REPORT: Ceramic cutting by Laser MicroJet®

for attention of Anonymous

by Ronan Martin, Synova SA

TASK

The Laser MicroJet® technology has been tested for cutting three different kinds of ceramic samples. A 10mm circle was cut in each of the provided plates, with emphasis on quality rather than speed.

SAMPLE DESCRIPTION

Three different ceramic parts were provided, as described below:

WHITE DISC PORTION	Material	Yttria-stabilized cubic zirconia with small addition of hafnium oxide, fine microstructure	
	Porosity	13	*%*
	Thickness	4.8	*mm*
YELLOW RECTANGLE	Material	Yttria-stabilized cubic zirconia, rough microstructure	
	Porosity	15	*%*
	Thickness	3.1	*mm*
WHITE TRIANGLE	Material	CMC: alumina fibers in a matrix of alumina and nano-zirconia	
	Porosity	20	*%*
	Thicknesses	2.8	*mm*

Release of application report			
Project Leader		Responsible Application Group	
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Date:	03.11.2015	Date:	11.11.2015
Visum:	ROM	Visum:	BC

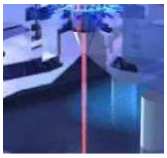
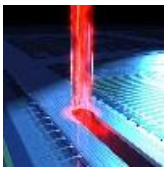
PROCESS: INSTRUMENT & TEST PARAMETERS

For these experiments, an LCS 150 equipped with a dual-cavity frequency-doubled Nd:YAG laser has been used as the machine configuration in our lab. This machine allows most ceramics (including diamond) and any kind of metal.

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

- Negligible heat damage to the material
- Excellent wall surface quality
- Limited chipping
- Advantageous process speed

The table below summarizes the optimized processing parameters used in the experiments.

	**SYSTEM**	Machine type	LCS 150	
		Optical head type	Standard	
		Fixture	Clamps, with bridge glued below	
	**MICROJET® PARAMETERS**	Nozzle diameter	40	*µm*
		MicroJet® diameter	33	*µm*
		Water pressure	400	*bar*
		Assist gas	He, 0.9	*L/min*
	**LASER PARAMETERS**	Laser type	L101G	
		Wavelength	532	*nm*
		Pulse frequency	6	*kHz*
		Internal power	18.2	*W*
		Power in jet	12.7	*W*
		Pulse width	130	*ns*
	**CUTTING PARAMETERS**	Working distance	10	*mm*
		Motion speed	Fine zirconia: 5	*mm/s*
			Rough zirconia: 20	*mm/s*
			CMC: 10	*mm/s*
		Number of passes	Fine zirconia: 100	
			Rough zirconia: 300	
			CMC: 125	
		Cutting time	Fine zirconia: 11.6	*min*
			Rough zirconia: 8	*min*
			CMC: 6.6	*min*

In order to avoid damaging the edge of the cut parts, a thin glass plate was glued below the samples to from a bridge and prevent the cut parts from falling down when cut through.

RESULTS

One circle was cut in each of the three provided plates, as shown in the pictures below.

PICTURES 1A, 1B & 1C: Camera pictures of the cut discs; left: fine zirconia, center: rough zirconia; right: CMC.

The microscope pictures below show in more detail the quality that was obtained.

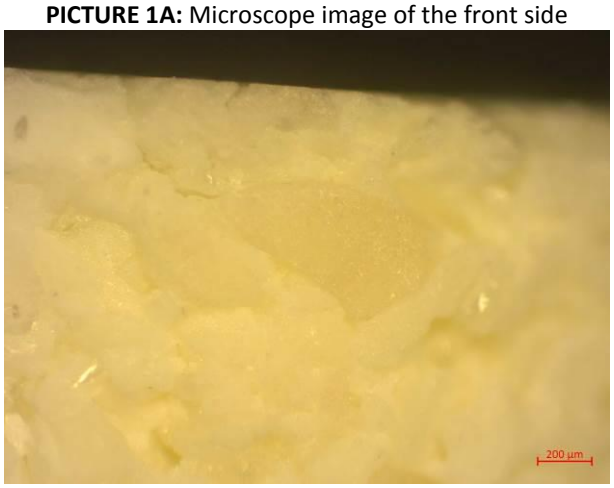
The fine zirconia was cut very smoothly, and there is hardly any chipping. There is some local discoloration on one part of the cut wall, but this is certainly due to a small motion of the cut part at the end of the cut, meaning that the glued bridge was not perfect.

The rough zirconia and the CMC have a microstructure that naturally leads to a rougher cut wall. There is some chipping, but no visible crack formation.

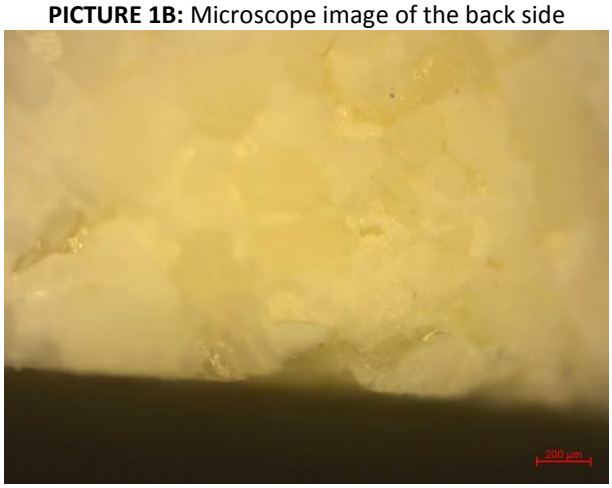
Rough zirconia

PICTURE 1A: Microscope image of the front side

PICTURE 1B: Microscope image of the back side

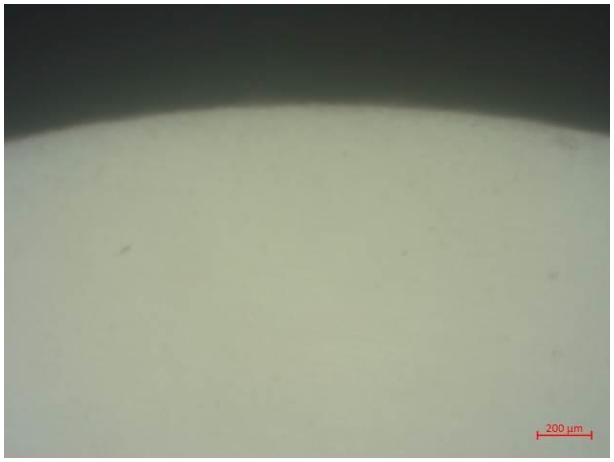


PICTURE 1C: Microscope image of the side wall top

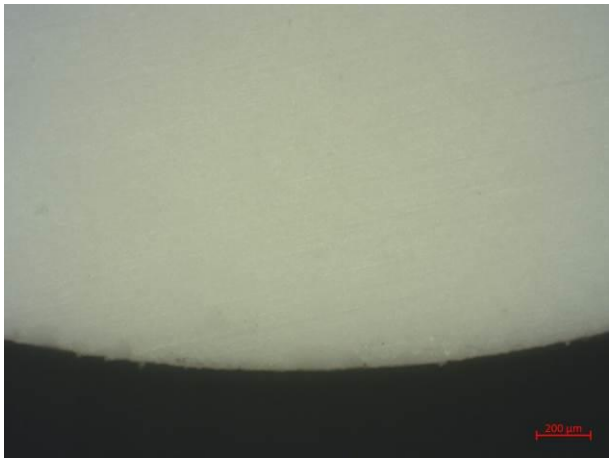


PICTURE 1D: Microscope image of the side wall bottom

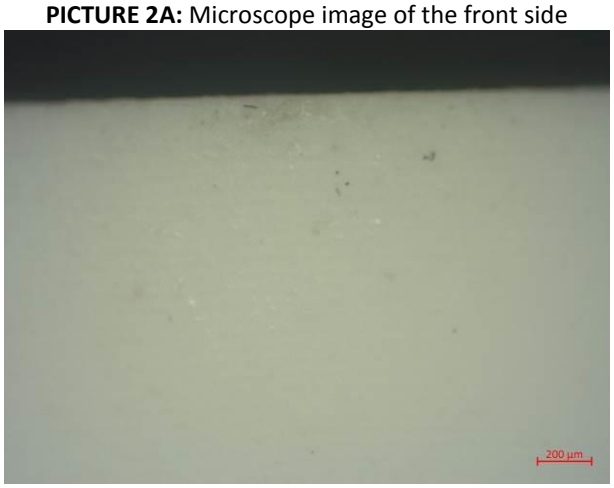
Fine zirconia



PICTURE 2A: Microscope image of the front side



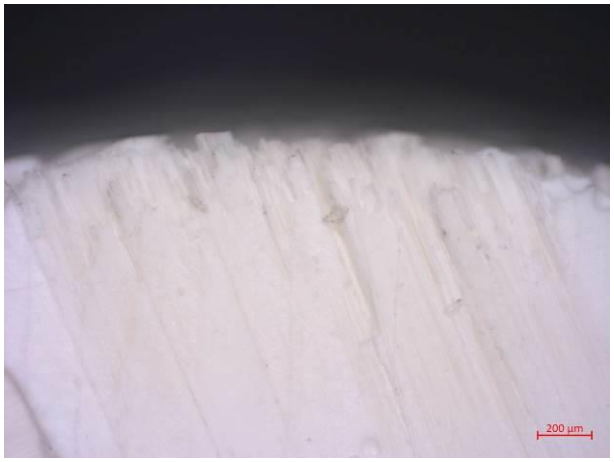
PICTURE 2B: Microscope image of the back side



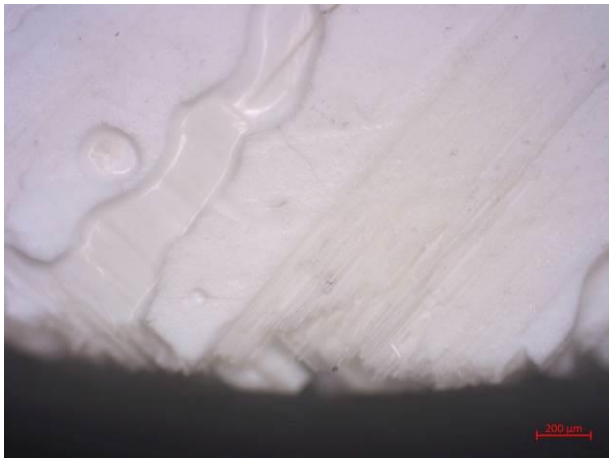
PICTURE 2C: Microscope image of the side wall top

PICTURE 2D: Microscope image of the side wall bottom

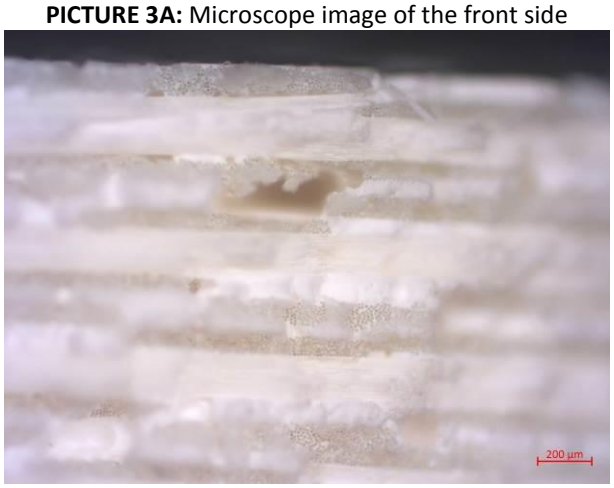
CMC



PICTURE 3A: Microscope image of the front side



PICTURE 3B: Microscope image of the back side



PICTURE 3C: Microscope image of the side wall top

PICTURE 3D: Microscope image of the side wall bottom

CONCLUSION

The cutting of ceramics 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 ceramics with high quality.

These tests have shown that:

- all the different provided ceramics can be cut;
- no visible cracks are formed;
- fine zirconia can be cut with excellent quality.

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