# REPORT: Scribing of machining tools by Laser-MicroJet®

*For* Anonymous

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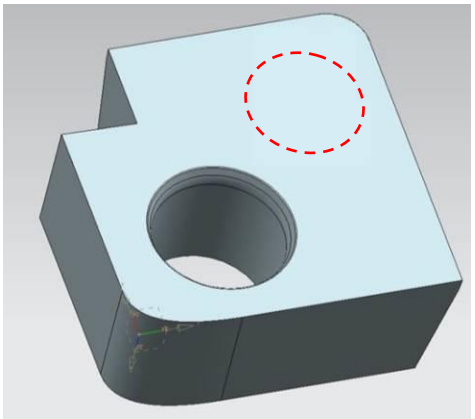
## 1. TASK

This application aimed at scribing machining tools in polycrystalline diamond (PCD) using the Laser-MicroJet® technology. The tools were the ones cut as explained in the report 144-5. The tools PCD2 and PCD3 will now be scribed on the front side.

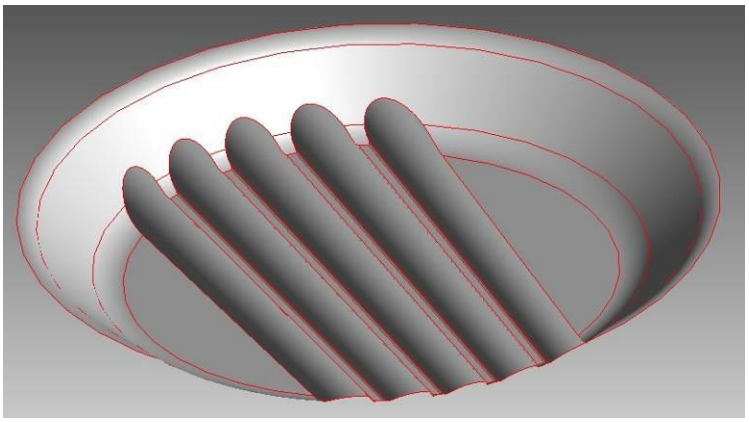
## 2. TASK DESCRIPTION

| | | |
|---|---|---|
| **SUPPLIED MATERIAL** | Sample | PCD2 & PCD3 |
| | Thickness | 1.5 mm |
| | Quantity | 2 |

Both samples have been scribed with the same geometry consisting of grooves. The red dashed circle shows were the scribing should be made on the 3D representation (picture 1). The volume to be ablated is shown in picture 2. Please note that the representation is not to scale. The upper side of the volume in picture 2 roughly corresponds to the red dashed circle on picture 1.



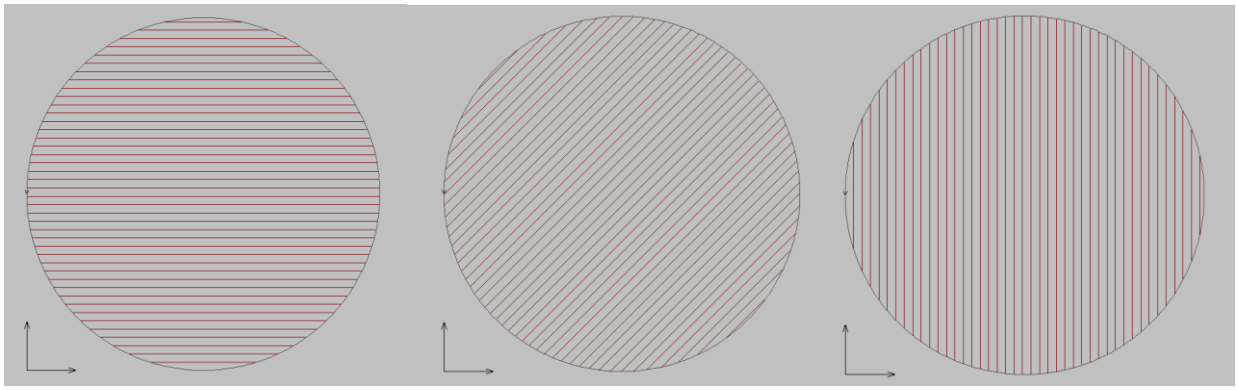
**PICTURE 1:** 3D representation of the tool before the scribing process



**PICTURE 2:** 3D representation of the volume to be ablated

| Release of application report | | | |
|---|---|---|---|
| Project Leaders | | Industry BU Responsible | |
| Name: | Mr Florent Bruckert, Mr Sylvain Hirth | Name: | Dr Carron Benjamin |
| Date: | 29.04.2014 | Date: | 29.04.2014 |
| Visum: | FBR, SHI | Visum: | BC |

The tool was scribed in 2 different steps. First the upper part of the volume shown in picture 2 was scribed uniformly until the top of the grooves was reached. This was done in 18 µm thick slices, on average. Note that the diameter decreases from one layer to another. To scribe one slice, the laser goes over the entire surface in parallel lines. The space between two consecutive lines is 20µm. Between two slices, the lines were rotated of 45° each time. Three consecutive slices are shown in picture 3.



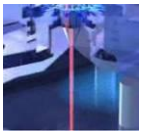
**PICTURE 3:** Hatching lines of three consecutive ablated slices

When the top of the grooves was reached, the path of the Laser-MicroJet® was adapted to ablate only the specific volume needed to create the grooves.

On the last slice, a finishing pass was used in order to eliminate some holes dug on the side by the on and off switching of the Laser-MicroJet®. This kind of defect is caused by the mechanical movement of the laser gate. It is an inherent phenomenon of the laser and microjet technology. The finishing pass consisted on tracing the outer contour twice with a 30mm/s speed.

## 3. PROCESS: INSTRUMENT & TEST PARAMETERS

For this application, the LCS150, equipped with a frequency doubled, Q-switched, Nd:YAG laser, has been selected as the best machine configuration available in the lab. In the table below, the optimised processing parameters used in the experiments are summarised:

| | | | | |
|---|---|---|---|---|
|  | **SYSTEM** | Machine type | LCS150 | |
| | | Fixture | Clamped | |
|  | **MICROJET® PARAMETER** | Nozzle diameter | 60 | *µm* |
| | | | | |
| | | Water pressure | 300 | *bar* |
| | | Working distance | 15 | *mm* |
| | | Assist gas | He | |
|  | **LASER PARAMETERS** | Laser type | L51G | |
| | | Wavelength | 532 | *nm* |
| | | SHG temperature | 32 | *°C* |

In order to optimize the scribing quality, the parameters below have been used.

| Frequency [kHz] | Power (intern) [W] | Power (water jet) [W] | Pulse duration [ns] | Scribing speed [mm/s] |
|---|---|---|---|---|
| 6 | 8.3 | 2.5 | 120 | 8 |

**TABLE 1**: Sets of scribing parameter used

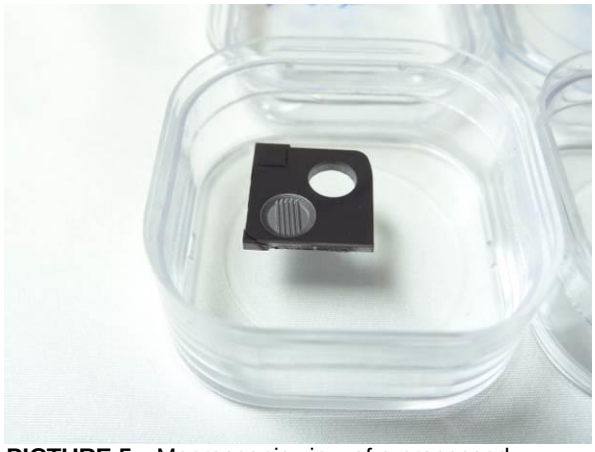
Several accelerations have been tested ranging from 500 mm/s$^2$ to 5000 mm/s$^2$. A too small acceleration resulted in creating hollows on the outer contours. A too big acceleration, on the other hand would create a difference in height between the centre and the peripheral part of the disk scribed before the grooves. The acceleration minimizing both effects has been found to be 4000 mm/s$^2$ and is therefore the one used during this process.

The process lasted **45 min** overall.

## 4. RESULTS

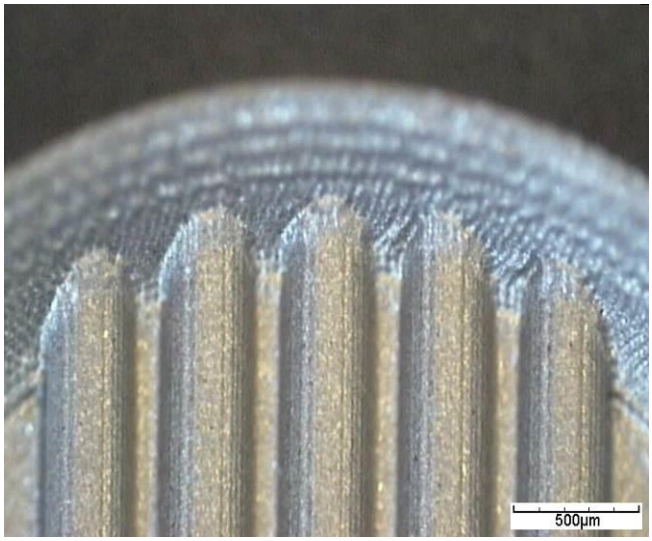
Picture 4 and 5 show a macroscopic view of the processed samples.

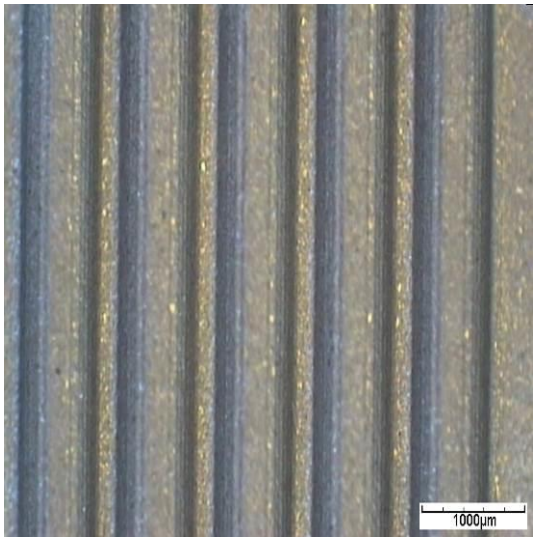
**PICTURE 4:** Macroscopic view of the processed samples



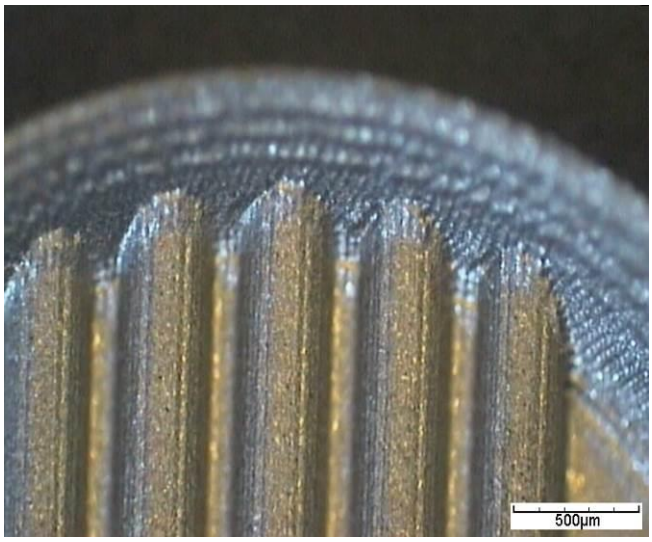
**PICTURE 5:** Macroscopic view of a processed sample

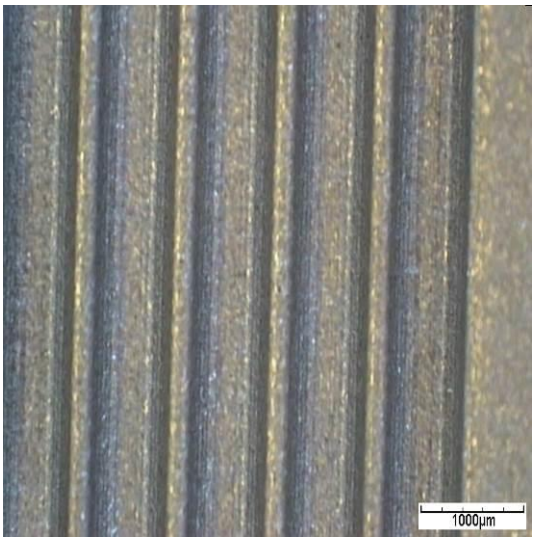
The following pictures show a microscopic view of the scribed samples:




**PICTURES 6 & 7:** Microscopic views of the scribing on sample PCD 2

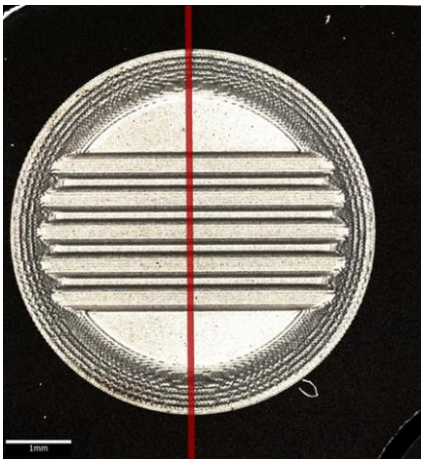



**PICTURES 8 & 9:** Microscopic views of the scribing on sample PCD 2

## 4.1 ROUGHNESS MEASUREMENTS RESULTS

**PICTURES 10:** PCD3 top side view



**PICTURES 11:** PCD3 top side view

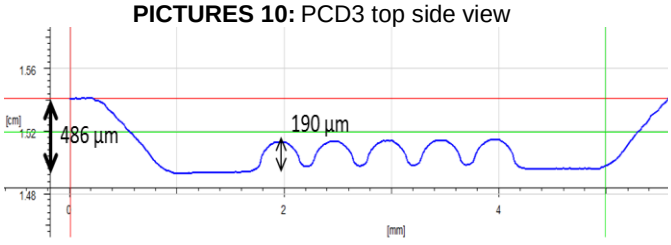



**FIGURE 1:** transversal measurement PCD3

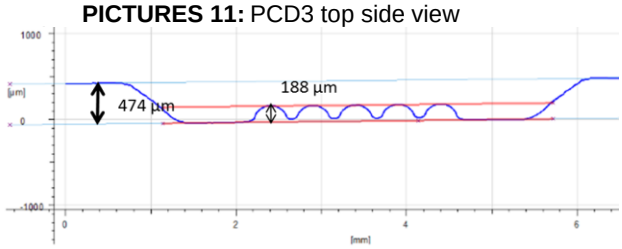



**FIGURE 2:** transversal surface rectangular

The roughness results are shown in Table 2

| **Number of measurement** | **Sa , $L_c$ = 250 µm, size = 3 x 2 mm²** | | **Ra, $L_c$ = 250 µm, roughness profile length = 2 mm average over 50 profiles = 25 µm** |
|---|---|---|---|
| #1 PCD2 | 0.56 µm | Bottom | 0.25 µm |
| #2 PCD3 | 0.47 µm | Bottom | 0.26 µm |

**TABLE 2**: Roughness results

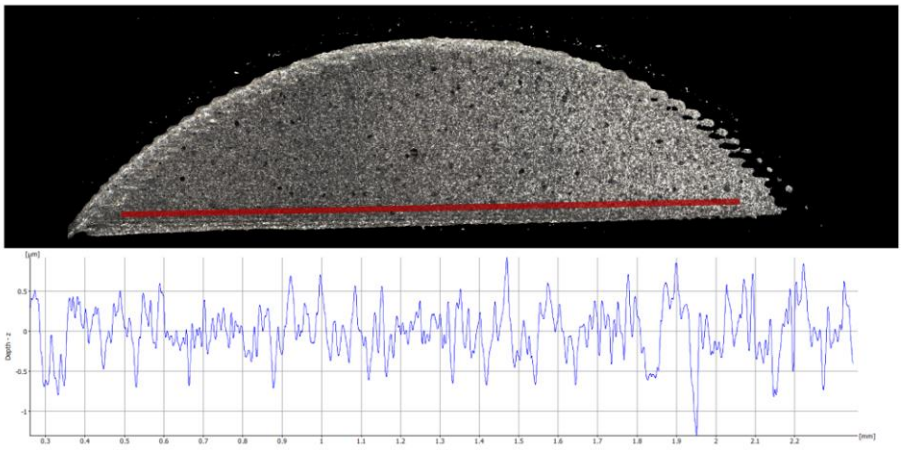


**FIGURE 31:** Profile measurement for roughness on top Ra #1

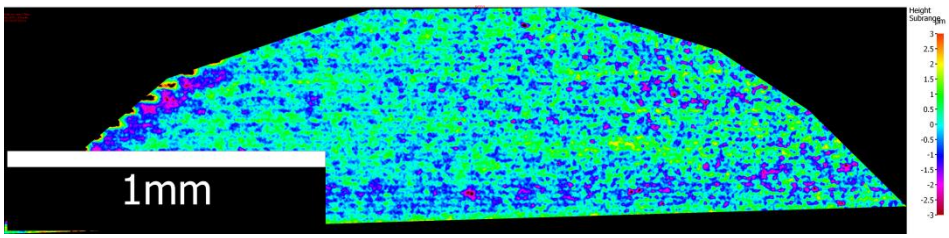



**FIGURE 4:** Measurement for surface roughness Sa #1

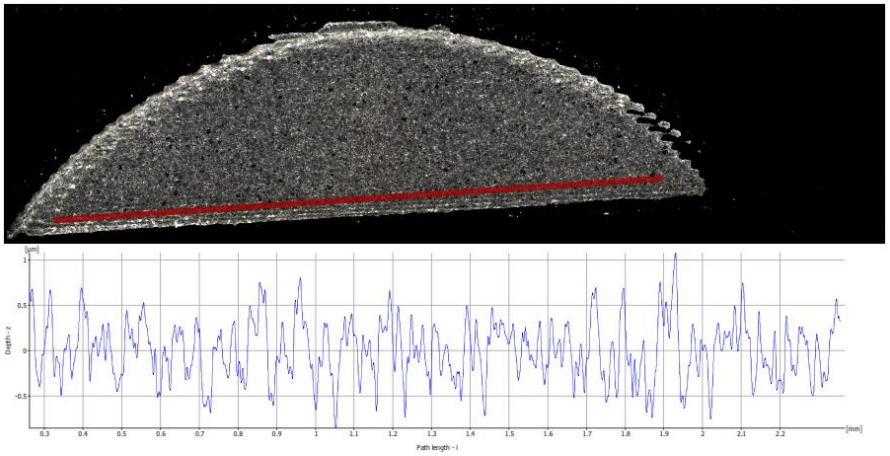


**FIGURE 5:** Profile measurement for roughness on top Ra #2

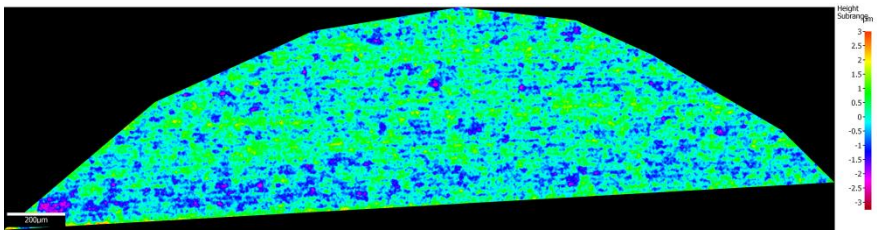


**FIGURE 6:** Measurement for surface roughness Sa #2

## 5. CONCLUSION

The scribing of machining tools has been performed with a SYNOVA LCS 150. This machine is based on the MicroJet® technology and combines the advantages of the high energy pulsed laser with a hair-thin water jet. While the laser is used for material ablation, the water jet is used for guiding the laser light, cooling the edges and preventing the sample from particle contamination, advantages that are essential for machining tools with high quality.

These tests show that:

- The process is stable and reliable
- The scribing is homogenous and precise
- The roughness is low (Ra = 0.25 µm and Ra= 0.26 µm)

We are open to further discuss your needs regarding:

- The final dimensions
- The process time at the cost of the scribing quality

We thank you for your interest in our technology and we hope our results meet your requirements.
Our sales agent will contact you soon to obtain a feedback about the analysis of these results and to discuss with you the further steps.