REPORT: Cutting of SCD tools by Laser-MicroJet®

For Anonymous

By Mr. Sébastien Kurzen, Synova SA

1. TASK

The Laser MicroJet® technology has been tested for cutting SCD tools. The aim of this application was to optimize the cutting speed regarding the geometry requested. The Laser MicroJet® technology gives precise cuts and no burns on the work-piece edges, thanks to the water jet. The latter enables to reach cutting speeds higher than other cutting processes like dry laser cutting, as well as competitive roughness.

2. SAMPLE DESCRIPTION AND PREPARATION

SAMPLE	Material	Single crystal diamond inserts
	Dimension	< 1x1 *mm*
	Thickness	< 1 *mm*
	Quantity	10 *pcs*

3. PROCESS: INSTRUMENT & TEST PARAMETERS

For this development, a Synova DCS 150, equipped with a 100 W diode-pumped solid state laser source, has been used as the machine configuration the most appropriated for your application in our lab.

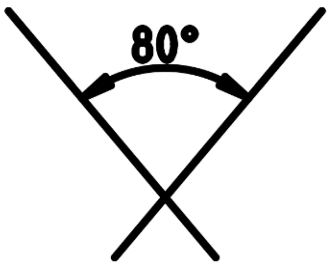


Figure 1a: cutting path.

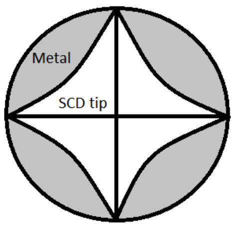


Figure 1b: front view of the tip

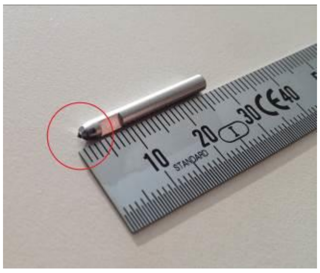
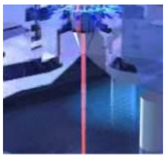
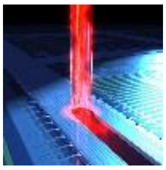


Figure 1c: final work piece.

Release of application report			
Project Leader		Industry BU Responsible	
Name:	Mr Sébastien Kurzen	Name:	Dr Benjamin Carron
Date:	31.10.2014	Date:	31.10.2014
Visum:	SEK	Visum:	BC

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

	**SYSTEM**	Machine type	DCS 150	
		Helium flow	0.9	*L/min*
		Working distance	12	*mm*
		Laser fibre diameter	150	*µm*
		Collimator	200	*mm*
	**MICROJET® PARAMETER**	Nozzle diameter	40	*µm*
		MicroJet® diameter	33	*µm*
		Water pressure	300	*bar*
		Assist gas	He	
	**LASER PARAMETER**	Laser type	LG101	
		Wavelength	532	*nm*
		Pulse frequency	6	*kHz*
		Power in jet	13.2	*W*
		Pulse width	150	*ns*
	**CUTTING PARAMETER**	Cutting speed	30	*mm/s*
		Number of passes	230	
		Process duration	6	*min*
		Overall speed	3.5	*mm/min*
		Fixation	Rotative axis	

4. RESULTS

During the development, different cutting strategies were tested:

1. The first one consisted in the cutting path depicted in figure 2, repeated 230 times. Once the first 80° angle was cut, a 90° rotation around the main axis of the insert was done and then, the second 80° angle was cut.

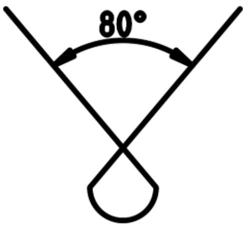


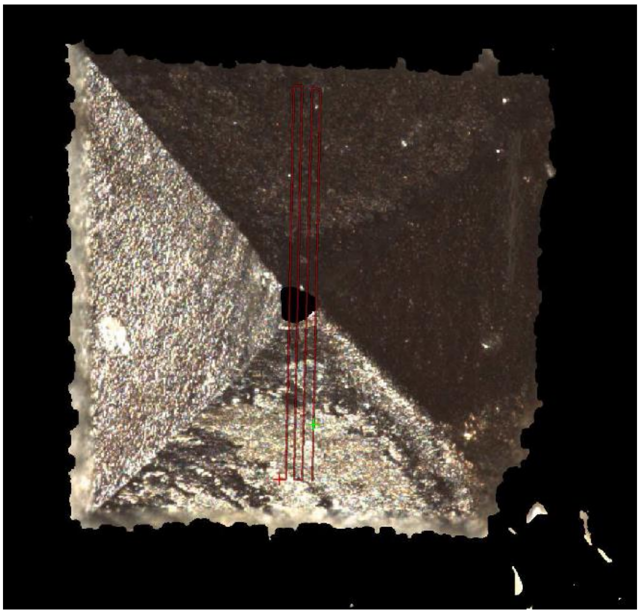
Figure 2: cutting path, strategy 1.

2. The second strategy consisted in the same cutting path as the first one, but a finishing pass was added by a 90° rotation around the main axis once more.
3. Finally, the third strategy consisted in the cutting path depicted in figure 1a. One straight line repeated 230 times and then, the other one also proceeded 230 times. Once the first 80° angle was cut, a 90° rotation around the main axis was done before cutting the second 80° angle.

The third strategy gave the best results and was used for the last 6 samples with the laser parameters detailed in section 3.

Here are presented the results of the development.

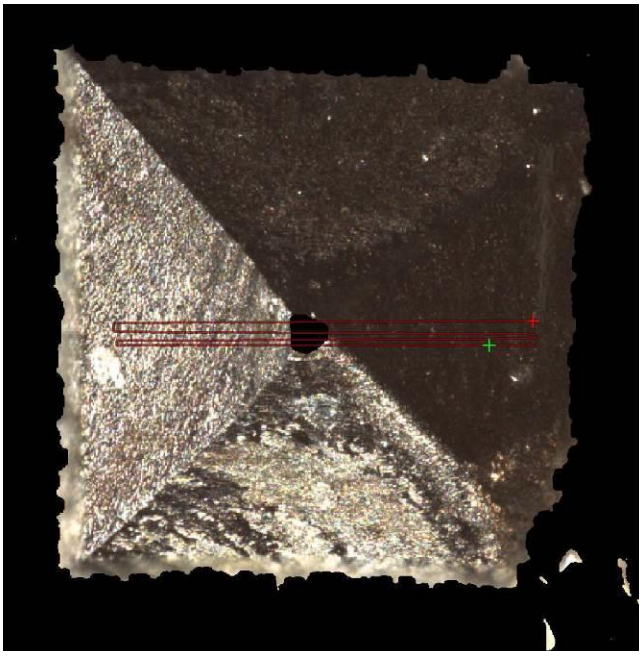
Sample	#1	#2	#3	#4	#5 to 10
Average power in the water jet [W]	13.2	10.1	10.1	10.1	13.2
Cutting strategy	1	1	2	3	3
Figure(s) associated	3 & 4	5 & 6	7 & 8	9 & 10	11 & 12



Angle

	Angle [°]	Apex X [µm]	Apex Y [cm]
Angle 1	75.0157	146.8995	2.2547
Angle 2	75.2874	508.4943	2.2546
Angle 3	76.2326	798.0840	2.2544
Angle 4	76.7745	1152.7622	2.2543
	Angle [°]	Apex X [µm]	Apex Y [cm]
Mean:	75.8275	651.5600	2.2545
Std. Dev.:	0.8189	427.3262	0.0002
Minimum:	75.0157	146.8995	2.2543
Maximum:	76.7745	1152.7622	2.2547
Range:	1.7588	1005.8627	0.0003
Sum:	303.3101	2606.2399	9.0181
Median:	75.7600	653.2891	2.2545
Robust:	75.1515	146.8995	2.2543
Count:	4	4	4

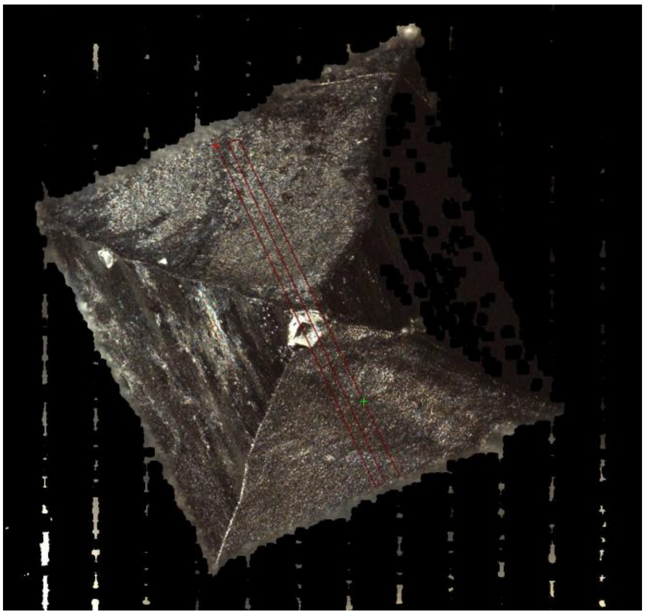
Figure 3: Sample 1, angle 1.



Angle

	Angle [°]	Apex X [µm]	Apex Y [cm]
Angle 1	80.4439	159.7571	2.2539
Angle 2	80.0674	467.7059	2.2539
Angle 3	79.7460	794.3486	2.2539
Angle 4	80.1271	1095.2667	2.2538
	Angle [°]	Apex X [µm]	Apex Y [cm]
Mean:	80.0961	629.2696	2.2539
Std. Dev.:	0.2860	404.5364	0.0000
Minimum:	79.7460	159.7571	2.2538
Maximum:	80.4439	1095.2667	2.2539
Range:	0.6979	935.5095	0.0001
Sum:	320.3843	2517.0783	9.0156
Median:	80.0972	631.0272	2.2539
Robust:	79.7460	159.7571	2.2539
Count:	4	4	4

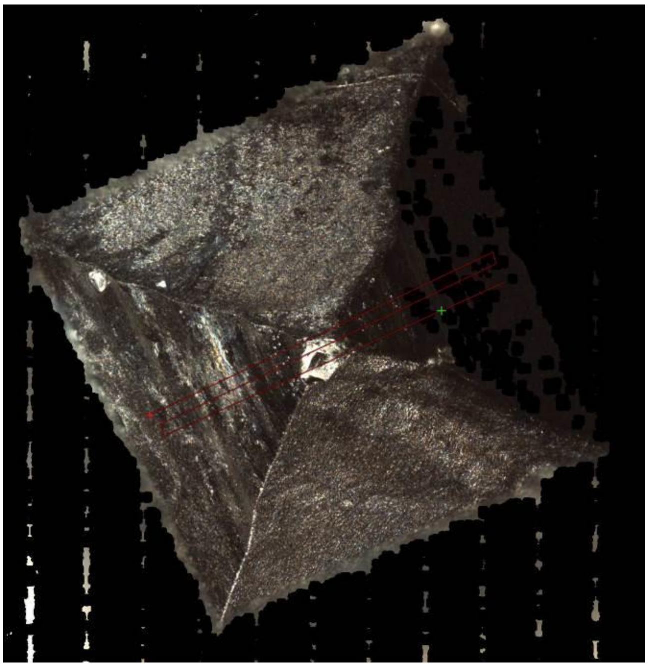
Figure 4: Sample 1, angle 2.



Angle

	Angle [°]	Apex X [µm]	Apex Y [cm]
Angle 1	78.8618	244.8611	2.2806
Angle 2	78.7852	718.0672	2.2807
Angle 3	78.8829	1212.8379	2.2807
	Angle [°]	Apex X [µm]	Apex Y [cm]
Mean:	78.8433	725.2554	2.2806
Std. Dev.:	0.0514	484.0285	0.0000
Minimum:	78.7852	244.8611	2.2806
Maximum:	78.8829	1212.8379	2.2807
Range:	0.0977	967.9768	0.0000
Sum:	236.5299	2175.7662	6.8419
Median:	78.8618	718.0672	2.2807
Robust:	78.7852	244.8611	2.2807
Count:	3	3	3

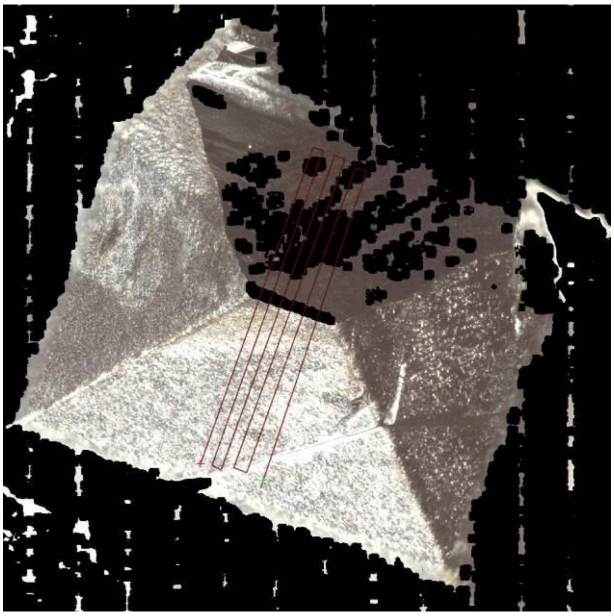
Figure 5: Sample 2, angle 1.



Angle

	Angle [°]	Apex X [µm]	Apex Y [cm]
Angle 1	91.8769	204.4914	2.2811
Angle 2	87.1502	653.6433	2.2818
Angle 3	91.1569	1067.0574	2.2810
	Angle [°]	Apex X [µm]	Apex Y [cm]
Mean:	90.0613	641.7307	2.2813
Std. Dev.:	2.5467	431.4063	0.0004
Minimum:	87.1502	204.4914	2.2810
Maximum:	91.8769	1067.0574	2.2818
Range:	4.7267	862.5659	0.0008
Sum:	270.1840	1925.1921	6.8439
Median:	91.1569	653.6433	2.2811
Robust:	91.5169	204.4914	2.2810
Count:	3	3	3

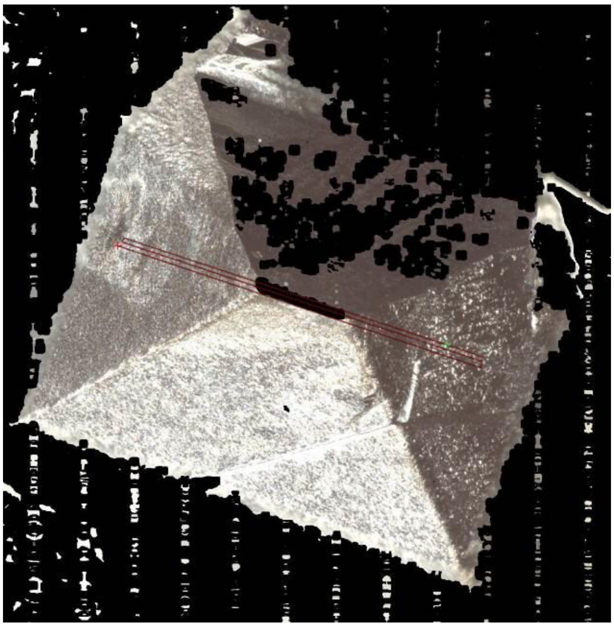
Figure 6: Sample 2, angle 2.



Angle

	Angle [°]	Apex X [µm]	Apex Y [cm]
Angle 1	81.8274	234.6699	2.2388
Angle 2	82.3040	652.9814	2.2386
Angle 3	82.4744	1127.9012	2.2386
Angle 4	81.8272	1547.0100	2.2386
Angle 5	82.2009	2011.0325	2.2386
Angle 6	82.6151	2385.8676	2.2385
	Angle [°]	Apex X [µm]	Apex Y [cm]
Mean:	82.2082	1326.5771	2.2386
Std. Dev.:	0.3273	815.4301	0.0001
Minimum:	81.8272	234.6699	2.2385
Maximum:	82.6151	2385.8676	2.2388
Range:	0.7878	2151.1977	0.0002
Sum:	493.2490	7959.4626	13.4318
Median:	82.2525	1337.4556	2.2386
Robust:	81.8273	890.4413	2.2386
Count:	6	6	6

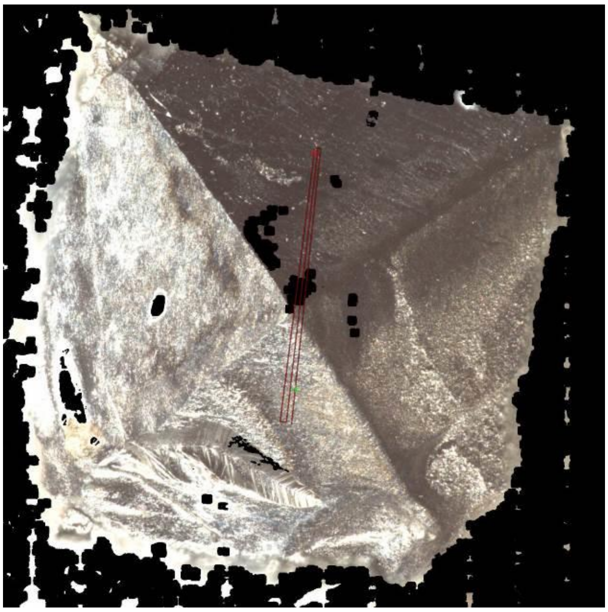
Figure 7: Sample 3, angle 1.



Angle

	Angle [°]	Apex X [µm]	Apex Y [cm]
Angle 1	76.4832	239.2945	2.2467
Angle 2	76.2531	741.0547	2.2468
Angle 3	76.2100	1215.9297	2.2468
	Angle [°]	Apex X [µm]	Apex Y [cm]
Mean:	76.3154	732.0930	2.2468
Std. Dev.:	0.1469	488.3792	0.0000
Minimum:	76.2100	239.2945	2.2467
Maximum:	76.4832	1215.9297	2.2468
Range:	0.2733	976.6351	0.0001
Sum:	228.9463	2196.2789	6.7403
Median:	76.2531	741.0547	2.2468
Robust:	76.2315	239.2945	2.2467
Count:	3	3	3

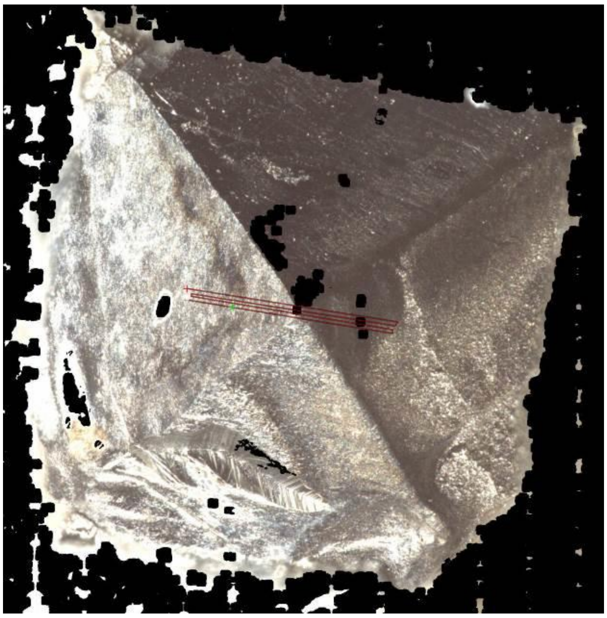
Figure 8: Sample 3, angle 2.



Angle

	Angle [°]	Apex X [µm]	Apex Y [cm]
Angle 1	78.1347	216.0693	2.2374
Angle 2	77.4952	953.1321	2.2375
Angle 3	78.5879	501.3155	2.2372
	Angle [°]	Apex X [µm]	Apex Y [cm]
Mean:	78.0726	556.8389	2.2374
Std. Dev.:	0.5490	371.6551	0.0001
Minimum:	77.4952	216.0693	2.2372
Maximum:	78.5879	953.1321	2.2375
Range:	1.0927	737.0627	0.0003
Sum:	234.2178	1670.5168	6.7121
Median:	78.1347	501.3155	2.2374
Robust:	77.4952	216.0693	2.2372
Count:	3	3	3

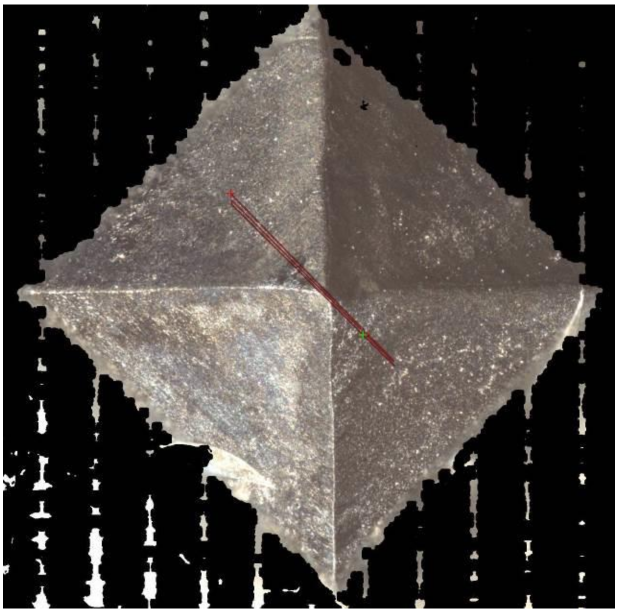
Figure 9: Sample 4, angle 1.



Angle

	Angle [°]	Apex X [µm]	Apex Y [cm]
Angle 1	76.1181	147.4127	2.2369
Angle 2	76.4112	406.3901	2.2369
Angle 3	75.3551	693.6157	2.2371
Angle 4	75.2890	946.0949	2.2371
	Angle [°]	Apex X [µm]	Apex Y [cm]
Mean:	75.7933	548.3783	2.2370
Std. Dev.:	0.5578	346.5095	0.0001
Minimum:	75.2890	147.4127	2.2369
Maximum:	76.4112	946.0949	2.2371
Range:	1.1222	798.6822	0.0003
Sum:	303.1734	2193.5134	8.9479
Median:	75.7366	550.0029	2.2370
Robust:	75.3221	147.4127	2.2369
Count:	4	4	4

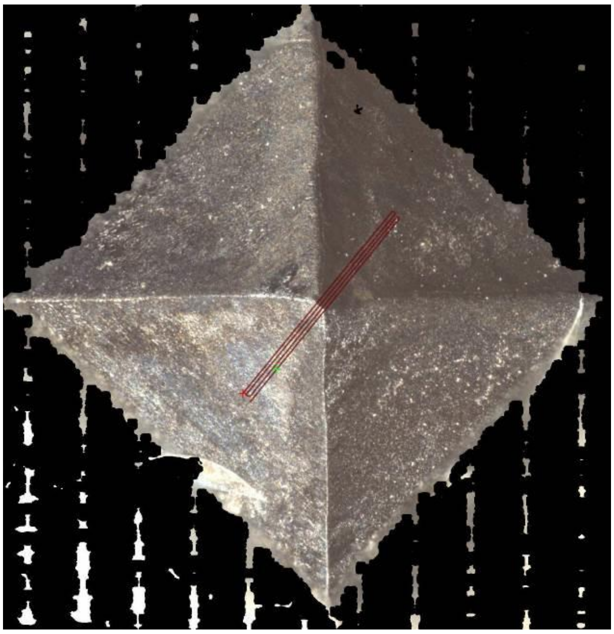
Figure 10: Sample 4, angle 2.



Angle

	Angle [°]	Apex X [µm]	Apex Y [cm]
Angle 1	80.5429	161.1417	2.2375
Angle 2	79.7397	393.7166	2.2376
Angle 3	77.2342	705.6248	2.2379
	Angle [°]	Apex X [µm]	Apex Y [cm]
Mean:	79.1723	420.1610	2.2377
Std. Dev.:	1.7258	273.2031	0.0002
Minimum:	77.2342	161.1417	2.2375
Maximum:	80.5429	705.6248	2.2379
Range:	3.3087	544.4831	0.0005
Sum:	237.5168	1260.4831	6.7130
Median:	79.7397	393.7166	2.2376
Robust:	77.2342	161.1417	2.2375
Count:	3	3	3

Figure 11: Sample 5, angle 1.



Angle

	Angle [°]	Apex X [µm]	Apex Y [cm]
Angle 1	77.4426	135.6316	2.2371
Angle 2	76.2430	411.8548	2.2374
Angle 3	78.2515	685.3716	2.2370
Angle 4	76.7447	959.9205	2.2373
	Angle [°]	Apex X [µm]	Apex Y [cm]
Mean:	77.1705	548.1946	2.2372
Std. Dev.:	0.8726	354.5572	0.0002
Minimum:	76.2430	135.6316	2.2370
Maximum:	78.2515	959.9205	2.2374
Range:	2.0085	824.2888	0.0004
Sum:	308.6819	2192.7786	8.9488
Median:	77.0937	548.6132	2.2372
Robust:	76.2430	135.6316	2.2374
Count:	4	4	4

Figure 12: Sample 5, angle 2.

4. CONCLUSION

The cutting of SCD tools has been performed with a SYNOVA DCS 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 processing all kinds of tools with high quality.

These tests show:

- A maximal cutting speed of 3.5 mm/min;
- A cutting duration of 6 minutes per tool;

- A cutting angle of 79.1 ±1.7° for one side, and a cutting angle of 77.2±0.9° for the 90° rotated side.

In short term, Synova SA will propose its new LCS50, a 5-axis machine with higher accuracy. Hence, we are confident that the angle precision can be significantly enhanced. We are open on the following points:

- Decrease of the cutting duration;
- Decrease of the edge roughness;
- Increase of the angle accuracy.

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