REPORT: Sapphire Cutting by Laser-MicroJet®

for Technocut; FAO: Montavon Julien

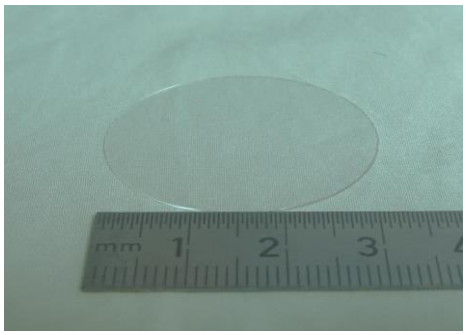
by Florent Bruckert, Synova SA

TASK

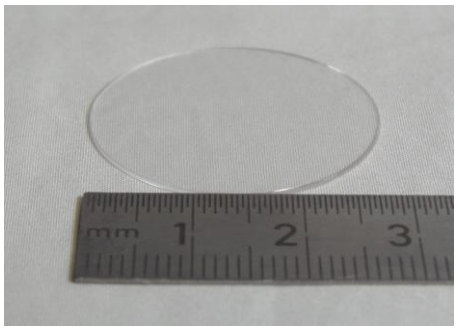
The Laser-MicroJet® technology has been tested for cutting sapphire. Two different thickness have been cut through.

SAMPLE DESCRIPTION

SAMPLES TYPE 1	Material	Sapphire (Al_2O_3)
	Dimension	Ø 32.0 *mm*
	Thickness	~300 *µm*
SAMPLES TYPE 2	Material	Sapphire (Al_2O_3)
	Dimension	Ø 28.5 *mm*
	Thickness	~600 *µm*



SAMPLES TYPE 1: Sapphire (300 µm thickness)



SAMPLES TYPE 2: Sapphire (600 µm thickness)

Release of application report			
Project Leader		Responsible Application Group	
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Date:	05.06.2012	Date:	06.06.2012
Visum:	FBR	Visum:	MM

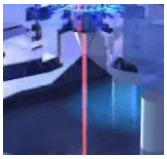
PROCESS: INSTRUMENT & TEST PARAMETERS

For these experiments, the LCS300, equipped with a frequency doubled, Q-switched, Nd:YAG laser, has been selected as the most suitable machine configuration.

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

- No chipping on front side, minimal chipping on backside
- Parallel and smooth cut walls
- No slag/burr formation
- Negligible contamination / re-deposition

In the table below, the optimised processing parameters used in the experiments are summarised:

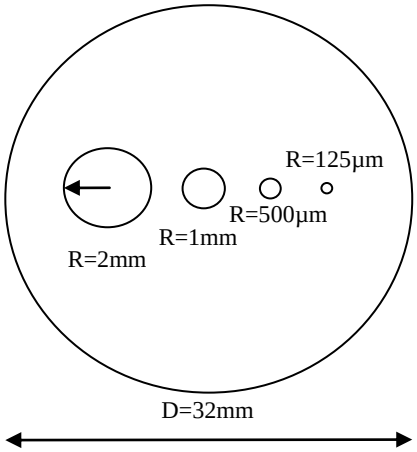
	**SYSTEM**	Machine type	LCS300
	**MICROJET® PARAMETER**	Nozzle diameter	50 *µm*
		MicroJet® diameter	45 *µm*
		Water pressure	350 *bar*
		Assist gas	He
	**LASER PARAMETER**	Laser type	L101G
		Wavelength	532 *nm*

LASER AND CUTTING SETS OF PARAMETERS

	Configuration A	**Configuration B**	
Pulse frequency	6	*10*	*kHz*
Average power	25	*24*	*W*
Motion speed (300 µm)	20	20	*mm/s*
Motion speed (600 µm)	10	10	*mm/s*

CUTTING STRATEGIES

Two different cutting strategies have been processed:
- The straight-line cutting
- Different radius circles (see picture 1)



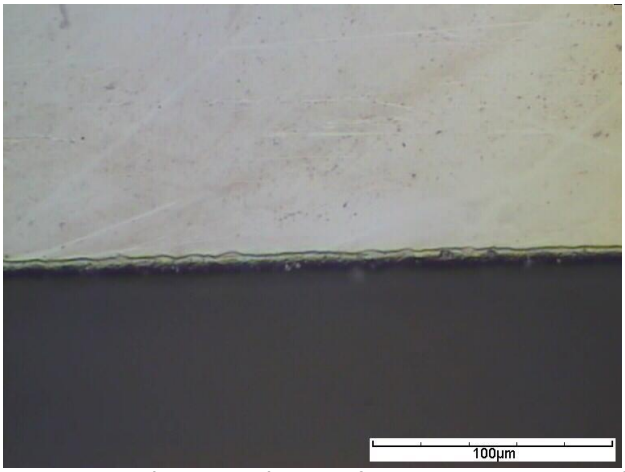
PICTURE 1: Drawing of the circular patterns on a 300µm sample.

RESULTS

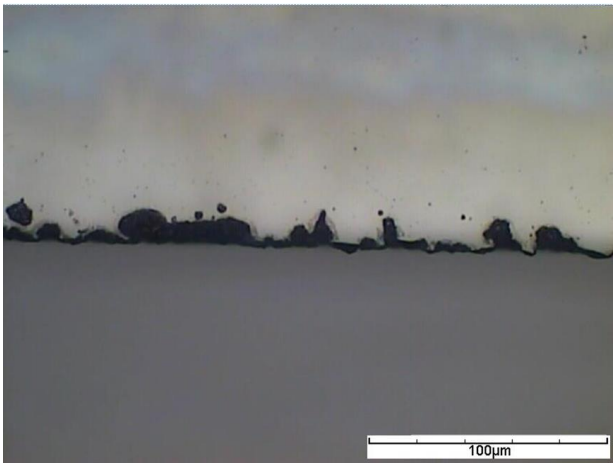
The following table summarizes the cutting parameters used to process 8 samples.

Cutting Strategy	Thickness [µm]	Cutting configuration	Number of passes	Cut through	Number of processed sample	Process time per sample
Straight line	300	A	**34**	√	2	1min02sec
Circles	300	A	**34**	√	1	42sec
Straight line	300	B	**30**	√	2	54sec
Circles	300	B	30	X	1	37sec
Straight line	600	A	70	X	1	3min20sec
Straight line	600	B	70	X	1	3min20sec

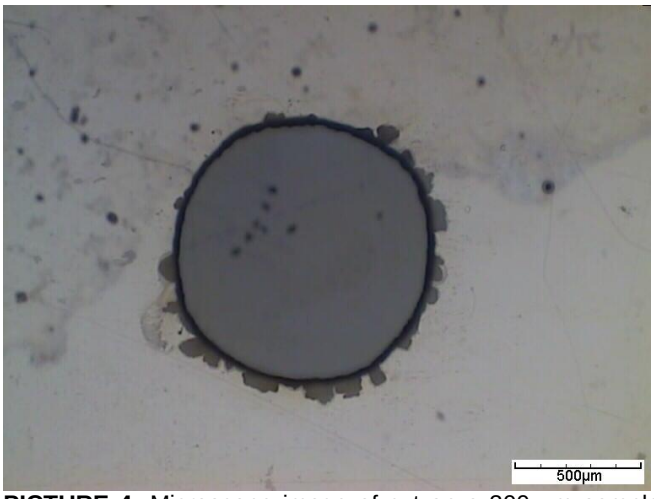
The following microscope pictures give an overview on the quality obtained with the Laser-Microjet® technology.



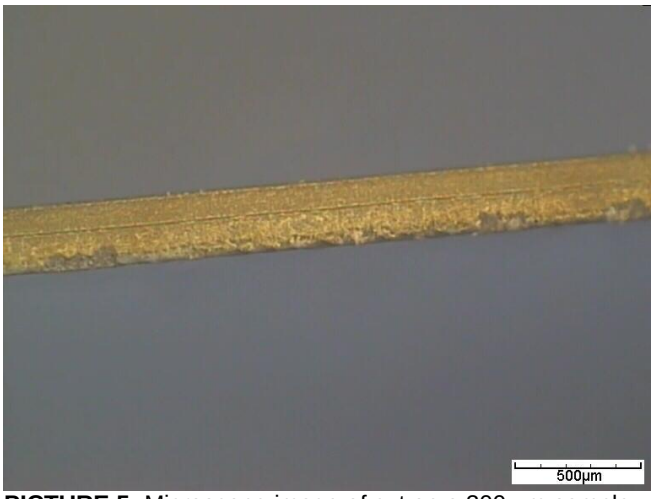
PICTURE 2: Microscope image of cut on a 300µm sample with the strategy A
(Straight line cutting; frontside view)



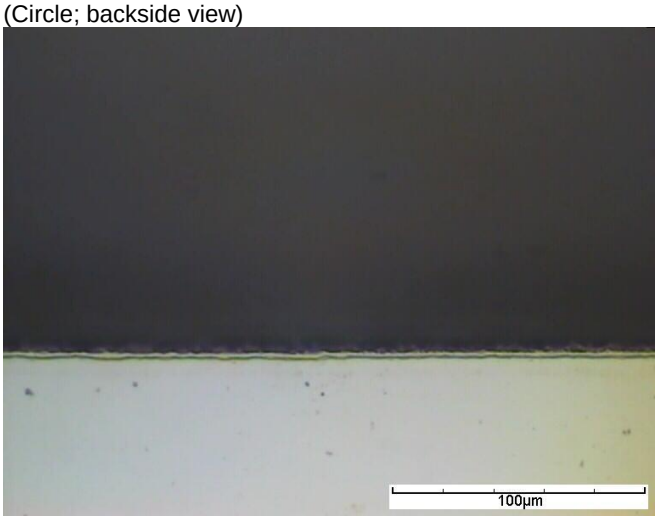
PICTURE 3: Microscope image of cut on a 300µm sample with the strategy A
(Straight line cutting; backside view)



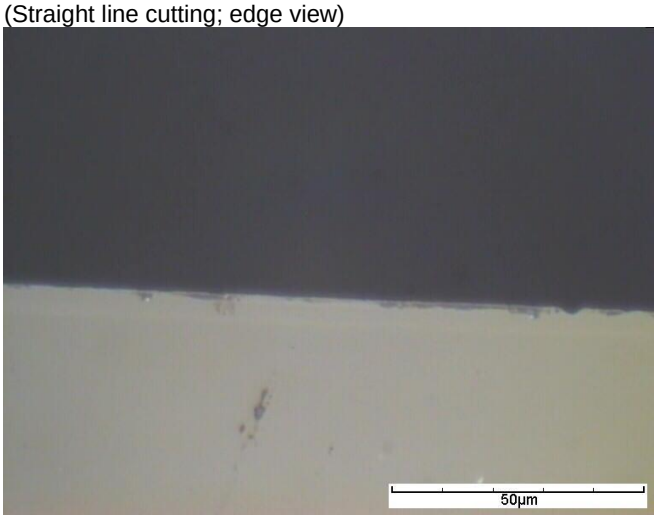
PICTURE 4: Microscope image of cut on a 300 µm sample with the strategy A
(Circle; backside view)



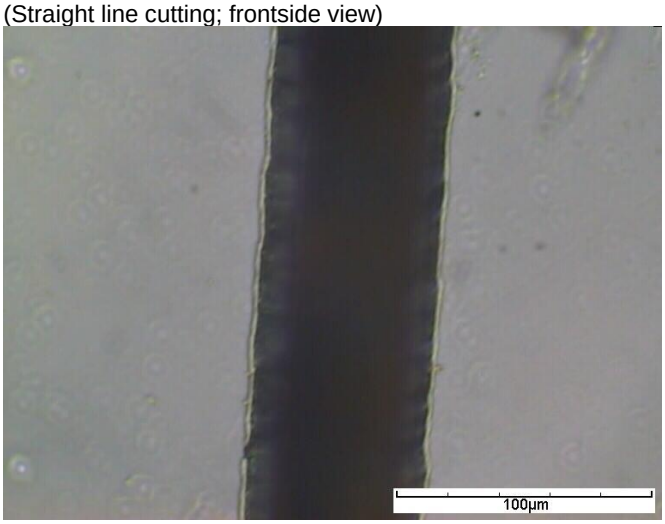
PICTURE 5: Microscope image of cut on a 300 µm sample with the strategy A
(Straight line cutting; edge view)



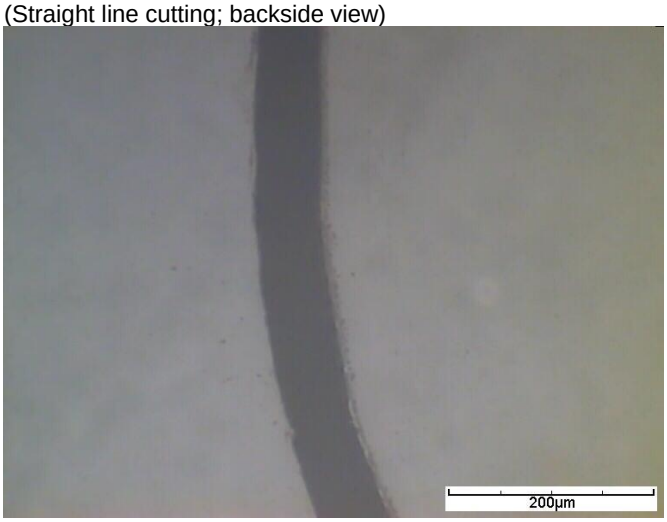
PICTURE 6: Microscope image of cut on a 300µm sample with the strategy B
(Straight line cutting; frontside view)



PICTURE 7: Microscope image of cut on a 300µm sample with the strategy B
(Straight line cutting; backside view)



PICTURE 8: Microscope image of the 250µm-depth scribing (due to saturation) on a 600µm sample with the strategy B
(Straight line cutting; frontside view)



PICTURE 9: Microscope image of the circular scribing on a 600µm sample with the strategy B
(Circular cutting; frontside view)

The cut quality is very high on 300µm sapphire samples cut in straight lines with both strategies (A & B). Nevertheless, some chipping can be observed on the backside with a circular cutting.
We can note a cutting saturation on the 600µm samples (with both strategies) and on the 300µm samples cut with a circular shape with the cutting strategy B.

We would also need some time to develop your specific cutting patterns process. The feasibility of it is most certain, but it will take some time to optimize all the parameters to reach the required dimensions.

	Anonymous priority (1=high, 2=middle, 3=low)	Results/ Specifications
• Chipping/Cracks:	1	To be optimized
• Edge roughness:	3	OK by optical analysis. Need to be measured
• Tolerances:	3	To be optimized
• Fracture strengh	2	To be measured

CONCLUSION

The cutting of sapphire samples was investigated on SYNOVA LCS300. 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 cutting sapphire with high quality.

We successfully cut 300µm sapphire samples. The cut quality is very high with a low process time. Some backside chipping can be observed with the circle shape and the specific cutting strategy B. This chipping could certainly be avoided by varying some cutting parameters such as the water jet pressure, the cutting speed and the working distance.

It has not been possible to cut through the 600µm and 1.0mm thick samples with this set of parameters. To solve this issue, we could try to use a bigger nozzle (and so a higher laser power) to avoid the saturation effect and by consequence to be able to cut thicker samples.

So, in a next step, we would like to optimize the process to avoid the backside chipping. We also would like to try again to cut the 600µm and 1.0mm thick samples using another cutting strategy.

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