REPORT: Cutting of brush springs by Laser-MicroJet®

for Anonymous

by Synova SA, Mr. Florent Bruckert

TASK

This application aimed at optimizing the cutting speed of brush springs using the Laser-MicroJet® technology.

TASK DESCRIPTION

SUPPLIED MATERIAL	Material	CuBe2 / CuNi15Sn8
	Thickness	0.09 mm

Two types of brush springs were provided for cutting. On the first type, the contacting fingers had to be completely cut into the piece. On picture 1, one can see the piece as provided (right arm) and the piece once cut (left arm). For the second type, each provided spring already had 9 contacting fingers attached to it. The task consisted in extending the cut between the fingers in the spring. On picture 2, we can see the piece as provided (left arm) and the piece once cut (right arm). Each type of brush spring was provided in CuBe and in CuNi15Sn8.

Release of application report			
	Project Leader		Industry BU Responsible
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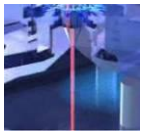
Date:	17.04.2014	Date:	17.04.2014
Visum:	FBR, SHI	Visum:	BC

PICTURE 1: Cut and original piece

PICTURE 2: Cut and original piece

PROCESS: INSTRUMENT & TEST PARAMETERS

For this application, the LCS150, equipped with a frequency doubled, Q-switched, Nd:YAG laser, has been selected as the best machine configuration available in the lab. In the table below, the optimised processing parameters used in the experiments are summarised:

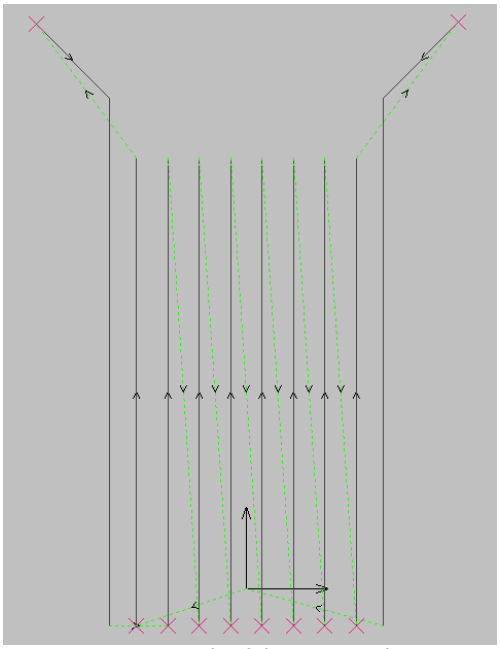
	**SYSTEM**	Machine type	LCS150	
		Fixture	Clamped	
	**MICROJET® PARAMETER**	Nozzle diameter	40	*µm*
		Kerf width	64	*µm*
		Water pressure	400	*bar*
		Working distance	12	*mm*
		Assist gas	He	
	**LASER PARAMETERS**	Laser type	L51G	
		Wavelength	532	*nm*

In order to optimize the cutting speed, four sets of cutting parameters have been tested. They are summarized in the table below:

Set	Frequency [kHz]	Power (internal) [W]	Power (in the water jet) [W]	Pulse duration [ns]
P1	6	24.3	8.8	120
P2	6	28.0	10.1	120
P3	12	33.1	11.9	130
P4	14	42	15.1	130

Table 1: Sets of cutting parameter used

The picture 3 shows the path of the Laser-MicroJet®.



PICTURE 3 : Path of the Laser-MicroJet®

The cut is done using a mono-pass strategy. The motion speed of the Laser-MicroJet® is therefore the effective cutting speed

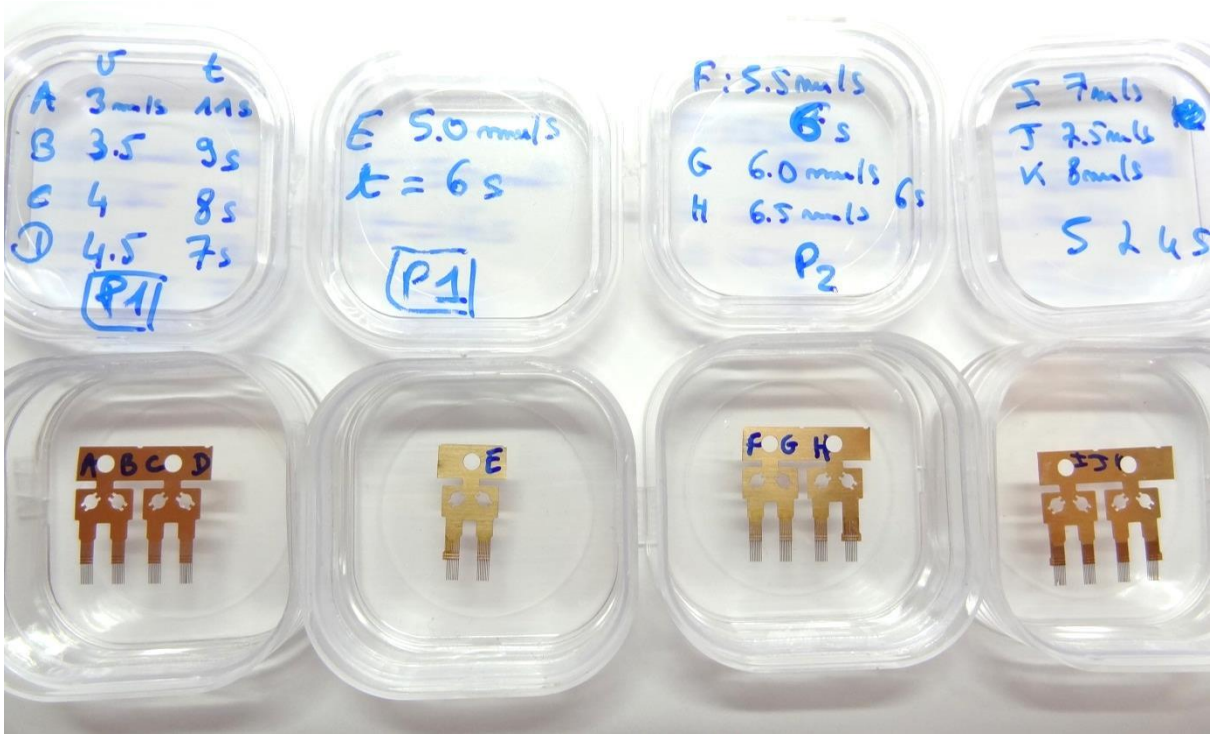
The effective cutting length is 27mm. The Laser-MicroJet®, however has to travel a slightly longer path in order to enter the piece at a constant speed and thus cut it properly. For this reason, the cutting times provided in the result section are slightly longer than travelling strictly 27mm at the indicated speed.

The path is the same for the brush springs provided with contact fingers as for the ones provided without.

RESULTS

1. CUTTING SPEED OPTIMIZATION

Picture 4 shows a macroscopic view of the springs cut for speed optimization.

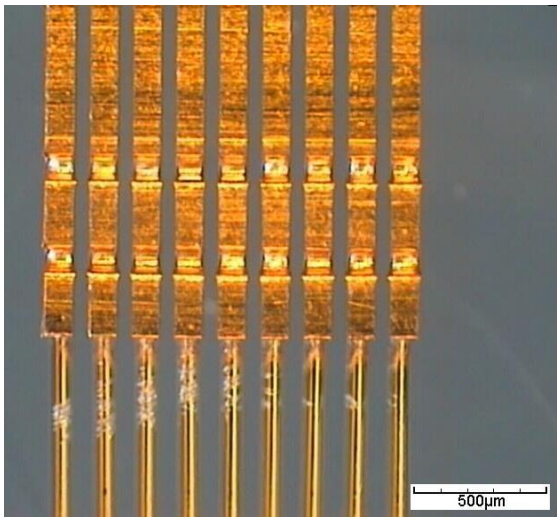


PICTURE 4: Macroscopic view of the springs cut for speed optimization

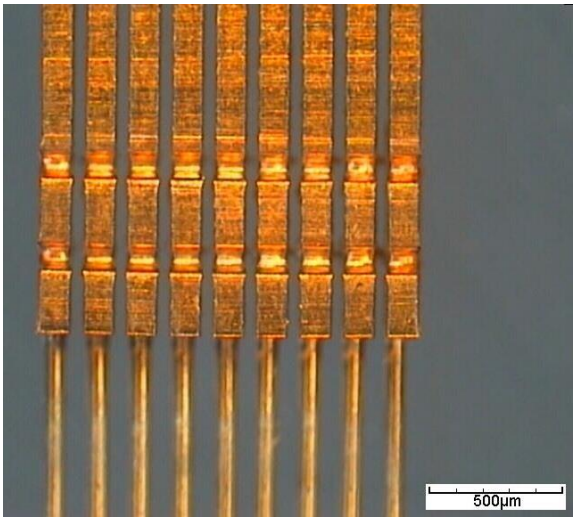
The following cutting times were found:

Parameter set	Sample Name	Speed [mm/s]	Time [s]
P1	A	3	11
	B	3.5	9
	C	4	8
	D	4.5	7
	E	5	6
P2	F	5.5	6
	G	6	Not recorded
	H	6.5	Not recorded
P3	I	7	5
	J	7.5	Not recorded
	K	9	Not recorded
P4		9	3

The following pictures show a macroscopic view of the samples A and K.



PICTURE 5: sample A, front side[1] view



PICTURE 6: sample K, front side view

From the microscopic views, we can conclude that the change in speed does not affect the cutting quality.

When changing through the parameter sets P1 to P4, the laser power has been increased, allowing for a greater speed. Wishing to keep on this track, the laser L51G was switched to a dual cavity laser able to offer up to 100W of internal power. A test has been done using 70W of internal power, a 50 µm nozzle to preserve the spacing between two contact fingers and a cutting speed of 15 mm/s. While the power was enough to cut the springs neatly, the speed proved too great to care for the steep changes in direction. Even at their maximum capacity (5000 mm/s^2), the steering axis could not provide the acceleration needed to support the variations in direction. Therefore the cutting time remained constant around 3s.

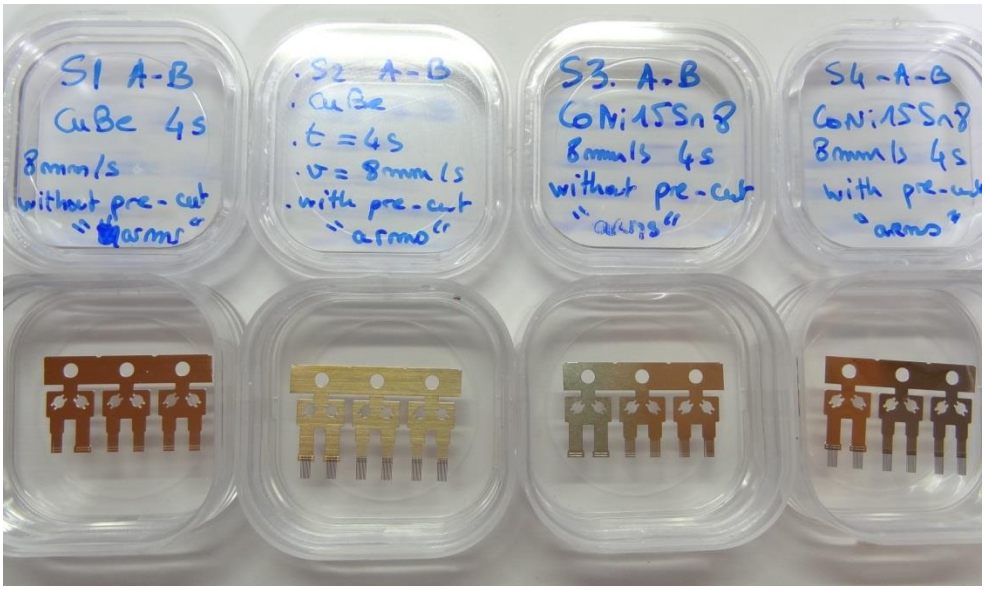
2. SPRINGS PRODUCED FOR DURABILITY TESTS

The parameters used for cutting these springs are the ones in the P4 set. In total, sixteen springs have been cut. The details of the production can be found in the table below. Each piece cut has two springs on it.

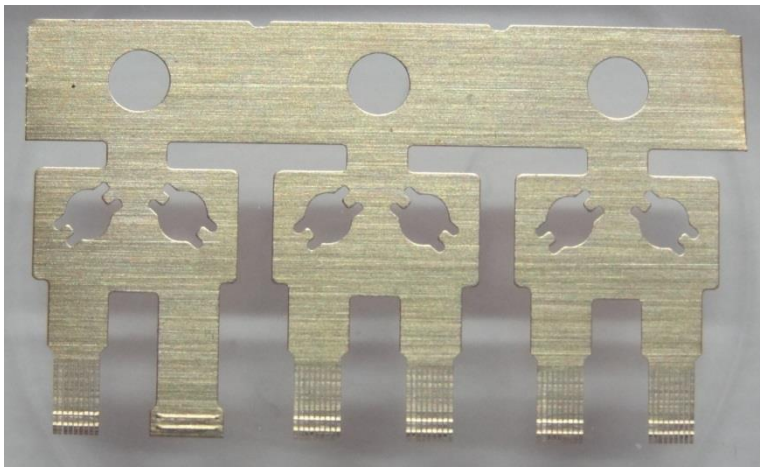
Material	Type (such as provided)	Number of springs	Reference
CuBe2	Without fingers	4	S1_A_B
CuBe2	With fingers	4	S2_A_B
CuNi15Sn8	Without fingers	4	S3_A_B
CuNi15Sn8	With fingers	4	S4_A_B

[1] The front side indicates the side onto which the laser shines directly during the cutting process.

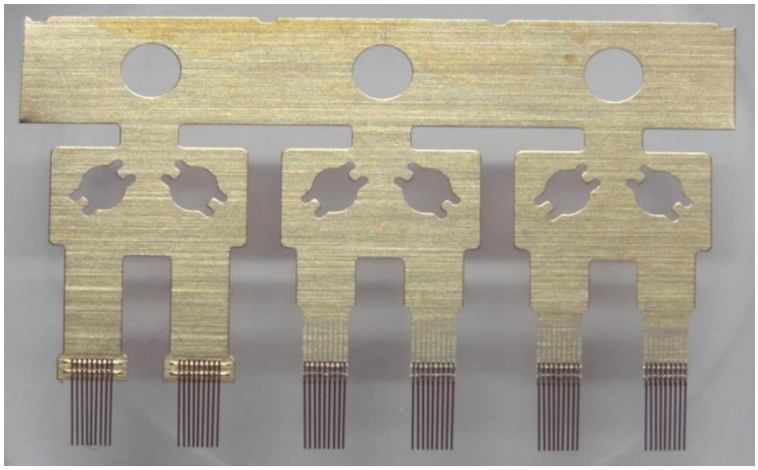
The following pictures show a macroscopic view of the production as well as each individual spring. Some springs have deliberately been left as such in order to underline the cutting process.



PICTURE 7: Macroscopic view of the production

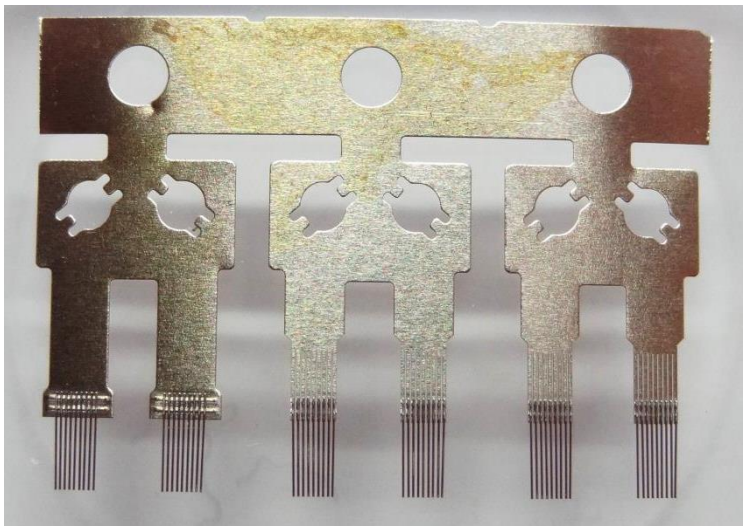


PICTURE 8: Macroscopic view of S1_A_B (Cube, without fingers)



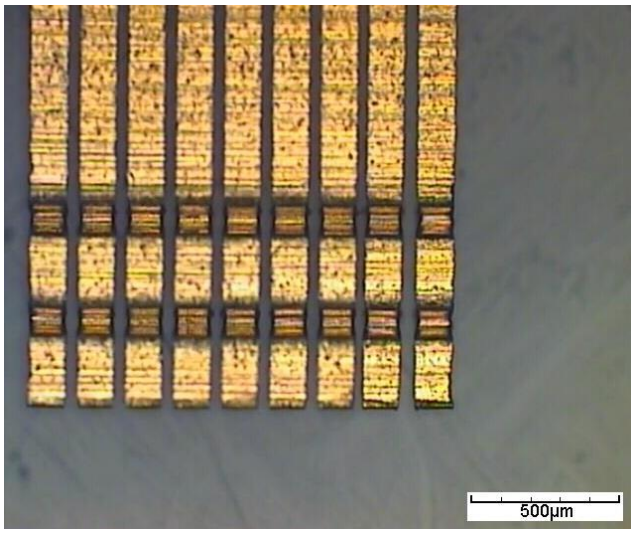
PICTURE 9: Macroscopic view of S2_A_B (Cube, with fingers)

PICTURE 9: Macroscopic view of S3_A_B (CuNi15Sn8, without fingers)

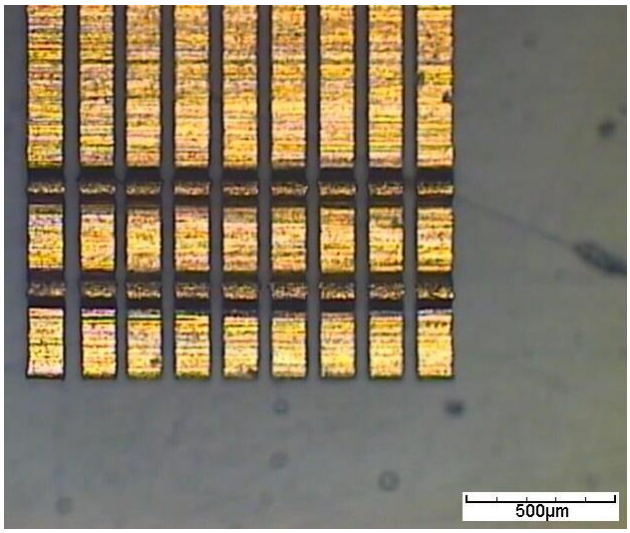


PICTURE 10: Macroscopic view of S3_A_B (CuNi15Sn8, with fingers)

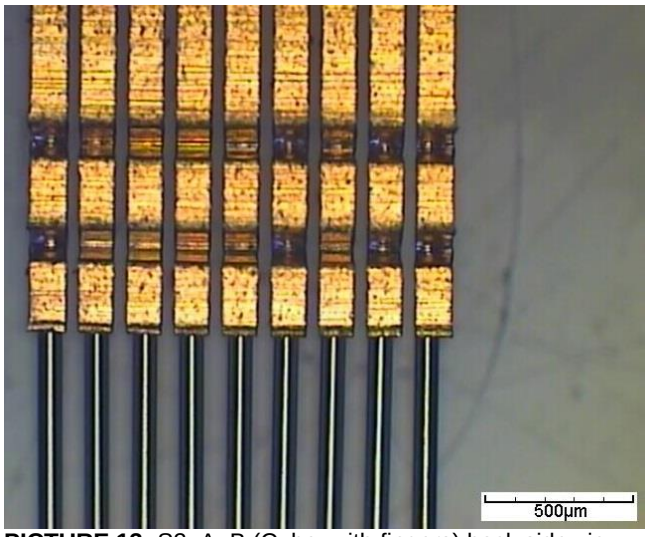
The following pictures show a microscopic view of a spring of each sample.



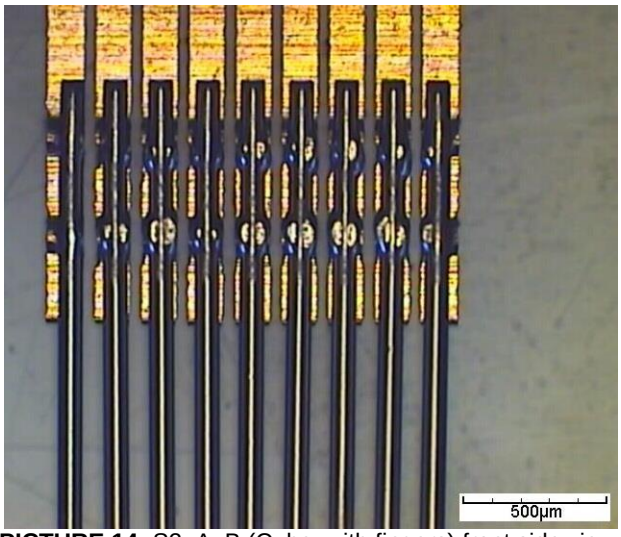
PICTURE 11: S1_A_B (Cube, without fingers) back side view



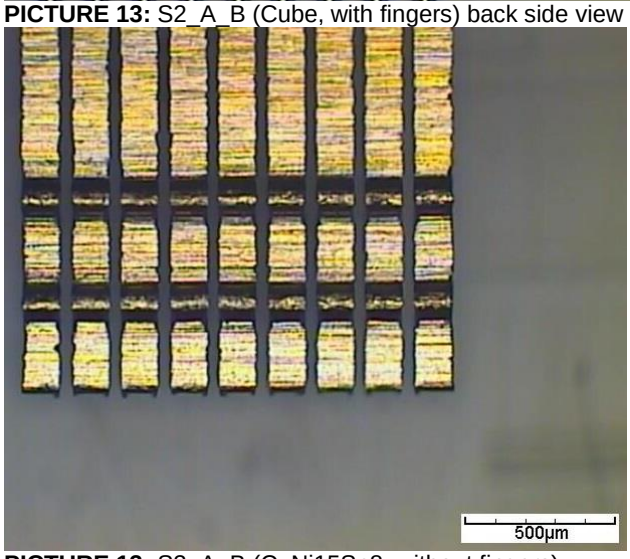
PICTURE 12: S1_A_B (Cube, without fingers) front side view



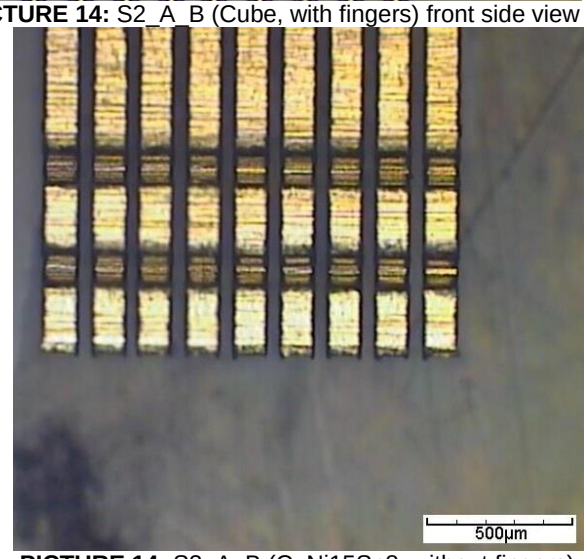
PICTURE 13: S2_A_B (Cube, with fingers) back side view



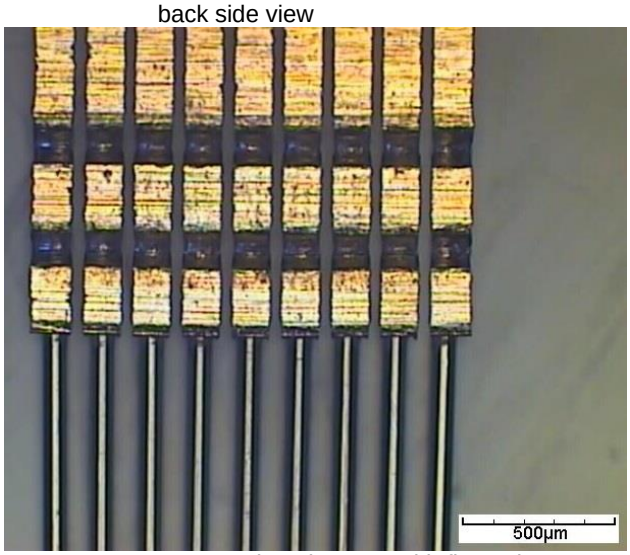
PICTURE 14: S2_A_B (Cube, with fingers) front side view



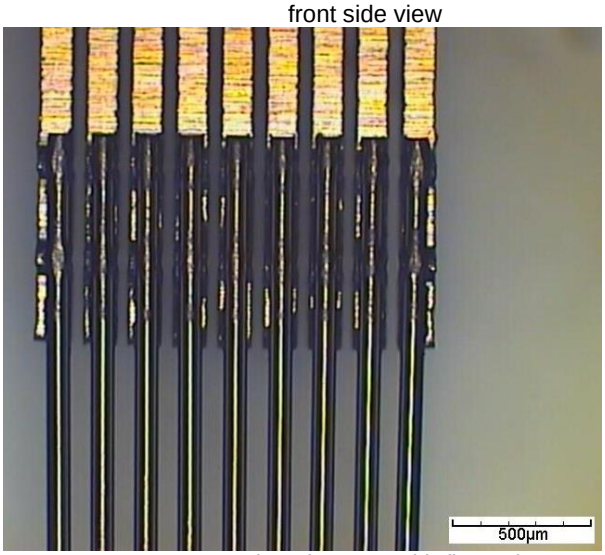
PICTURE 13: S3_A_B (CuNi15Sn8, without fingers) back side view



PICTURE 14: S3_A_B (CuNi15Sn8, without fingers) front side view



PICTURE 13: S3_A_B (CuNi15Sn8, with fingers) back side view



PICTURE 14: S3_A_B (CuNi15Sn8, with fingers) front side view

CONCLUSION

The cutting of brush springs has been performed with a 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 preventing the sample from particle contamination, advantages that are essential for cutting brush springs with high quality.

This development shows that:

- The fixation of the spring on the moving axis is optimal as it is easy and reliable
- The cutting quality is good on the front/ back side and is not affected by an increasing speed
- The spring do not vibrate during the cutting process making it completely stable
- A cutting speed of 9mm/s can be achieved allowing for an effective cutting time of 3s per spring

We are open to further discuss your needs regarding:

- The improvement of the cutting time. As discussed previously, an increase in speed is mainly hindered by the physical limits of the machine, not the process. The Laser-MicroJet® might not be limited strictly to our machines; we look forward to discussing the solutions to this problem with you.

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