REPORT: Brass, steel and Durnico cutting by Laser-MicroJet®

for Anonymous

by Stephane Delahaye; Synova SA

TASK

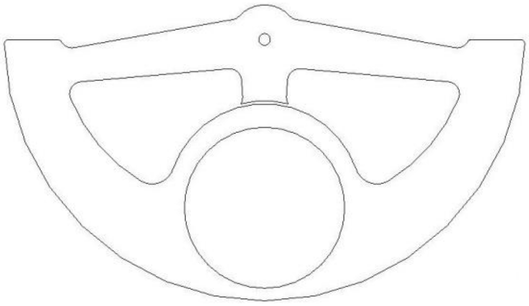
The Laser-MicroJet® technology has been tested for cutting steel and brass samples
Three different materials were available for the tests. The goal was to show the feasibility of the process and to give a first estimation of the speed and the quality that we can achieve.

SAMPLE DESCRIPTION AND PREPARATION

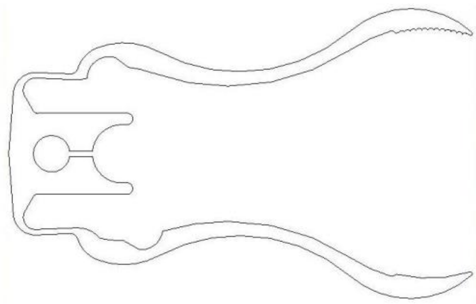
SAMPLE 1	Material	CuZn39Pb2
	Dimension	~50*50 *mm*
	Thickness	1400 *µm*
	Quantity	2 *pcs*
SAMPLE 2	Material	Stainless steel
	Dimension	~50*20 *mm*
	Thickness	300 *µm*
	Quantity	4 *pcs*
SAMPLE 3	Material	Durnico
	Dimension	~30*20 *mm*
	Thickness	1000 *µm*
	Quantity	2 *pcs*

Release of application report			
Project Leader		Responsible Application Group	
Name:	Stephane Delahaye	Name:	D[r] Benjamin Carron
Date:	31.10.2012	Date:	31.10.2012
Visum:	SDE	Visum:	BC

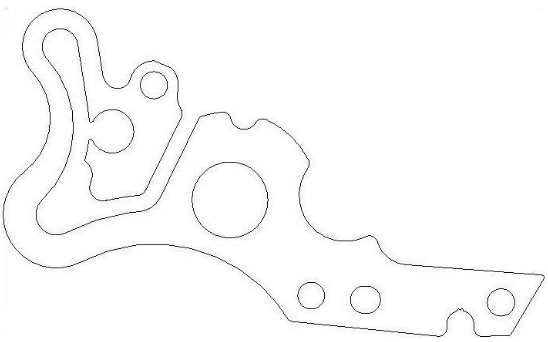
The pictures below show the drawings used to process the 3 samples:



Sample 1



Sample 2



Sample 3

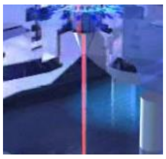
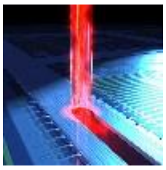
PROCESS: INSTRUMENT & TEST PARAMETERS

For these experiments, the LCS 300 equipped with an Nd:YAG laser has been used as the machine configuration in our lab.
It is a manually loaded machine, allowing to cut, drill, groove, scribe, trench, mark, or grind nearly any kind of material.

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

- Advantageous process rates
- Cutting of arbitrary shapes
- Parallel cut
- Excellent wall surface quality
- Negligible heat affected zones

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

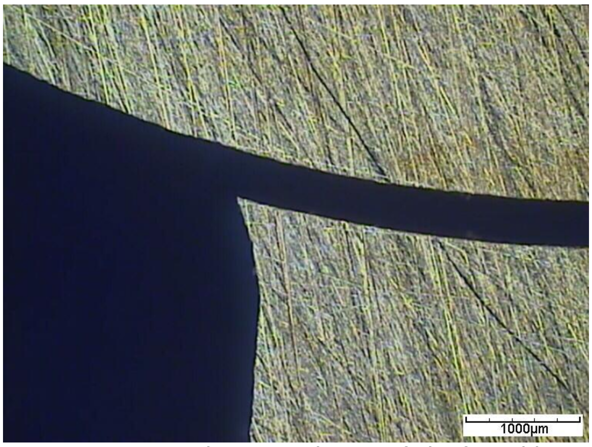
	**SYSTEM**	Machine type	DCS 300	
	**MICROJET® PARAMETER**	Nozzle diameter	40	*µm*
		MicroJet® diameter	32	*µm*
		Water pressure	350	*bar*
		Assist gas	He	
	**LASER PARAMETER**	Laser type	L101G	
		Wavelength	532	*nm*
		Pulse frequency	See results	*kHz*
		Average power	See results	*W*
		Pulse width	See results	*ns*
	**CUTTING PARAMETER**	Cutting speed	See results	*mm/s*
		Number of passes	See results	
		Overall speed	See results	*mm/s*
		Fixing system	clamps	

RESULTS

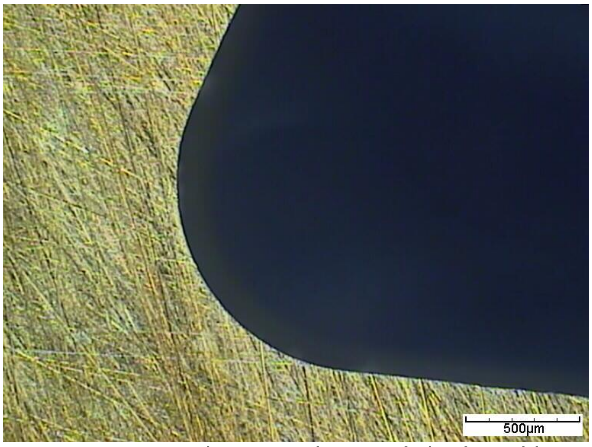
The following microscope pictures give an overview on the quality obtained with the Laser-Microjet® technology on the 3 samples.

Sample 1:

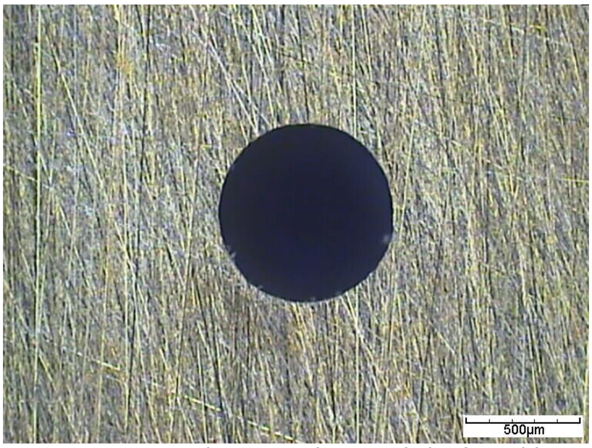
LASER PARAMETER	Pulse frequency	6	*kHz*
	Average power	10	*W*
	Pulse width	*~140*	*ns*
CUTTING PARAMETER	Cutting speed	5	*mm/s*
	Number of passes	40	
	Overall speed	0.125	*mm/s*
	Process time	35	*min*



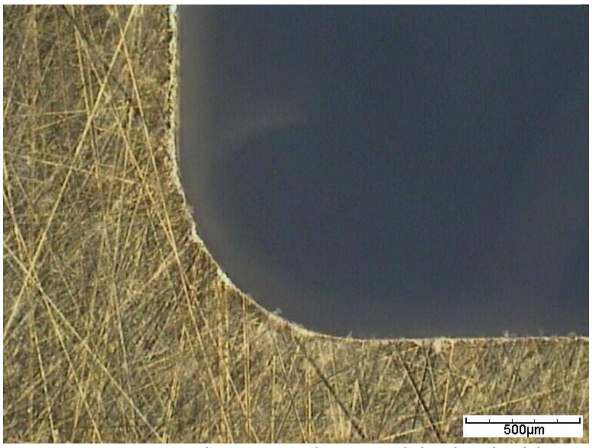
PICTURE 1: Microscope image of the frontside (dark field illumination)



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

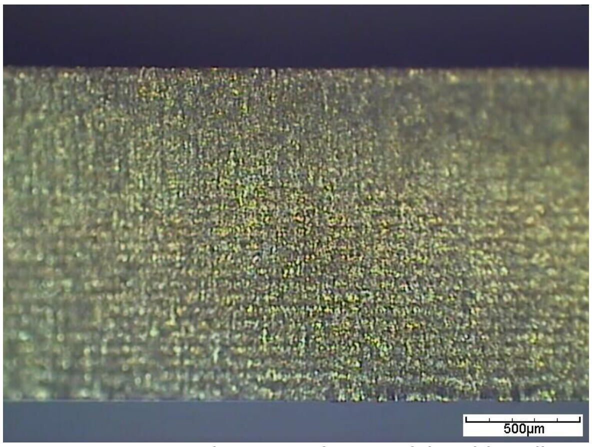


PICTURE 3: Microscope image of the frontside (dark field illumination)



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

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



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

Conclusion:
As mentioned above the 2 samples were processed at 6kHz with a pulse energy of ~1.7mJ and a motion speed of 5mm/s.
Both sides show very good quality. The edges are sharp and clean and the cutting walls are smooth. Some marks may be found on the walls because the sample is not correctly handled and may move at the end of the cut. A fixing system must be developed to avoid that issue.

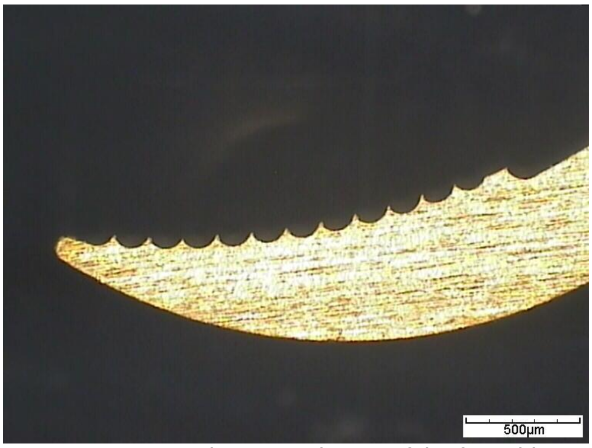
Sample 2:

The table below shows the most relevant results:

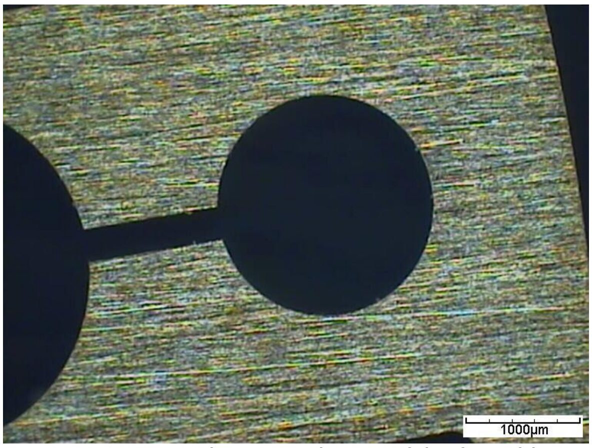
TEST	Sample	B	F	J	K	
LASER PARAMETER	Pulse frequency	6	30	6	6	*kHz*
	Average power	9	10	11	11	*W*
	Pulse width	*~140*	*~140*	*~110*	*~110*	*ns*
CUTTING PARAMETER	Cutting speed	0.2	0.2	0.6	0.8	*mm/s*
	Number of passes	1	1	1	1	
	Overall speed	0.2	0.2	0.6	0.8	*mm/s*
	Process time	~360	~360	~125	~94	*s*

As described in the parameter table above, samples B was processed at 6 kHz with a motion speed of 0.2 mm/s. Sample F was also processed at 0.2 mm/s but at 30 kHz to reduce the pulse energy and limit heat damage. In order to decrease the process time, samples J and K were processed at 6 kHz with a higher pulse energy and a motion speed varying from 0.6 to 0.8 mm/s.

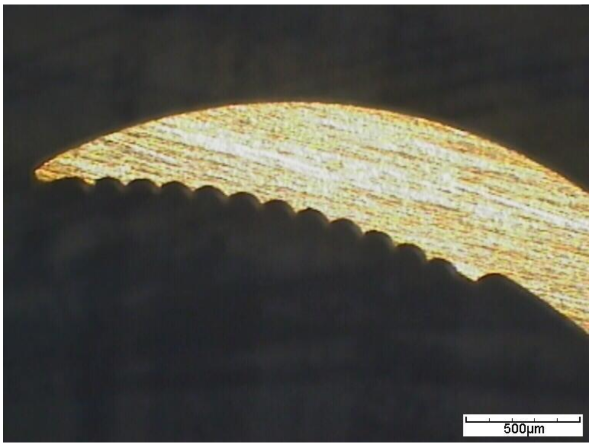
Sample B



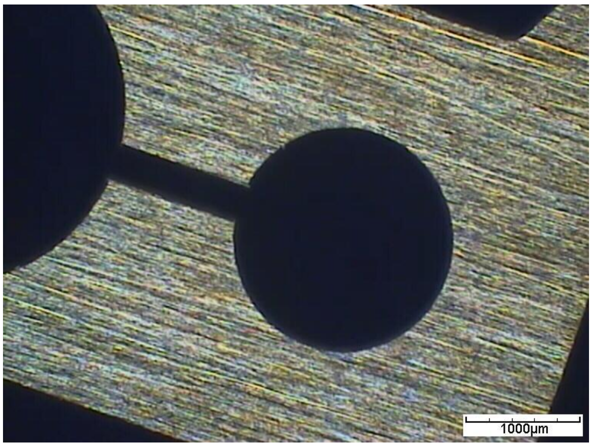
PICTURE 7: Microscope image of the frontside (dark field illumination)



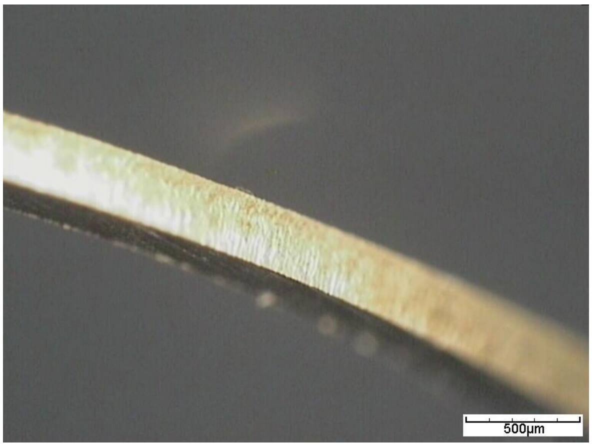
PICTURE 8: Microscope image of the frontside (dark field illumination)



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

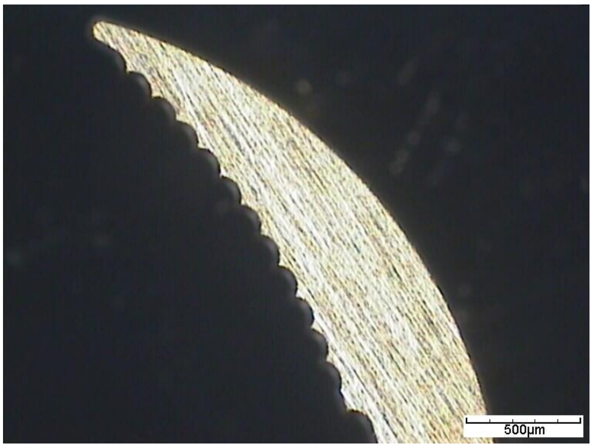


PICTURE 10: Microscope image of the backside (dark field illumination)

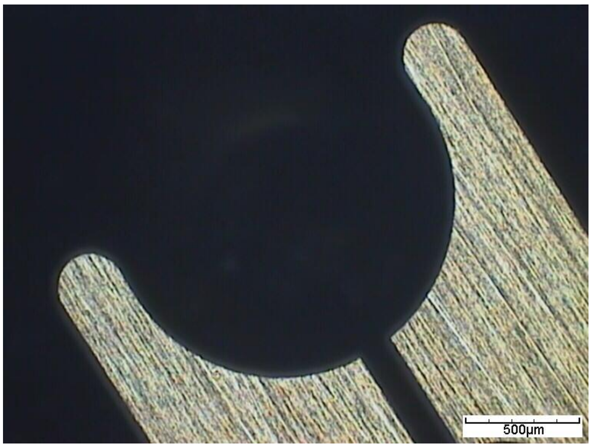


PICTURE 11: Microscope image of the sidewall (dark field illumination)

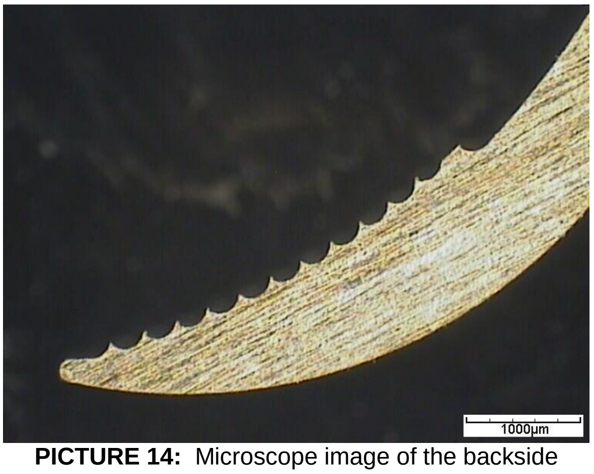
Sample F



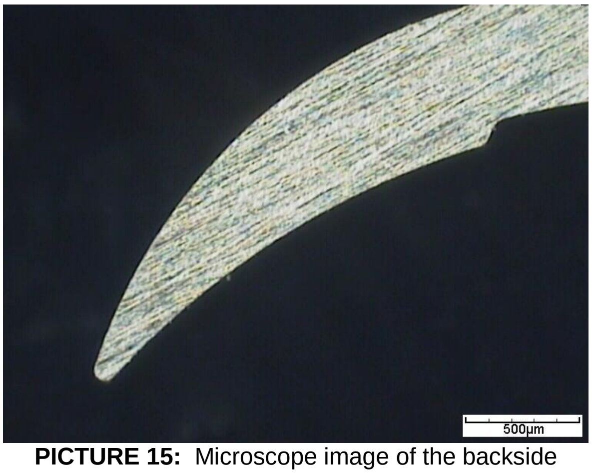
PICTURE 12: Microscope image of the frontside (dark field illumination)



PICTURE 13: Microscope image of the frontside (dark field illumination)

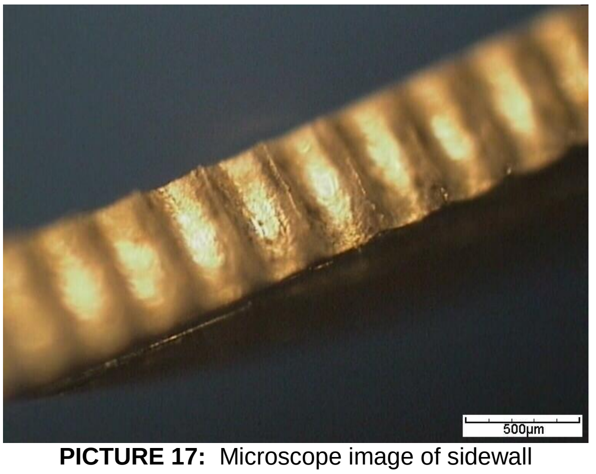


PICTURE 14: Microscope image of the backside (dark field illumination)



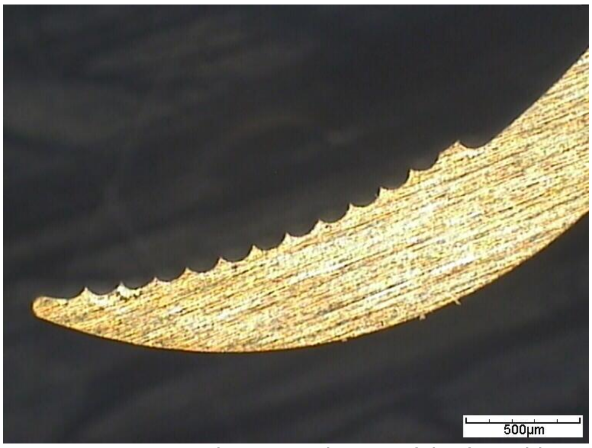
PICTURE 15: Microscope image of the backside (dark field illumination)

PICTURE 16: Microscope image of sidewall (dark field illumination)

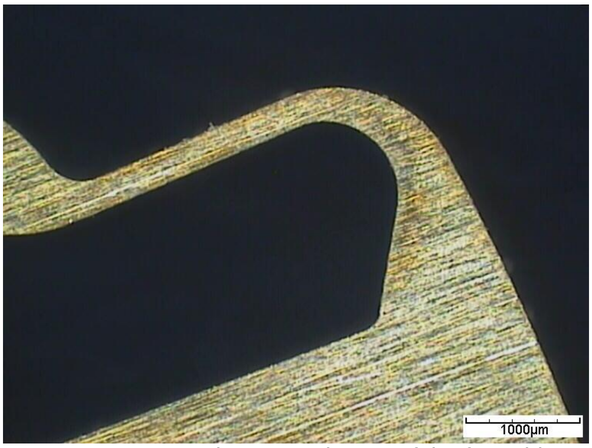


PICTURE 17: Microscope image of sidewall (dark field illumination)

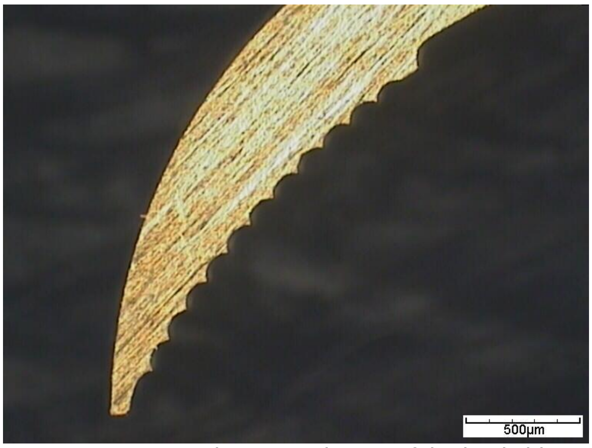
Sample J



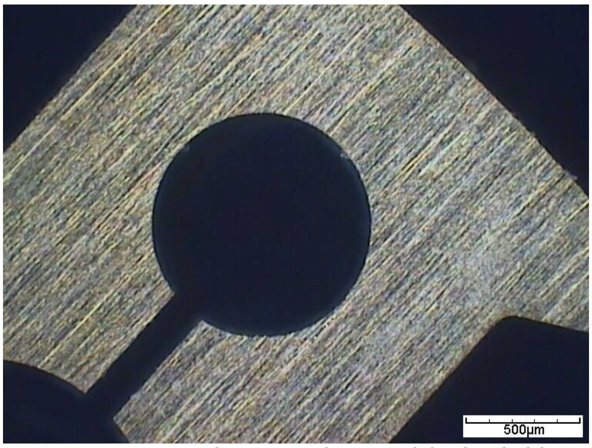
PICTURE 18: Microscope image of the frontside (dark field illumination)



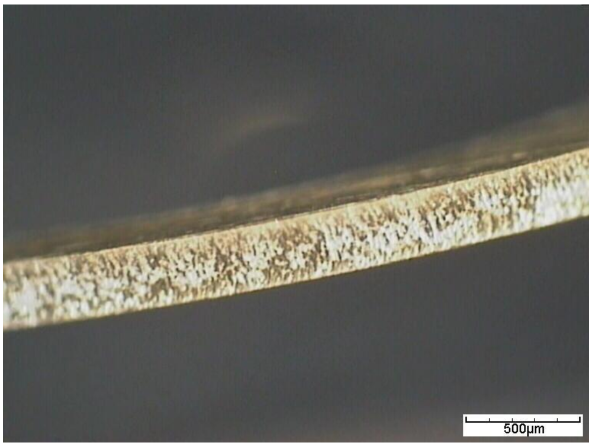
PICTURE 19: Microscope image of the frontside (dark field illumination)



PICTURE 20: Microscope image of the backside (dark field illumination)

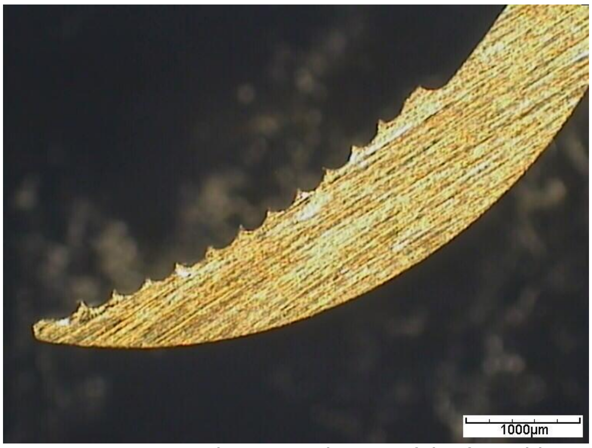


PICTURE 21: Microscope image of the backside (dark field illumination)

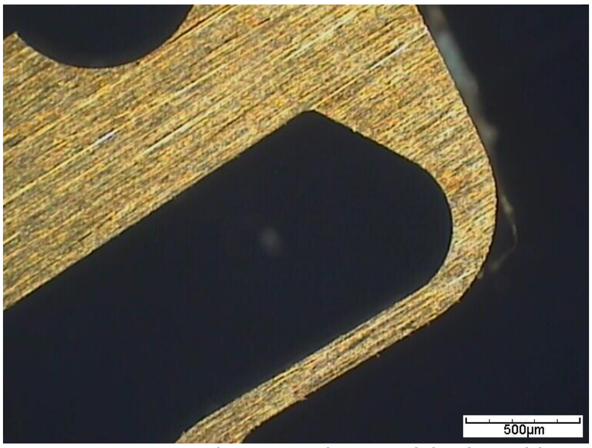


PICTURE 22: Microscope image of sidewall (dark field illumination)

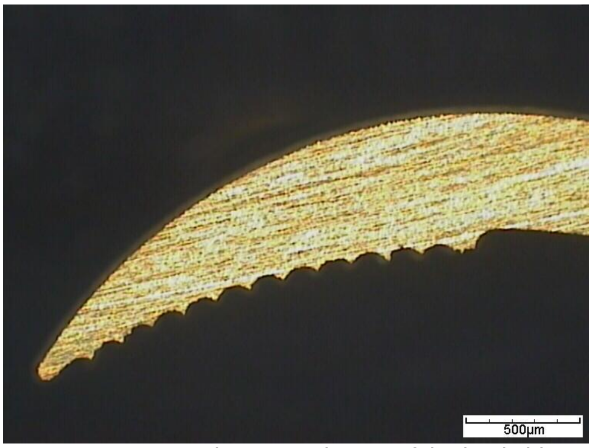
Sample K



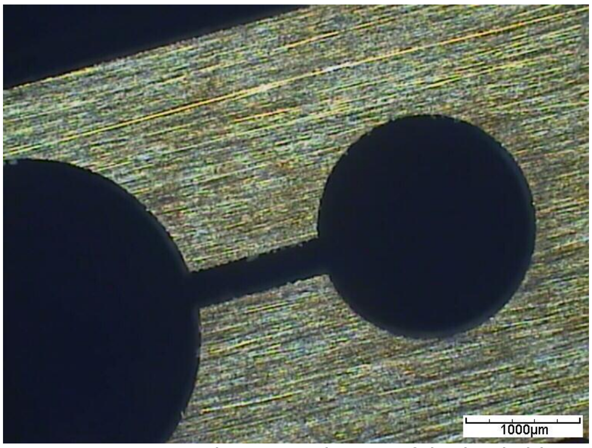
PICTURE 23: Microscope image of the frontside (dark field illumination)



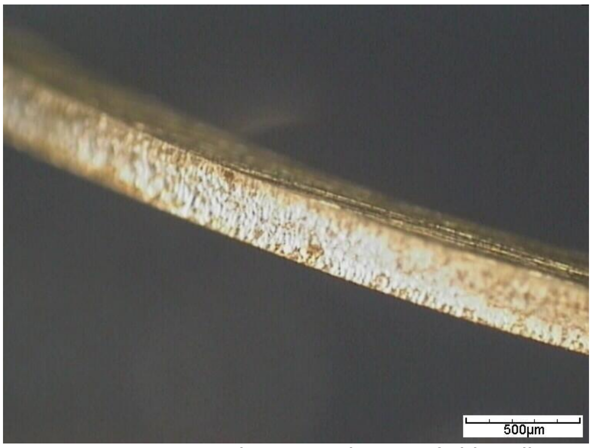
PICTURE 24: Microscope image of the frontside (dark field illumination)



PICTURE 25: Microscope image of the backside (dark field illumination)



PICTURE 26: Microscope image of the backside (dark field illumination)



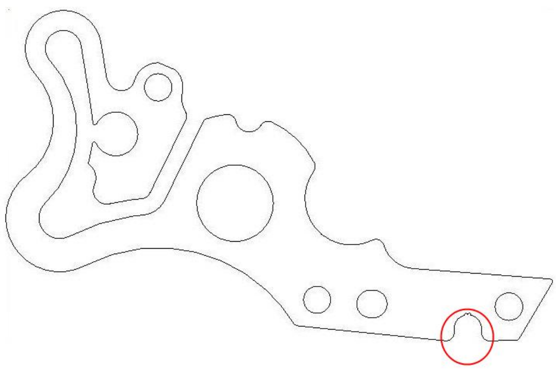
PICTURE 27: Microscope image of sidewall (dark field illumination)

Conclusion:
Samples processed with low speed show the best cutting quality. They present no burrs on the backside and very good sidewalls.
When the speed increases some irregularities/ burrs appear on the backside.

Sample 3:

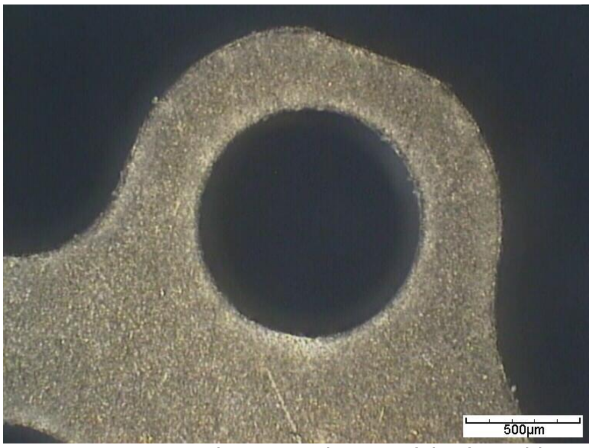
TEST	Sample	A	C	
LASER PARAMETER	Pulse frequency	6	6	*kHz*
	Average power	11	11	*W*
	Pulse width	*~110*	*~110*	*ns*
CUTTING PARAMETER	Cutting speed	5 and 1(red area)	5	*mm/s*
	Number of passes	~25	~25	
	Overall speed	0.2	0.2	*mm/s*
	Process time	~9	~8.5	*min*

The cutting strategies were different for the 2 samples.
For the first one the cutting speed was adjusted for the red part at 1mm/s. As the feature is very small the cutting speed must be adjusted to respect the geometry of the sample.

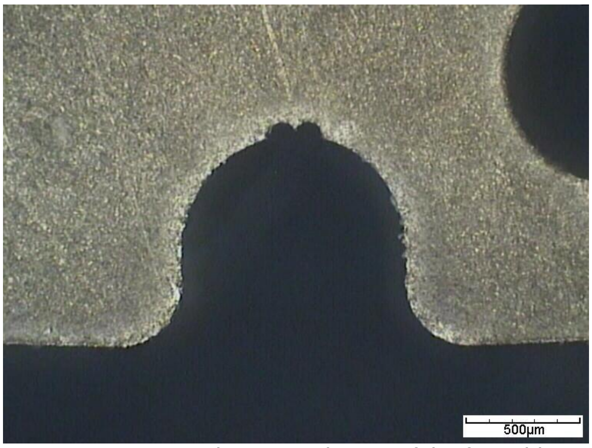


The second was processed with a constant cutting speed (the red part was simplified)

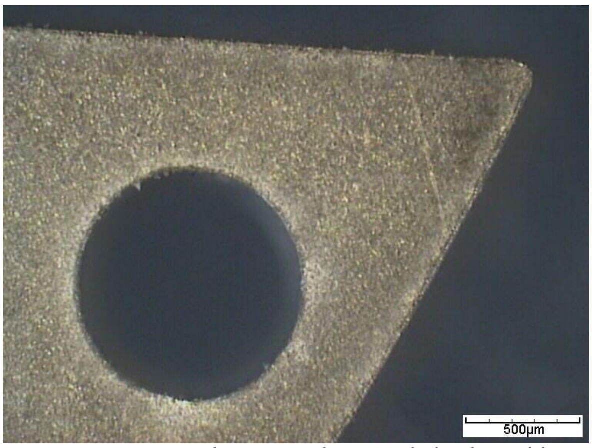
Sample A



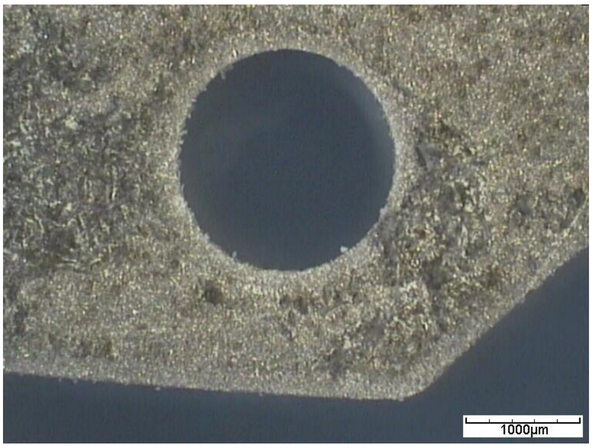
PICTURE 28: Microscope image of the frontside (dark field illumination)



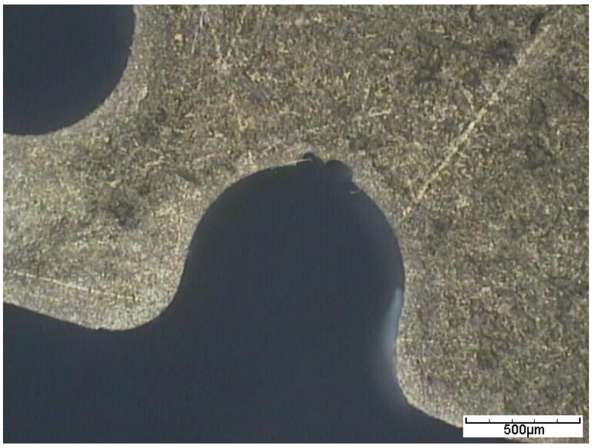
PICTURE 29: Microscope image of the frontside (dark field illumination). Some irregularities are visible



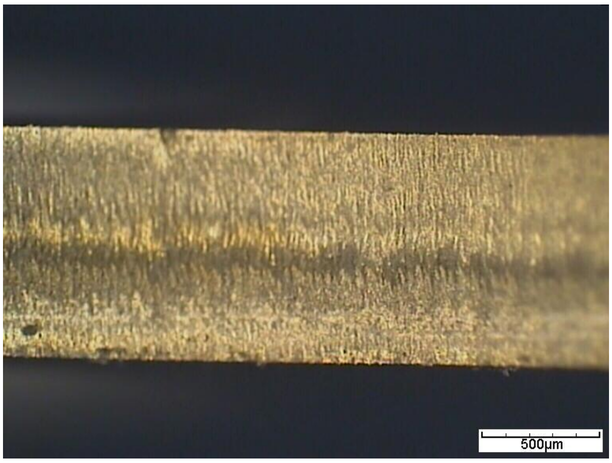
PICTURE 30: Microscope image of the frontside (dark field illumination)



PICTURE 31: Microscope image of the backside (dark field illumination)



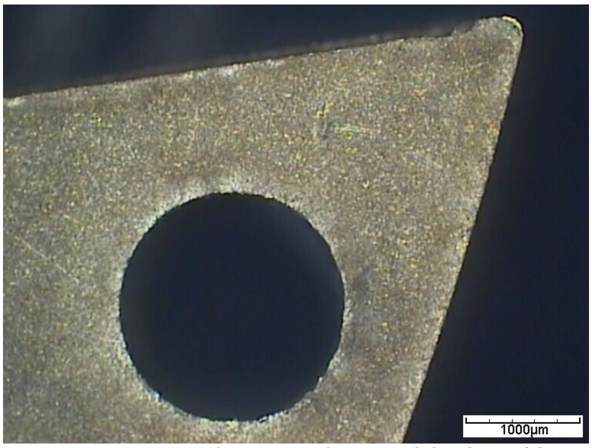
PICTURE 32: Microscope image of the frontside (dark field illumination).



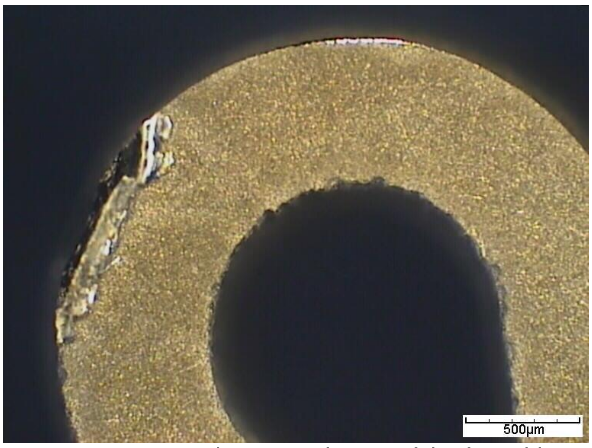
PICTURE 33: Microscope image of the sidewall (dark field illumination). Sidewall is not totally uniform.

Please note that the red part has been damaged during the cleaning and the handling of the sample. As the dimensions are very small further process development are necessary to achieve good cutting quality

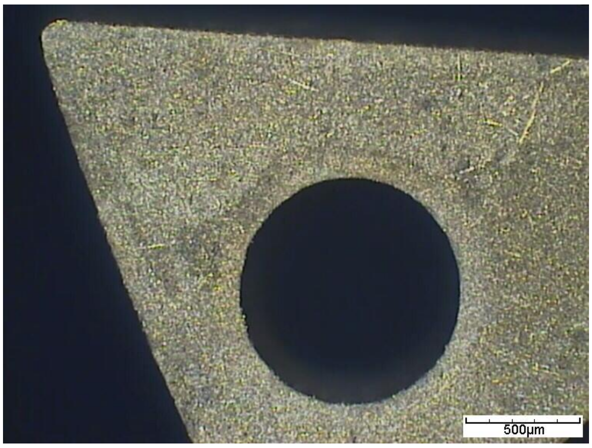
Sample C



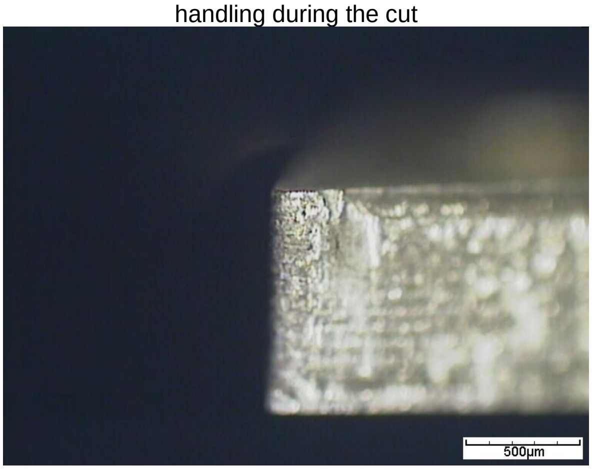
PICTURE 34: Microscope image of the frontside (dark field illumination).



PICTURE 35: Microscope image of the frontside (dark field illumination). A mark is visible due to a bad handling during the cut



PICTURE 36: Microscope image of the backside (dark field illumination)



PICTURE 37: Microscope image of the frontside (dark field illumination)

Conclusion:

This last sample is the most difficult due to its complex geometry. Sample A offers good front side and backside quality but sidewall quality is not totally uniform and further developments are necessary to fix that issue. Moreover additional tests are necessary to optimize cutting quality of the red part.
Sample C can be cut more easily because we removed the smaller part on the drawing so the speed is constant during the cut. It offers a better sidewall quality but some marks are visible due to a bad handling of the sample during the cut.

The table below summarises Anonymous expectations and our results.

	What are your priorities? (please put a cross)	Synova's results
Speed / throughput:	high	Sample 1: ~35 min Sample 2: from 6min to 1min30s Sample 3: ~9 min Further developments will decrease the process time
Kerf-width:	high	-
Burr-free:	high	Very limited
Depth control:	medium	-
Contamination/Particles:	Low	Negligible
Heat-damage free:	high	No visible heat damage
Chipping/Cracks:	high	Limited especially on sample 1 and 2
Edge Roughness:	high	Very low on edges
Tolerances:	medium	Need to be confirmed
Fracture strength:	medium	-

CONCLUSION

The cutting of brass, steel and Durnico samples was investigated on SYNOVA LCS 300. 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 brass, steel and Durnico with high quality.

These tests show that:

- Very good cutting quality is achievable for sample 1 and 2. These Samples offer an excellent front side quality, smooth cut walls and good backside quality (burrs are almost inexistent). Moreover no heat affected zone is visible
- Sample 3 (Durnico) shows good cutting quality but few burrs are visible especially for the "red" area. Additional tests are necessary to optimize cutting parameters.

The processing times are given in the table above. Please note that they could be improved with further developments.
Indeed several options are possible:

- Motion speed can be adjusted depending on the area of interest. Functional zones can be processed at low speed for a better cutting quality.
- The processing time can also be decreased by factor 2 or 3 (depends on the sample geometry) by increasing the frequency and the motion speed and keeping the pulse energy and the overlap constant
- Pulse energy can be increased (can affect the quality).

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