REPORT: CVD diamond Cutting by Laser-MicroJet®

for Anonymous

by D^{r} Benjamin Carron, Synova SA

TASK

The Laser-MicroJet® technology has been tested for cutting CVD diamond plates.

The goal of this study is to demonstrate the feasibility and the quality of our process and to give an estimation of the cutting time of the Laser MicroJet process on CVD diamond.

Three pieces of different dimensions were processed with straight line cuts, as requested by the customer.

The samples were glued on a metallic mount, hold up with a clamp.

Release of application report			
Project Leader		Responsible Application Group	
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Date:	01.03.2013	Date:	01.03.2013
Visum:	BC	Visum:	BC

SAMPLE DESCRIPTION AND PREPARATION

SAMPLE A	Material	**CVD diamond**
	Size	7.2 x 7.2 *mm²*
	Thickness	~ 2 *mm*
	Quantity	1 *pc*
SAMPLE B	Material	**CVD diamond**
	Size	6.6 x 6.6 *mm²*
	Thickness	~ 2 *mm*
	Quantity	1 *pc*
SAMPLE C	Material	**CVD diamond**
	Size	9.2 x 9.2 *mm²*
	Thickness	~ 2 *mm*
	Quantity	1 *pc*

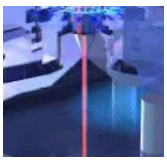
PROCESS: INSTRUMENT & TEST PARAMETERS

For these experiments, the LCS 150 equipped with a frequency-doubled Q-switched Nd-YAG laser has been used as the machine configuration in our lab.

The major advantages of Laser-MicroJet® technology with regards to your application are:

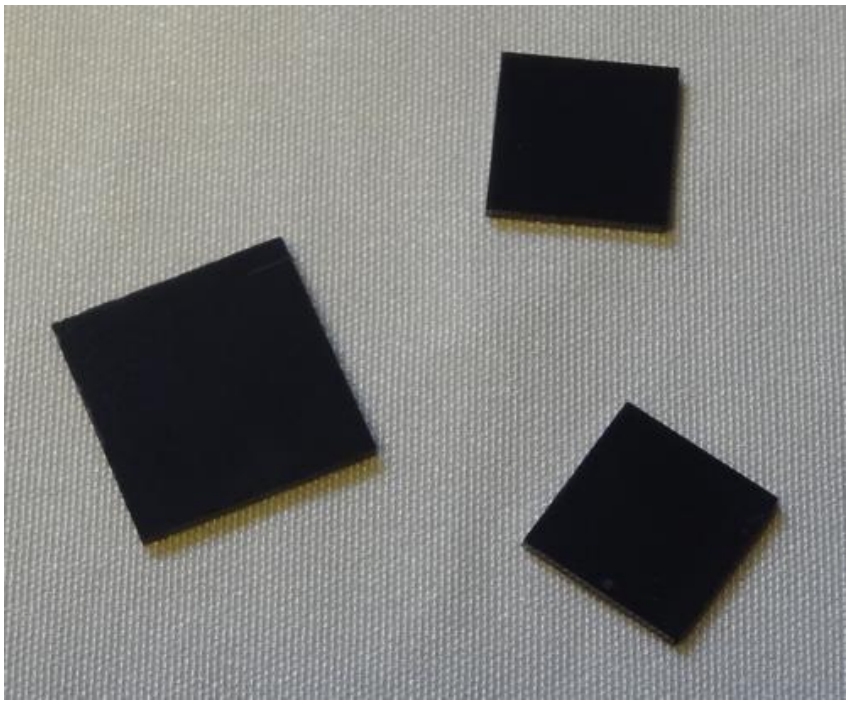
- Parallel and smooth cut walls
- Negligible heat damage to the material
- Cutting of arbitrary shapes

In the table below, the optimized processing parameters used in the experiments are summarized:

	**SYSTEM**	Machine type	LCS 150
	**MICROJET® PARAMETER**	Nozzle diameter	40 *µm*
		MicroJet® diameter	~33 *µm*
		Water pressure	400 *bar*
		Assist gas	1.1 l/min of He
	**LASER PARAMETER**	Laser type / Wavelength	L51G / 532 *nm*
		Average power	28 *W*
		Power in WaterJet	13 *W*
		Pulse frequency	6 *kHz*
		Pulse width	~130 *ns*

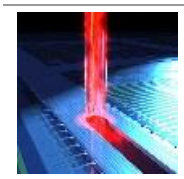
RESULTS

The following image shows three samples (2 **Sample 2** pieces and one **Sample 3**) on one of their processed side.



PICTURE 1: Image of **Sample 2 and 3** parts after process, from one of the cut sides

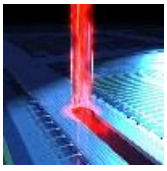
- *Results on **Sample A***



CUTTING PARAMETER			
→ Sample A	Cutting speed	5	*mm/s*
	Number of passes	400	
	Overall Process time	12:15	*min:sec*
	Ablation rate	18	*µm / per pass*

One slice has been produced with the **Sample A**. The thickness is ~660 µm.

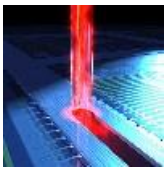
- *Results on **Sample B***



CUTTING PARAMETER			
→ Sample B	Cutting speed	5	*mm/s*
	Number of passes	360	
	Overall Process time	10:30	*min:sec*
	Ablation rate	18	*µm / per pass*

Two slices have been produced with the **Sample B**. The thicknesses are ~605 and ~645 µm.

- *Results on **Sample C***

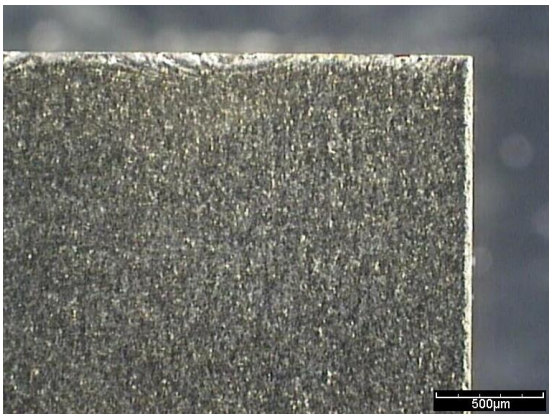


CUTTING PARAMETER		
→ Sample C	Cutting speed	5 *mm/s*
	Number of passes	800
	Overall Process time	30:20 *min:sec*
	Ablation rate	12 *µm / per pass*

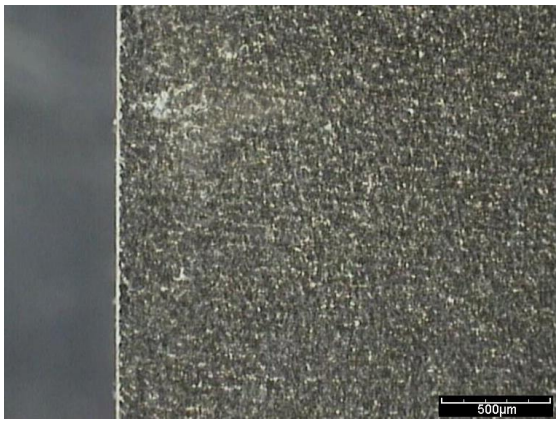
One slice has been produced with the **Sample C**. The thickness is ~650 µm.

We used the remaining part of this sample, that we called **Sample S**, to groove a 80% deep channel. This will allow you to observe the parallelism and thinness of our cutting tool.

The following microscope pictures give an overview on the quality obtained with the Laser-MicroJet® technology on the **CVD diamond** samples.



PICTURE 2: Microscope image of the cut wall, top right corner (dark field illumination)



PICTURE 3: Microscope image of the cut wall, middle left side (dark field illumination)

- *Results analysis*

  - **Width of the cut**
    Using a 40 µm nozzle, we obtain a cut width of ~45 µm, all along the 9.2 mm thickness of your sample. There is a very small widening of the kerf on the first 50 µm at the extremities of the sample. This is why it is very difficult to estimate the kerf width with a visual inspection.

  - **Ablation rate**
    The ablation rate, for an axis motion of 5 mm/s, is not linear with respect to the thickness. During the first ~5 mm, the ablation rate is about 20 µm / pass. Then, the water jet has to go deeper in the material, fighting against accumulation of water inside the kerf. This will reduce the efficiency of the cut.

    The ablation rate is a bit lower for 7 mm thick (18 µm / pass). This effect increases for larger and thicker diamonds, down to 12 µm / pass for the 9.2 mm piece. This will not stop the process but it makes it slower.

To increase the ablation rate the solution is to use a 50 µm nozzle. The water jet is more powerful and therefore can reach deeper thicknesses without losing too much of efficiency. It can cut up to 25 mm thick diamonds at a very acceptable ablation rate. The kerf width will be slightly larger (~65 µm).

- **Roughness**
  The roughness of the process on CVD diamonds is ~0.35 µm Ra. This is an average of several measurements taken on the surfaces of the cut samples.

- **Sample thickness**
  The thickness of the parts is not the same. We did several tests to determine precisely the cutting width of our tool on your diamond. You should not worry about it. This will be perfectly under control once the tool correction has been determined.

CONCLUSION

The cutting of CVD diamonds was investigated on 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 allowing an excellent accuracy, advantages that are essential for cutting diamond samples with high quality.

This test shows that:

- Excellent quality is achievable on both side of the diamond. The edge roughness is ~0.35 µm Ra.
- The process time depends on the diamond thickness: from 10 minutes (6.6 mm thick) to 30 minutes for the 9.2 mm plate.
- The cut width is ~45 µm – about 4 times less than your current process. This should allow you to produce more plates with one piece.

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