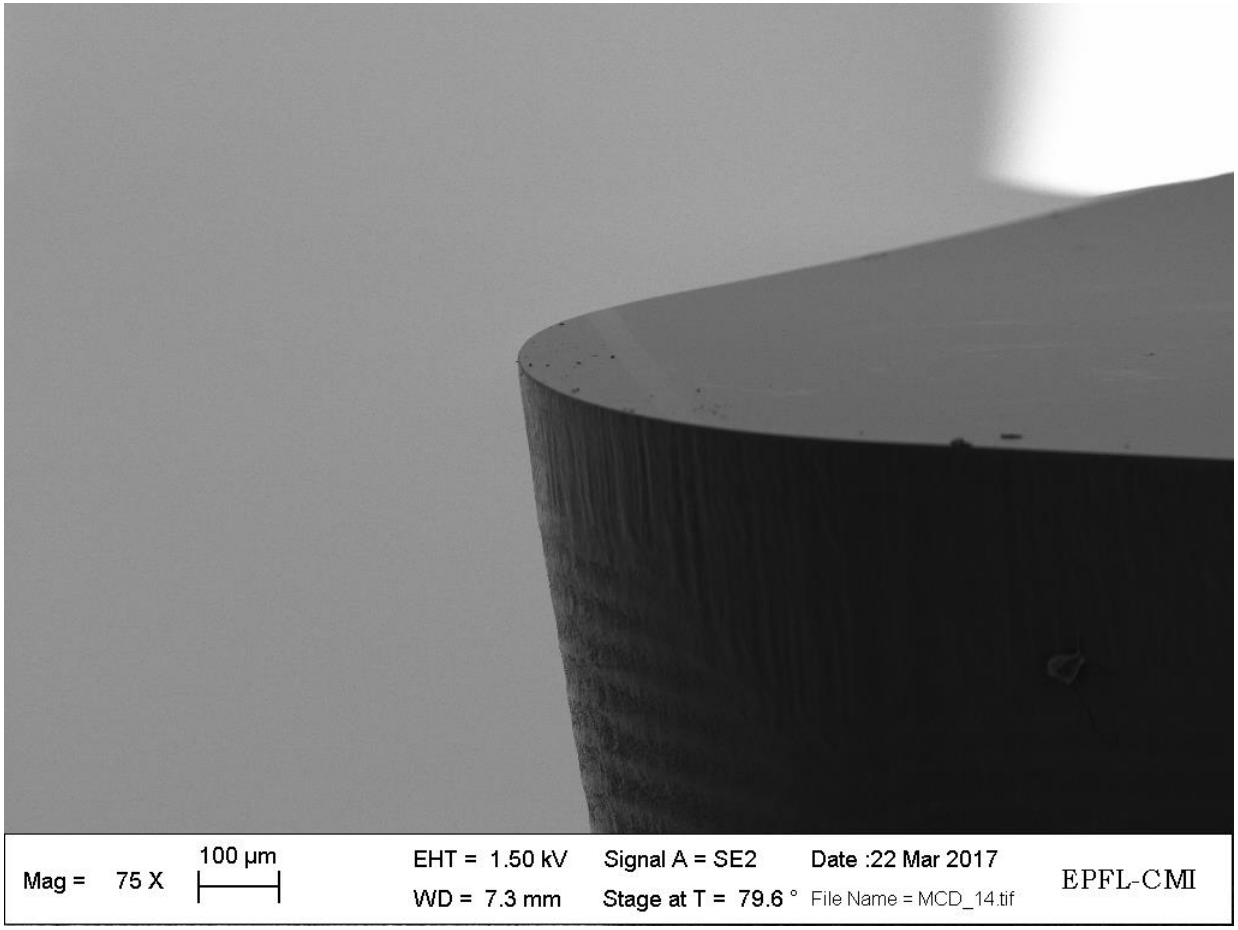


e [°]	Distance [nm]	P1.x
5091	980.7433	99.1

	Angle [°]	Distance [nm]	P1.x [µm]	P1.y [cm]	P2.x [µm]	P2.y [cm]	P3.x [µm]	P3.y [cm]	P4.x [µm]	P4.y [cm]
Heightstep 1	136.6091	980.7433	99.1734	1.7528	168.1201	1.7462	167.2750	1.7462	99.1734	1.7526

Wave height < 1 µm

5. State of the art results cutting SCD



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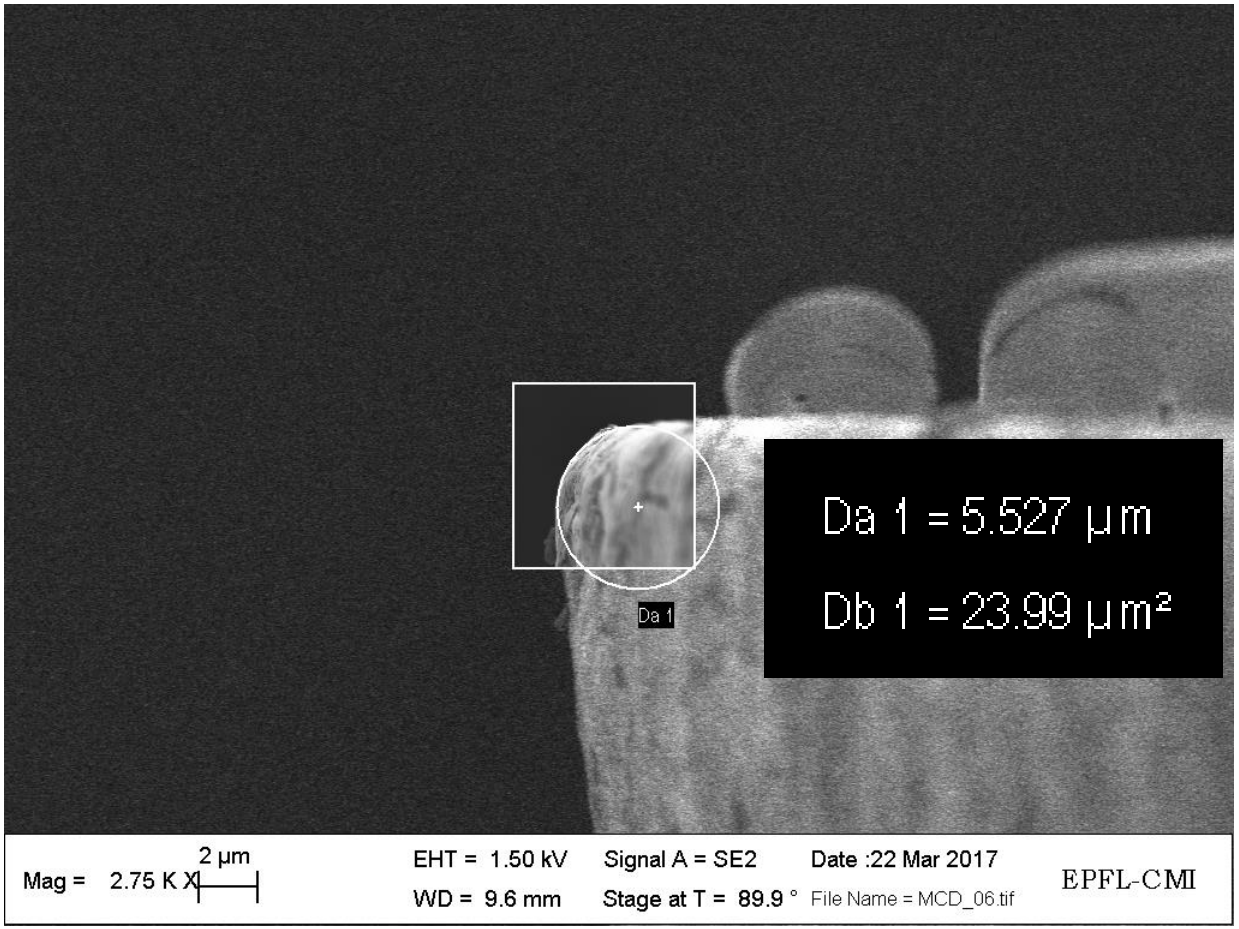
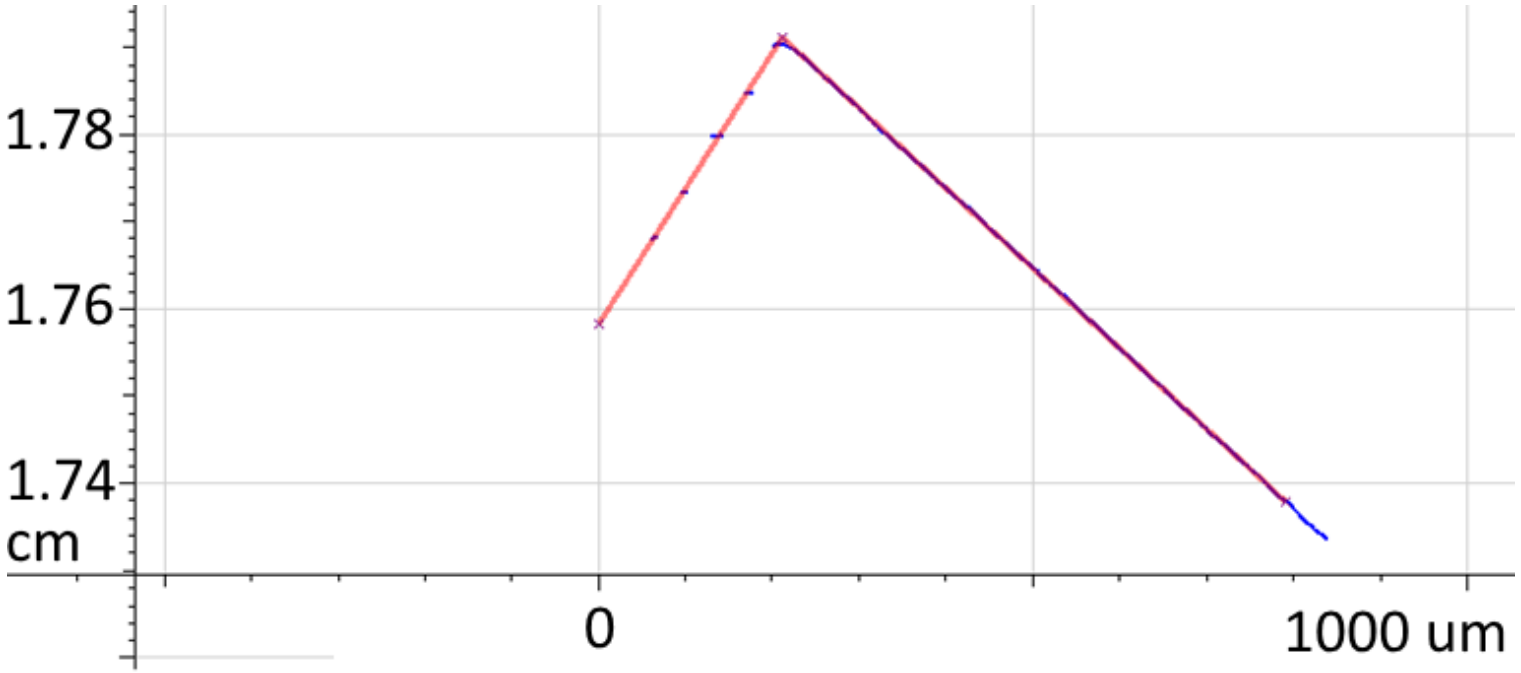


5. State of the art results cutting SCD



5. State of the art results cutting SCD

	Programmed	Measured
Clearance angle	10.0°	9.9°
Cutting edge radius	-	2.7 µm
Roughness below cutting edge	-	Ra = 0.25 µm, Rz = 1.4 µm
Effective cutting speed	-	2.6 mm/min

6. Conclusion 1/3 – The results

- Sub-micron surface finish can be reached for both PCD and SCD materials
- Such result is possible even at cutting speeds up to 1.5 mm/min for PCD and 2.6 mm/min for SCD
- HAZ depth is 5 µm, according to Sumitomo
- Edge micro-cracking compared to dry lasers reduced or eliminated

6. Conclusion 2/3 – the machine

- Very compact machine (800 x 1200 x 1650 mm)
- Full 5-axis capability
- Very easy to operate (HMI)
- Intuitive CAM software for diamond tools including auto-probe-correction and batch processing
- Automatic probe-based correction by CAD/CAM for more complex tools (“SynovaCut”)

6. Conclusion 3/3 – the machine

- Cutting strategies can be implemented in a production mode
- Unlimited choice of materials and thicknesses
- Low cost of ownership
- Faster cutting/shaping means fewer machines required → reduced capital investment

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Thank you for your attention!

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6. Appendix – SynovaCut demo


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