SYNOVA Ch. Dent-d'Oche CH-1024 Ecublens Switzerland www.synova.ch	APPLICATION REPORT	Report No: 149-7 Sample No: 2.2.1496 **CONFIDENTIAL**

REPORT: High purity Alumina cutting by Laser MicroJet®

for attention of Anonymous

by Stéphane Delahaye, Synova SA

TASK

The Laser MicroJet® technology has been tested on high purity alumina materials. The goal of this new iteration was to cut different geometries into ceramic blocks.

SAMPLE DESCRIPTION AND PREPARATION

SAMPLE	Material	Ceramic block of high purity alumina
	Wall thickness	1.6-1.8 *mm*
	Quantity	3 *pcs*

The objective was to cut several geometries in order to show Laser MicroJet® technology capabilities. Ceramic plates were hold up with clamps during the tests.

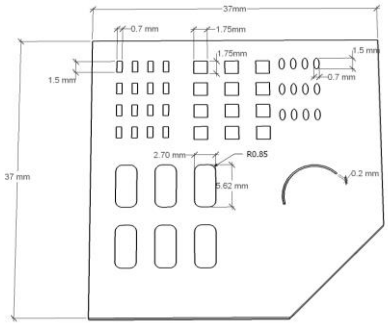


FIGURE 1: Illustration of the sample

Release of application report			
Project Leader		Responsible Application Group	
Name:	Stephane Delahaye	Name:	Benjamin Carron
Date:	12.09.2014	Date:	12.09.2014
Visum:	SDE	Visum:	BC

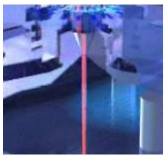
PROCESS: INSTRUMENT & TEST PARAMETERS

For these experiments, an LCS 150 equipped with a frequency-doubled Q-switched Nd:YAG laser has been used as the machine configuration in our lab. It is a manually loaded machine, allowing cutting and drilling any kind of materials.

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

- Cutting of non-conductive materials
- Advantageous process rates
- Cutting of arbitrary shapes
- Low heat damage to the material

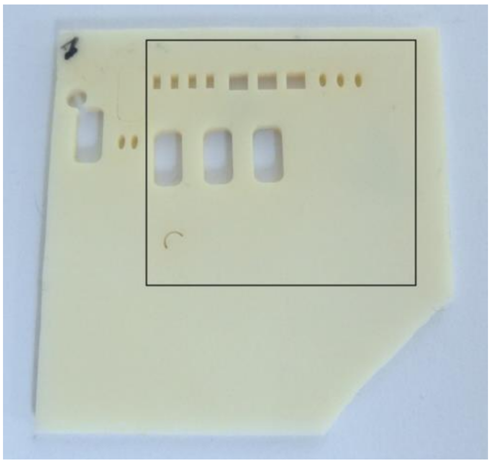
In the table below, the optimized processing parameters used in the experiments are summarized. Please note that the laser has one cavity, the process time could be reduced with the use of a double cavity laser.

	**SYSTEM**	Machine type	LCS150
	**MICROJET PARAMETERS**	Nozzle diameter	60 *µm*
		MicroJet diameter	~48 *µm*
		Water pressure	180 *Bar*
		Working distance	~12 *mm*
		Assist gas	He (0.9 *L/min*)
	**LASER PARAMETERS**	Laser type	L101G
		Wavelength	532 *nm*
		Frequency	6 *kHz*
		Pulse width	120 *ns*
		Power	35 *W*
		Power in jet	~21 *W*

RESULTS

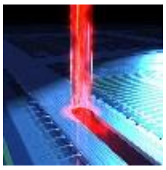
The preliminary tests were performed with a 50 µm nozzle but the process was not stable. Indeed at the end of the process the sample may slightly move if no suitable holder is used so a higher number of passes is requested too cut through the plate. Using a larger nozzle increases the cut width and limits this effect. Please note that a 100 µm radius has been also added to the rectangles and squares to facilitate the cut. Investigations regarding the frequency, power and cutting speed were performed during the first experiments to determine the best parameters but the purity and the thickness of the samples require high pulse energy and reduce the range of cutting speed. Nevertheless the latest was optimized for each shape.

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

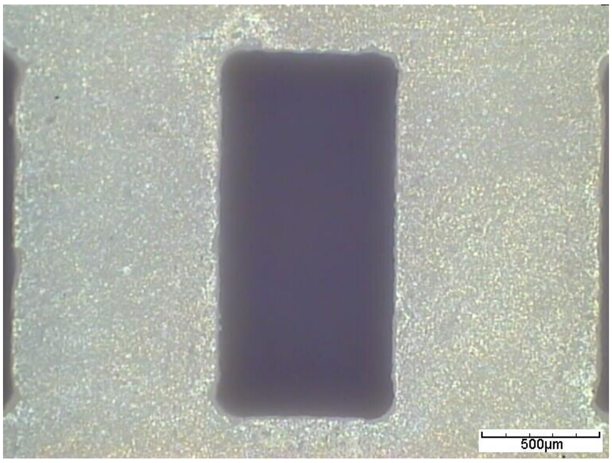


PICTURE 1: Digital camera picture of the sample.
The black window shows repeatability tests.

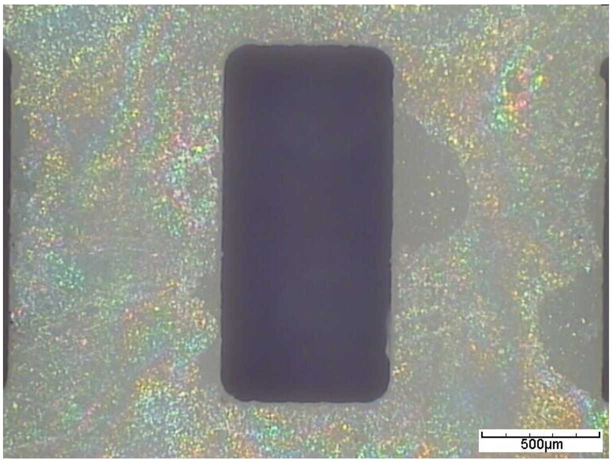
1. Small rectangles: 1.5*0.7mm



CUTTING PARAMETERS		
	Motion speed	4 *mm/s*
	Pass numbers	300
	Process speed	0.8 *mm/min*

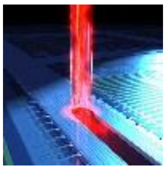


PICTURE 2: Microscope image of the frontside (dark field illumination)

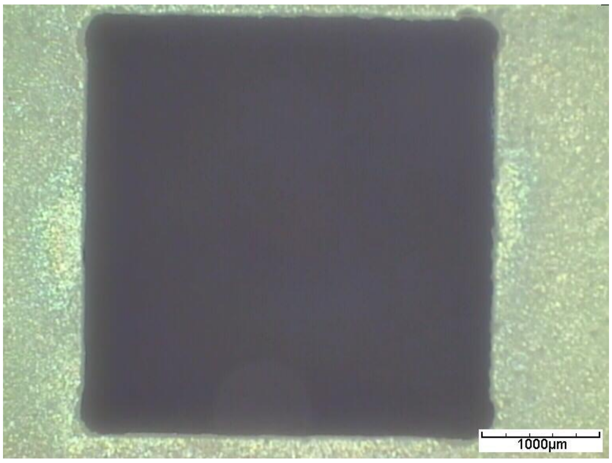


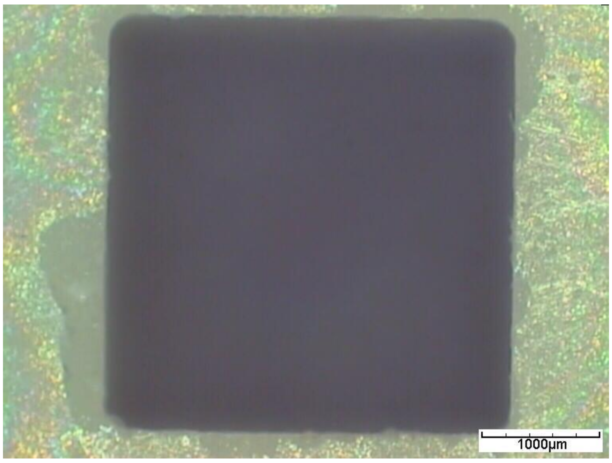
PICTURE 3: Microscope image of the backside (dark field illumination)

2. Squares 1.75*1.75 mm



CUTTING PARAMETERS		
	Motion speed	4 *mm/s*
	Pass numbers	200
	Process speed	1.2 *mm/min*

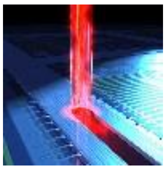




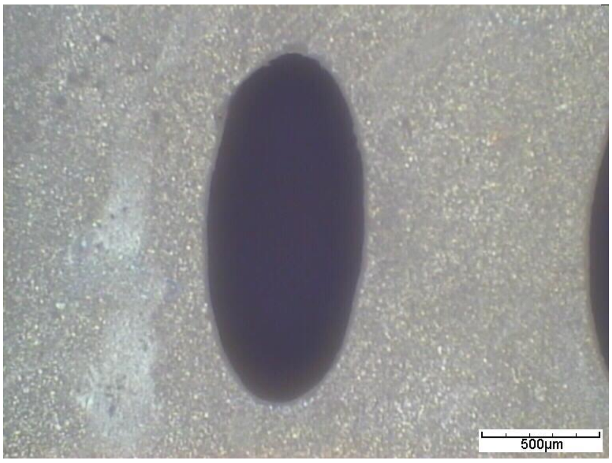
PICTURE 4: Microscope image of the frontside (dark field illumination)

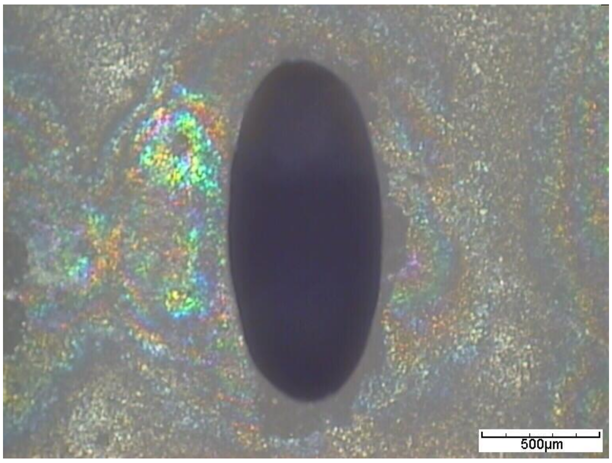
PICTURE 5: Microscope image of the backside (dark field illumination)

3. Oval 0.7*1.5 mm



CUTTING PARAMETERS		
	Motion speed	10 *mm/s*
	Pass numbers	400
	Process speed	1.5 *mm/min*

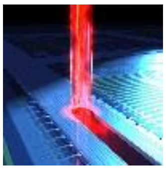




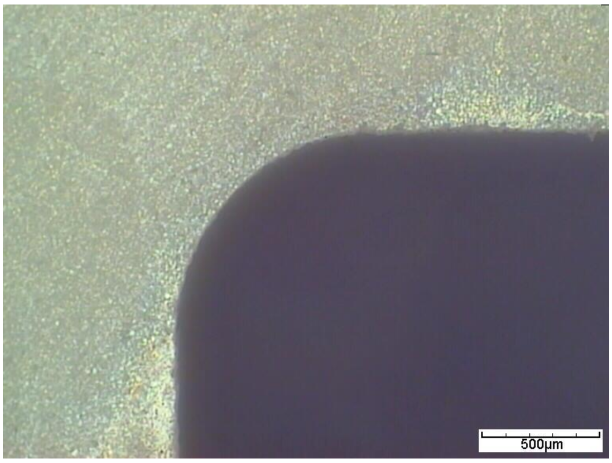
PICTURE 6: Microscope image of the frontside (dark field illumination)

PICTURE 7: Microscope image of the backside (dark field illumination)

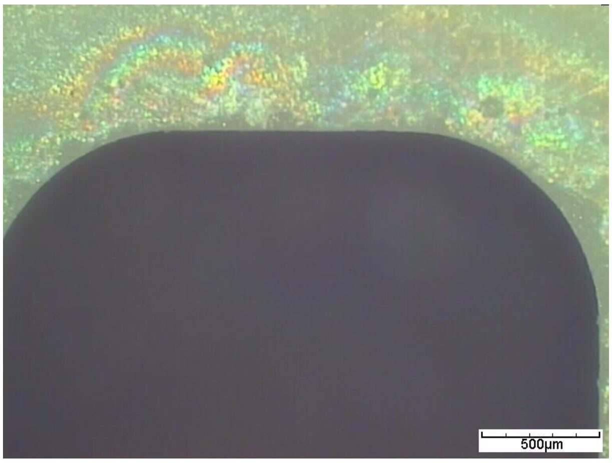
4. Rectangle 2.7*5.62 mm



CUTTING PARAMETERS		
	Motion speed	10 *mm/s*
	Pass numbers	150
	Process speed	4 *mm/min*

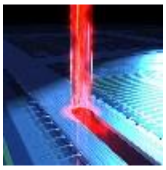


PICTURE 8: Microscope image of the frontside (dark field illumination)

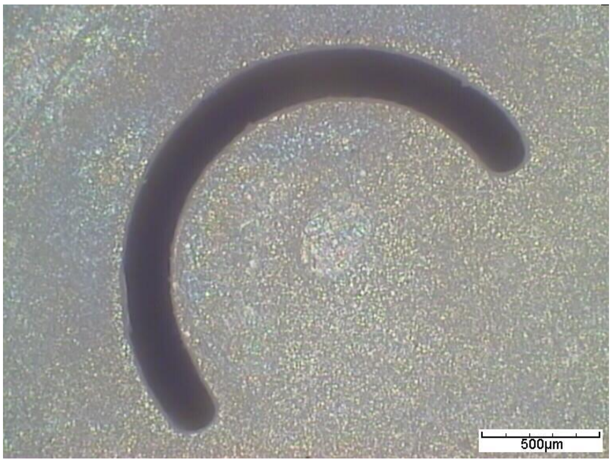


PICTURE 9: Microscope image of the backside (dark field illumination)

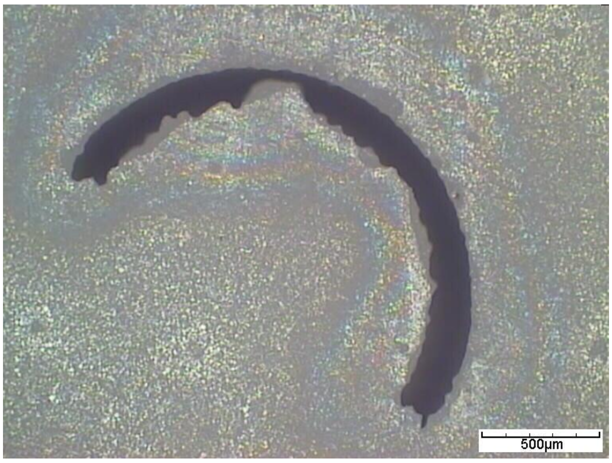
5. Slot



CUTTING PARAMETERS		
	Motion speed	3 *mm/s*
	Pass numbers	150
	Process speed	1.2 *mm/min*



PICTURE 10: Microscope image of the frontside (dark field illumination)



PICTURE 11: Microscope image of the backside (dark field illumination)

CONCLUSION

The Cutting of high purity alumina was investigated on a Synova LCS 150. This machine is based on the Laser MicroJet® technology and combines the advantages of a 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 and grooving hard materials with high quality.

This test shows that:

- High purity alumina requires high pulse energy and short pulse width to be cut. This will limit the parameters range for process development especially on thick samples (>1mm).
- Good cutting quality is achievable on the frontside while some chipping is visible on the backside. This could be improved depending on the sample thickness and the geometry to be cut by adjusting the cutting speed and pulse energy.
- Overall cutting speed may vary depending on the sample geometry. Sharp angles requires more passes to be cut
- Cutting speed can be improved (with a factor of ~1.5) by using a double cavity green laser (not available for these tests).

We thank you for your interest in our technology. We will contact you soon to receive your feedback and the analysis of these results and to discuss the further steps.