SYNOVA

The Synergy of Water and Fire

Cut quality tests for Report # 144-4

Week 16/2014

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Date: 27/04/2014

Test Cutting with the LMJ150 – 3 axis wet laser

- Cut product - E6 sub-micron grade CMX850
  - PCD layer thickness – 0.5mm
  - Cemented carbide substrate
  - Total product thickness - 3.2mm
- Demonstration to show cutting of:
  - Straight lines
  - Concave curves
  - Convex curves
  - Wide /narrow slots
  - Small and large holes
  - V cuts with included radii

Test demo piece A

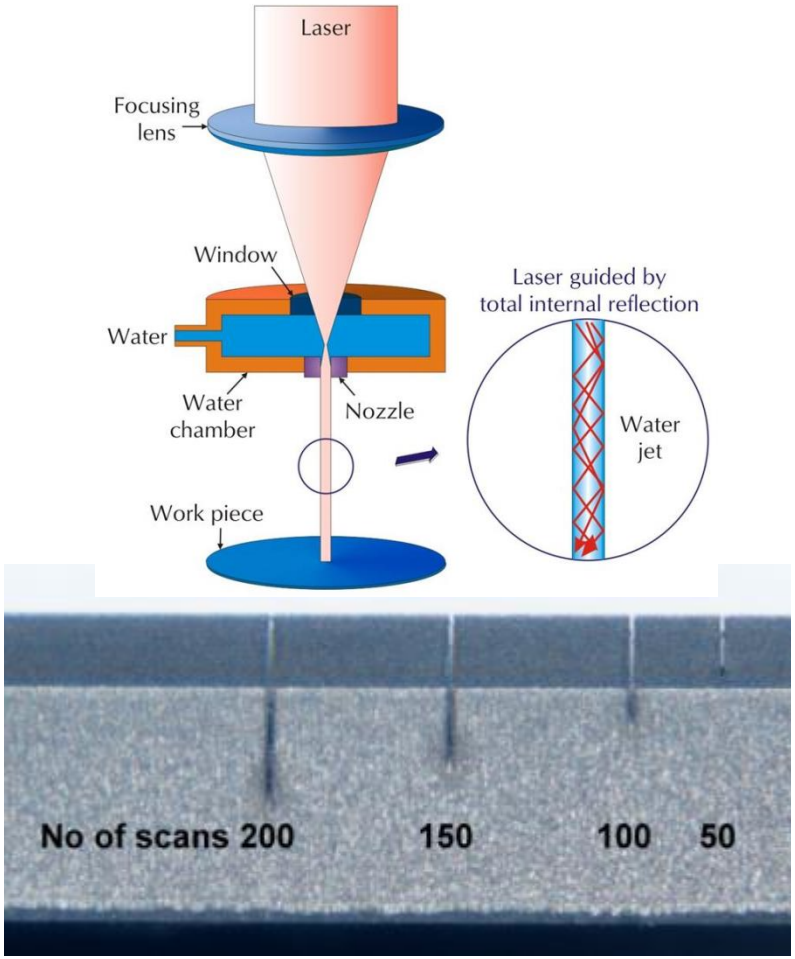
- Two samples cut (A & B) from mother disc

LMX150 – basic wet laser

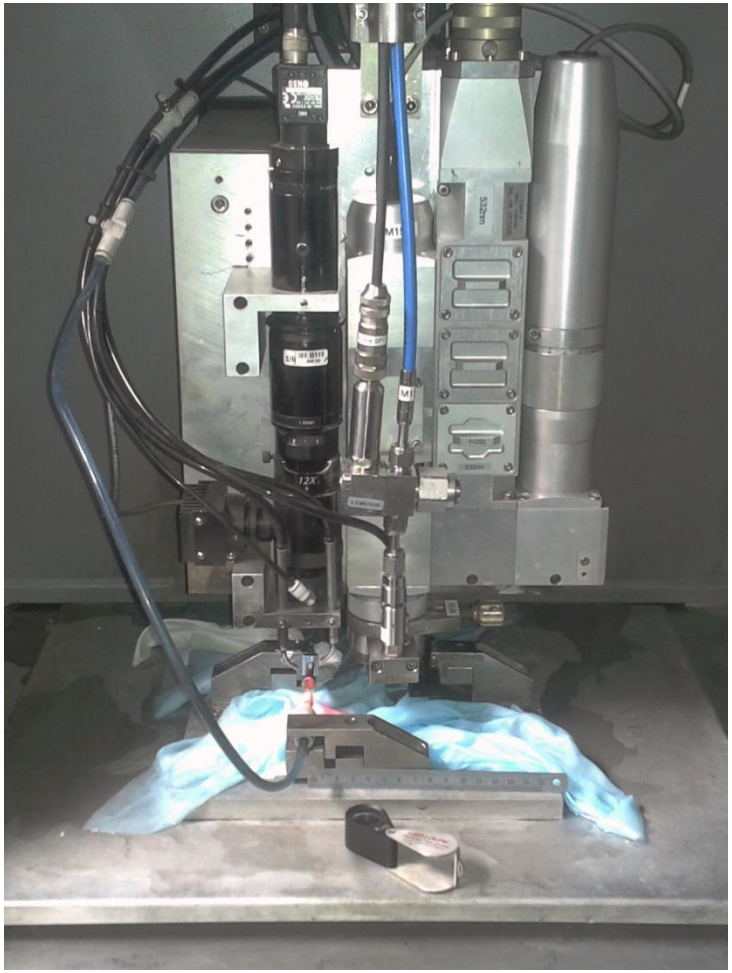
- Wet laser manufactured by Synova S.A., Switzerland
- LMX150 – smallest machine
- 3 axis machine
  - Z axis normally fixed at working height
  - No focussing necessary
- 150 x 150mm work table
- +/- 5 µm accuracy
- +/- 2 µm repeatability

Laser and water treatment units not shown

LMJ150 – the wet laser work chamber



Typcial scanning speed = 10-20mm/sec



Laser head where water & laser are combined

Process Parameters

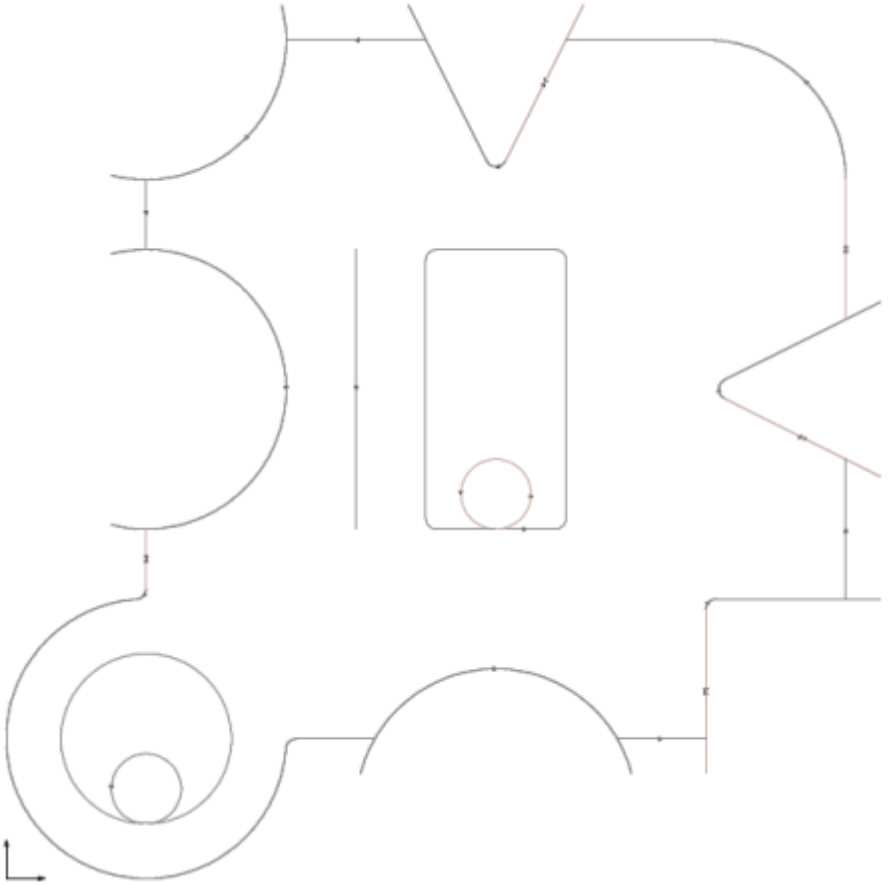
Material CMX850 – PCD layer on carbide substrate WC

SYSTEM	Machine type	LCS150	
	Fixture	Clamped	
MICROJET® PARAMETER	Nozzle diameter	40	µm
	Working distance	10	mm
	Assist gas	He	
	Water pressure Sample A	400	bar
	Water pressure Sample B	470	bar
LASER AND CUTTING PARAMETERS	Laser type	L51G	
	Wavelength	532	nm
	Pulse duration	120	ns
	Repetition rate	6	kHz
	Laser power in water jet	8.4	W

- Scanning speed (A&B)= 10 mm/s
- # passes (A&B)= 220 passes
- Cutting time (A&B)= 30 min
- Contour length (A&B)= 70.47 mm
- Effective cutting speed (A&B)= 2.35 mm/min

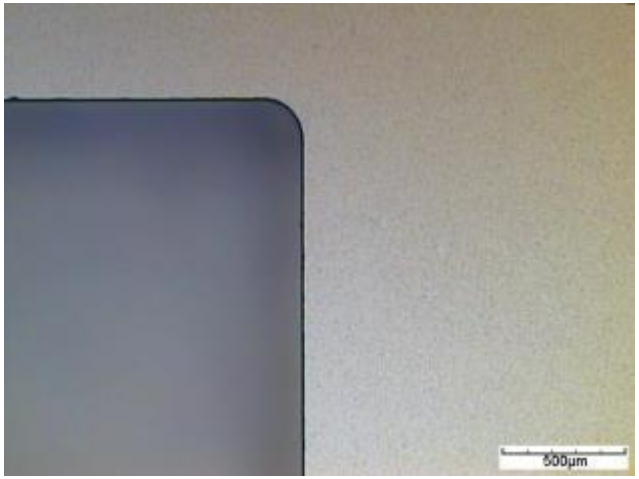
PICTURE 1: Backside view of SA

LMJ150 - cutting path program

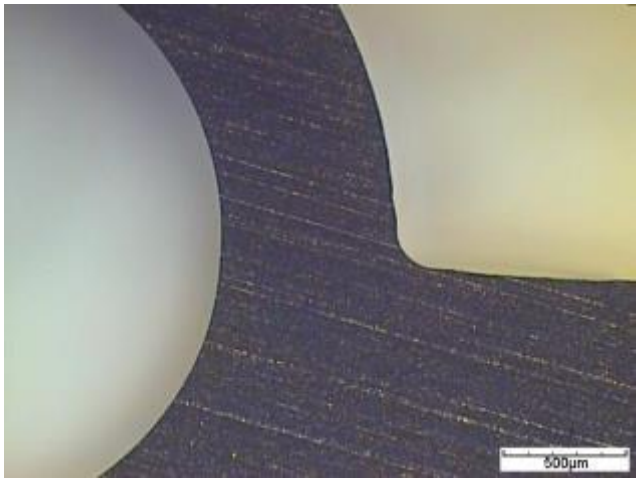


PICTURE 2: Program pattern – optimised to give sharp corners, smooth radii etc.

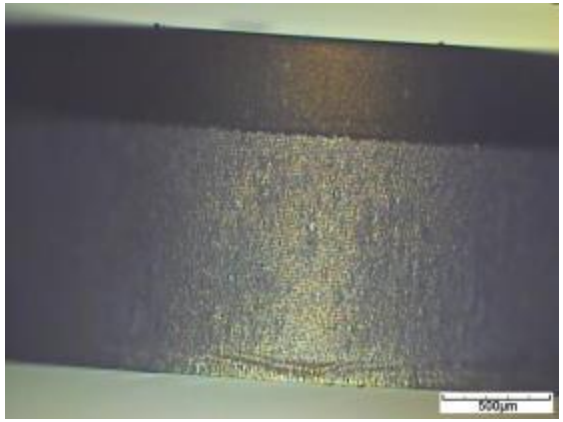
Microscope pictures: sample A



PCD beam entry side:
Note - minimal edge chipping

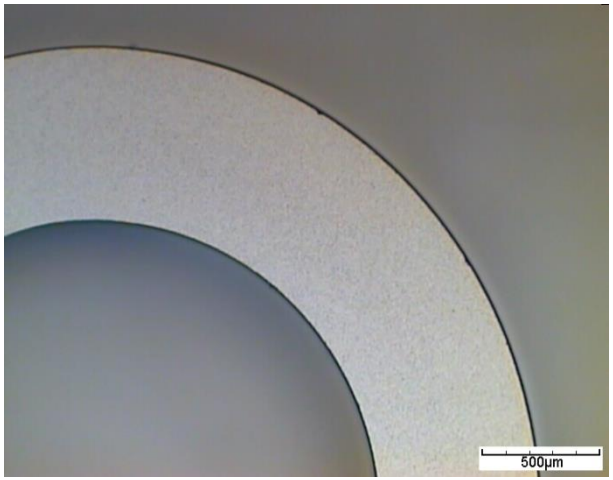


Carbide exit side:
Note - clean exit, no burs or burning

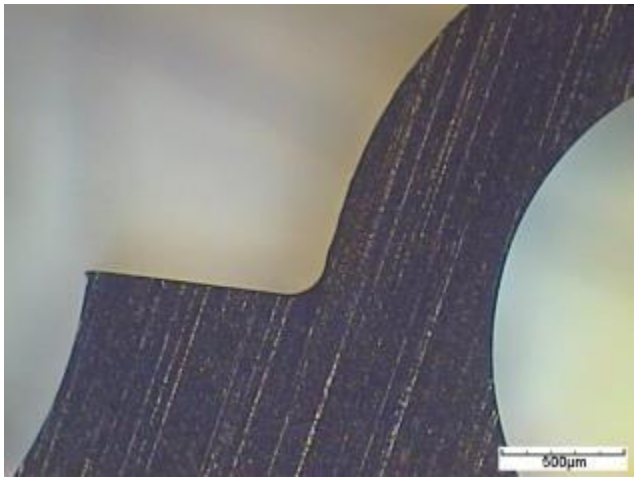


PCD / WC flank

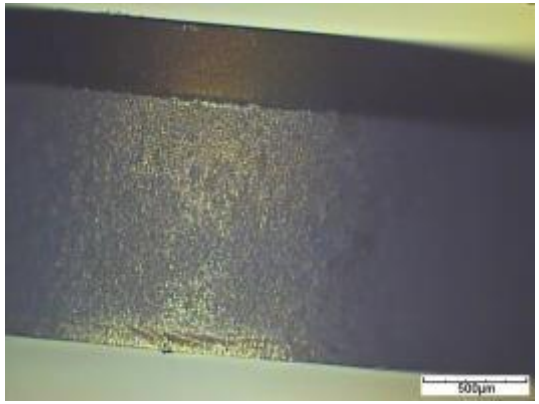
Microscope pictures: sample B



PCD beam entry side:
Note - minimal edge chipping



Carbide exit side:
Note - clean exit, no burs or burning

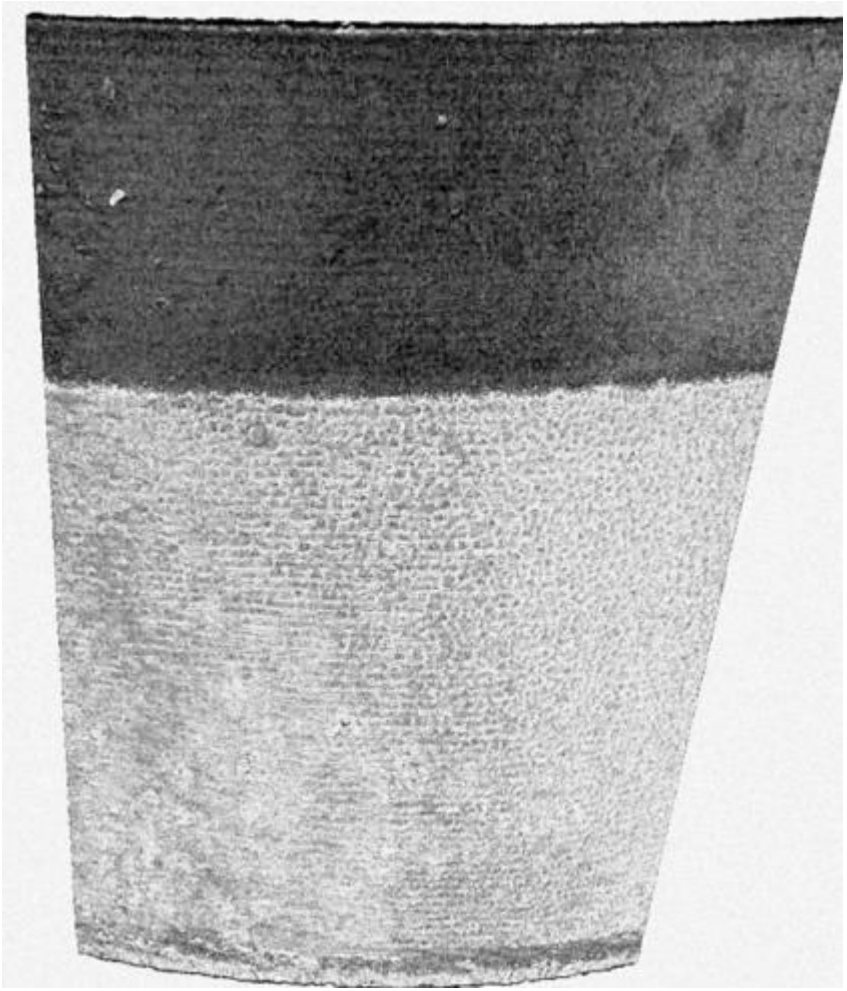


PCD / WC flank

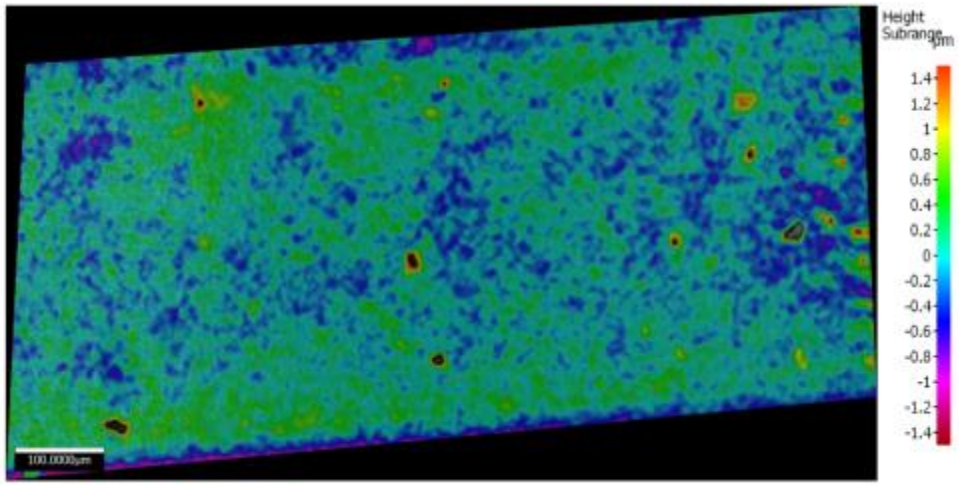
Alicona 3D microcope imagery:

Sample A

- Digital 3D image
- Position: circle

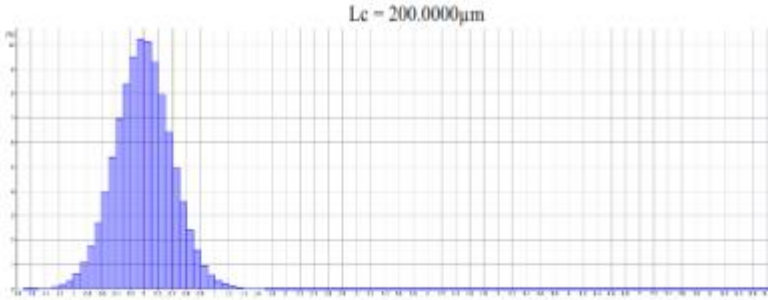


Alicona: Ra Measurements (position: circle)



Lc: 200µm

Width: 981.3451µm
Height: 499.6666µm
True Area: 408276.5161µm²
Projected Area: 407209.2118µm²
True to Projected Area Ratio: 1.0026
Area Surplus Amount: 0.0026



Histogram Histogram Settings

Number of Classes: 112
Minimum Value: -1.7043µm
Maximum Value: 9.4957µm
Class Width: 0.1000µm

Statistics

Name	Value	[u]
Elements	3828265	
Classes	112	
Mean Value	-0.0112	µm
Standard Deviation	0.4261	µm

Parameters

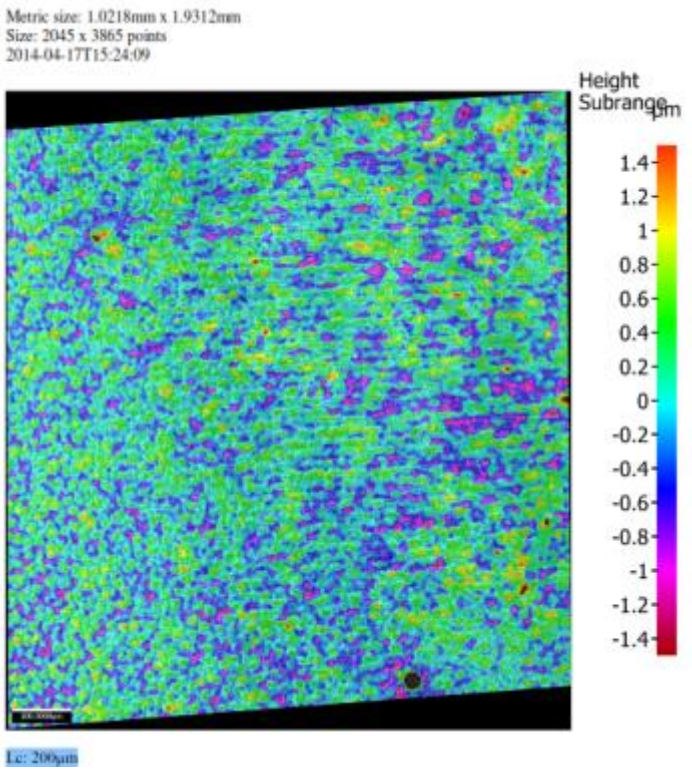
Name	Value	[u]	Description
Sa	320.2400	nm	Average height of selected area
Sq	426.2642	nm	Root-Mean-Square height of selected area
Sp	9.4822	µm	Maximum peak height of selected area
Sv	1.7043	µm	Maximum valley depth of selected area
Sz	11.1865	µm	Maximum height of selected area
S10z	6.8141	µm	Ten point height of selected area
Ssk	1.9332		Skewness of selected area

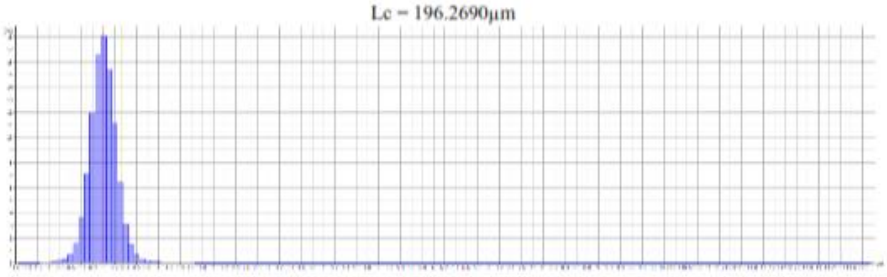
Sample A: PCD flank

Ra = 0.320µm

Note: optical measurements of Ra subject to set up conditions

Alicona: Ra Measurements (position: circle)





Histogram Histogram Settings

Number of Classes: 155
Minimum Value: -1.5520µm
Maximum Value: 13.9480µm
Class Width: 0.1000µm

Statistics

Name	Value	[u]
Elements	1633782	
Classes	155	
Mean Value	0.0006	µm
Standard Deviation	0.3259	µm

Parameters

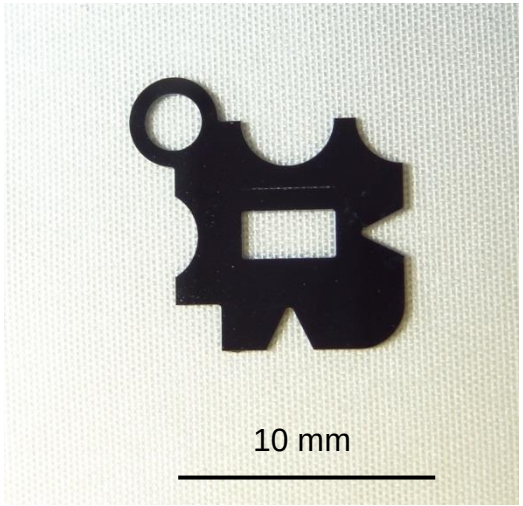
Name	Value	[u]	Description
Sa	193.8673	nm	Average height of selected area
Sq	325.8794	nm	Root-Mean-Square height of selected area
Sp	13.8502	µm	Maximum peak height of selected area
Sv	1.5520	µm	Maximum valley depth of selected area
Sz	15.4022	µm	Maximum height of selected area
S10z	8.0919	µm	Ten point height of selected area
Ssk	12.0615		Skewness of selected area

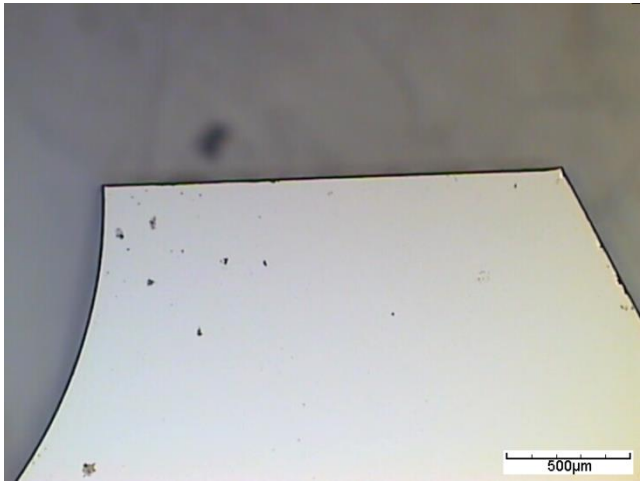
Sample B: PCD flank

Ra = 0.193µm

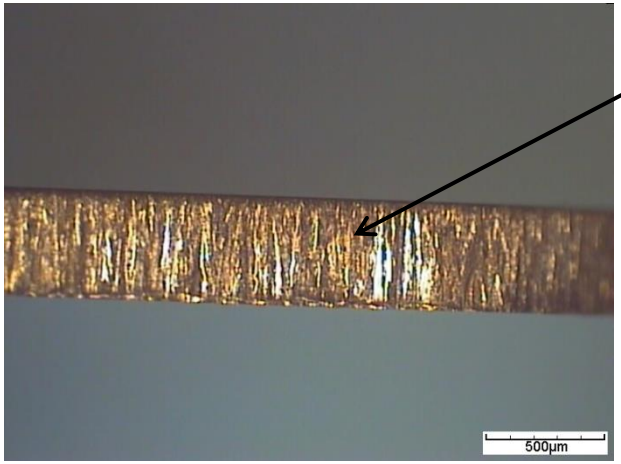
Note: optical measurements of Ra subject to set up conditions

Optical microscope images: polycrystalline CVD





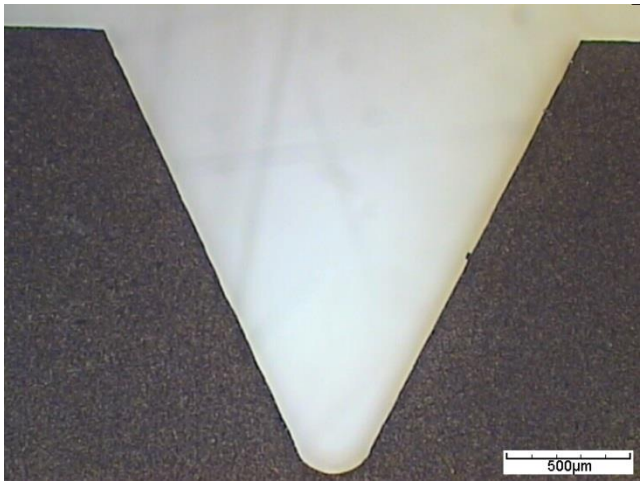
PCD beam entry side:
Note - minimal edge chipping



PCD / WC flank

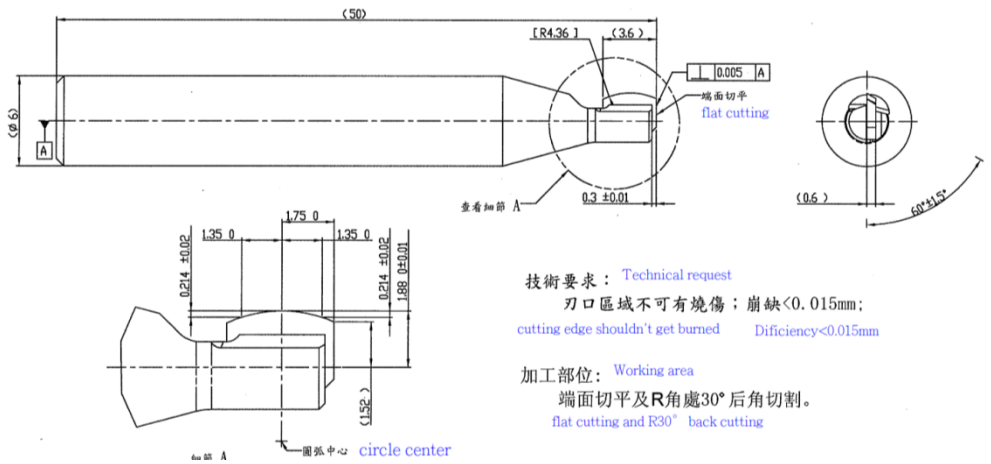
Polycrystalline CVD:

- columnar grain structure easily visible
- laser sensitive so detects grain orientation
- different grain orientations ablate at different rates
- grain orientation visible
- minimal thermal damage



Carbide exit side:
Note - clean exit, no burs or burning

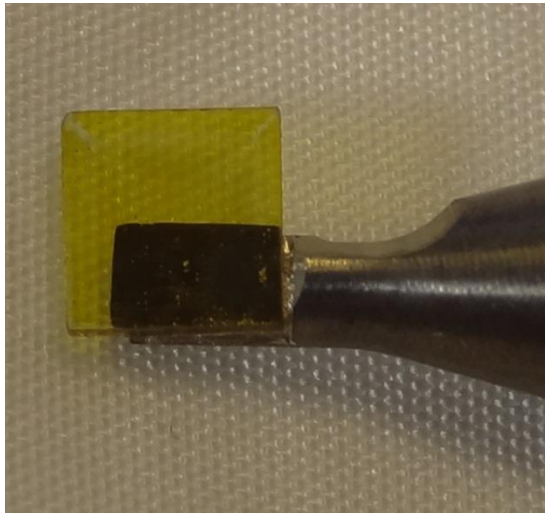
Test #2 : HP/HT SCD cutting tool: 90 and 60° clearance angles



Thickness 0.66mm

2 steps:

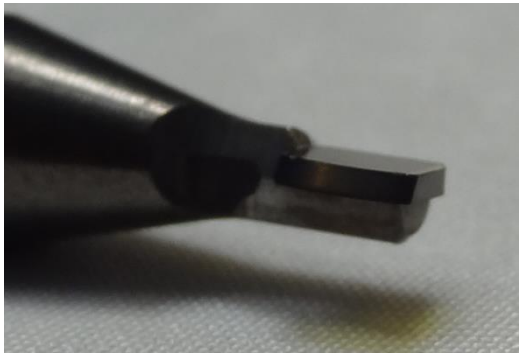
- 90° clearance angle cut
- 60° clearance angle cut



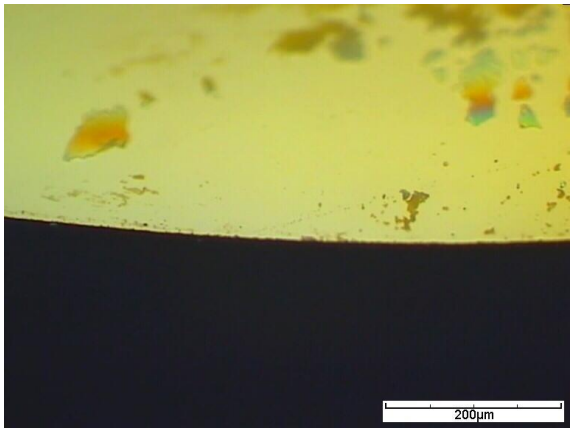
Before cutting

Parameters	
Nozzle diam.	50µm
Water pressure	300bar
RR	6kHz
Pulse width	170ns
Power in jet	20W
Motion speed	10mm/s

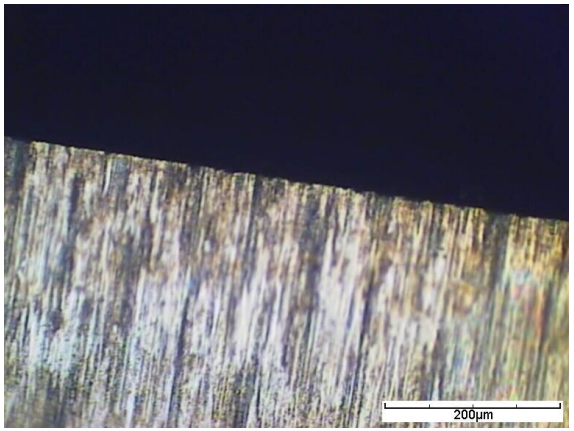
Test #2 : HP/HT SCD cutting tool: 90 and 60° clearance angle cut



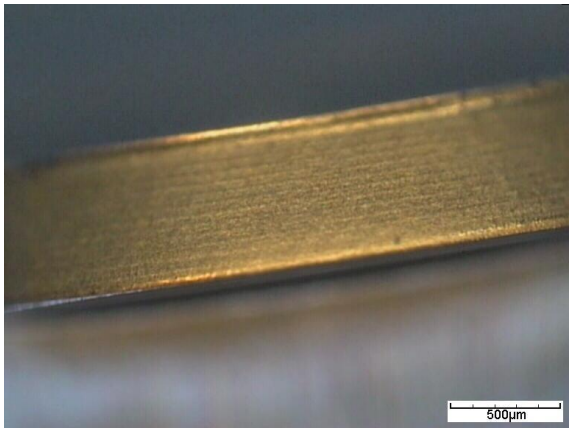
	Step 1: 90° cut (L=10.9 mm)	Step 2: 60° cut (L=5.4 mm)
# of passes	26 passes	29 passes
Process time	21 s	19 s
Cutting speed	31.0 mm/min	16.9 mm/min



Frontside

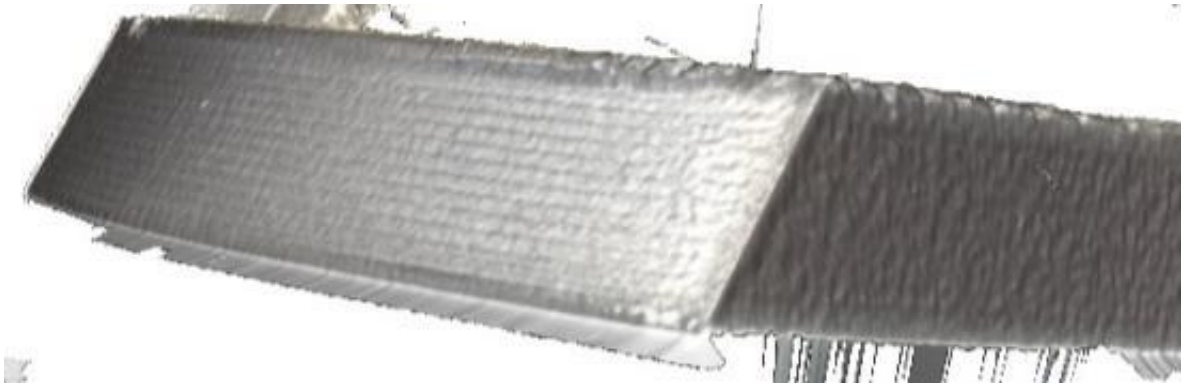


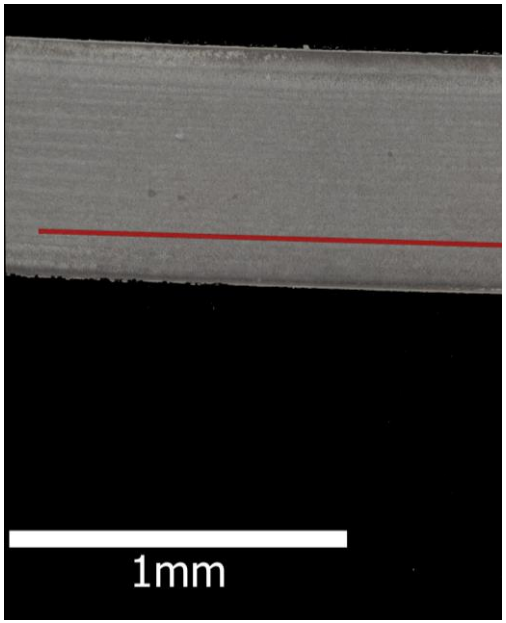
Backside

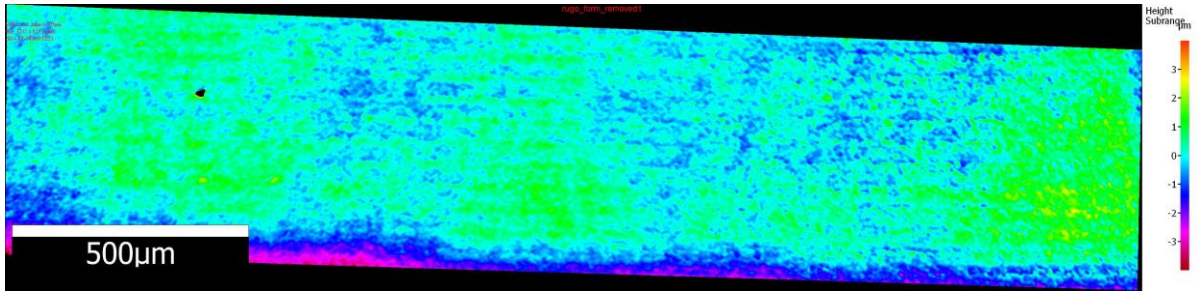


Edge

Test #2 : HP/HT SCD cutting tool: 90 and 60° clearance angles

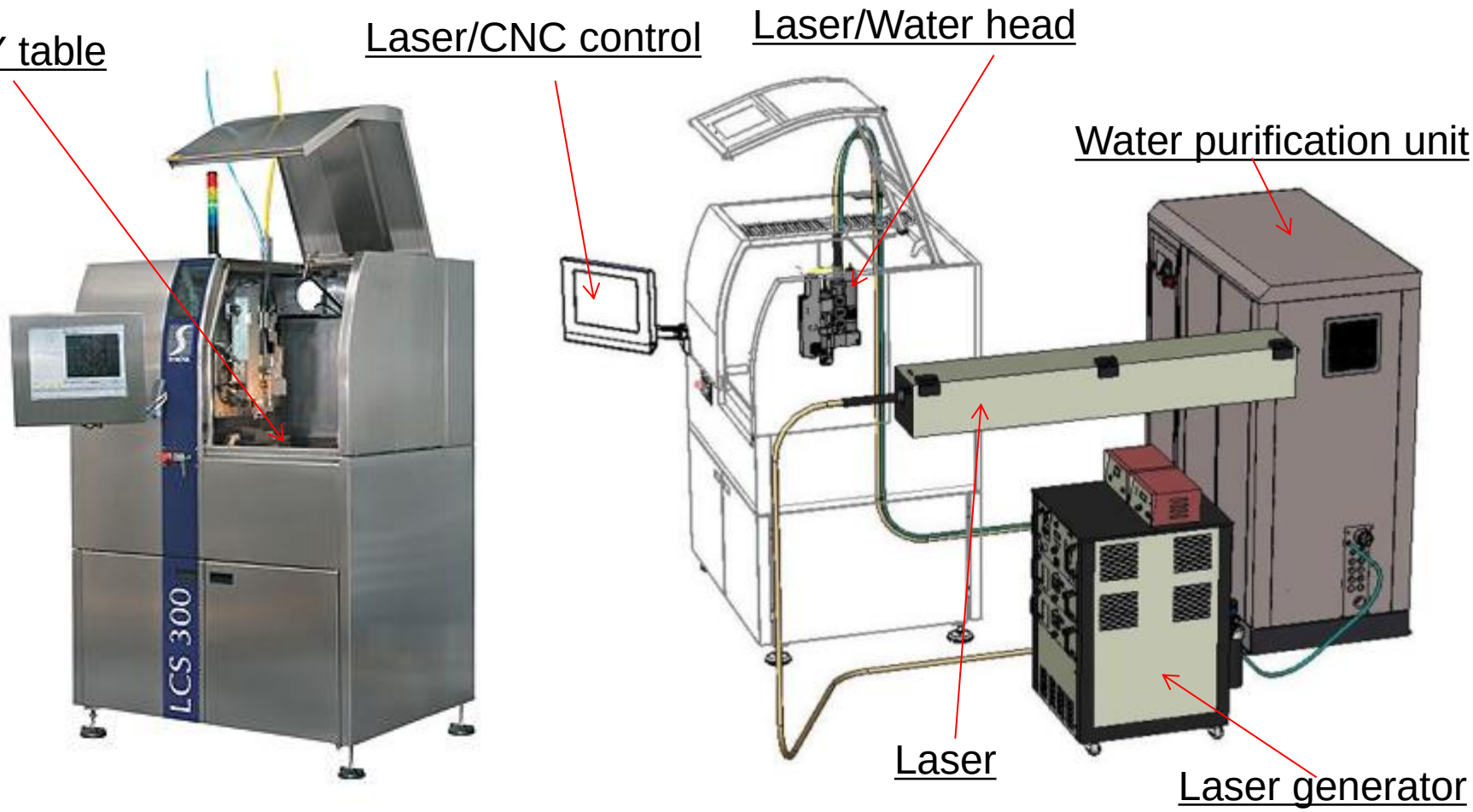




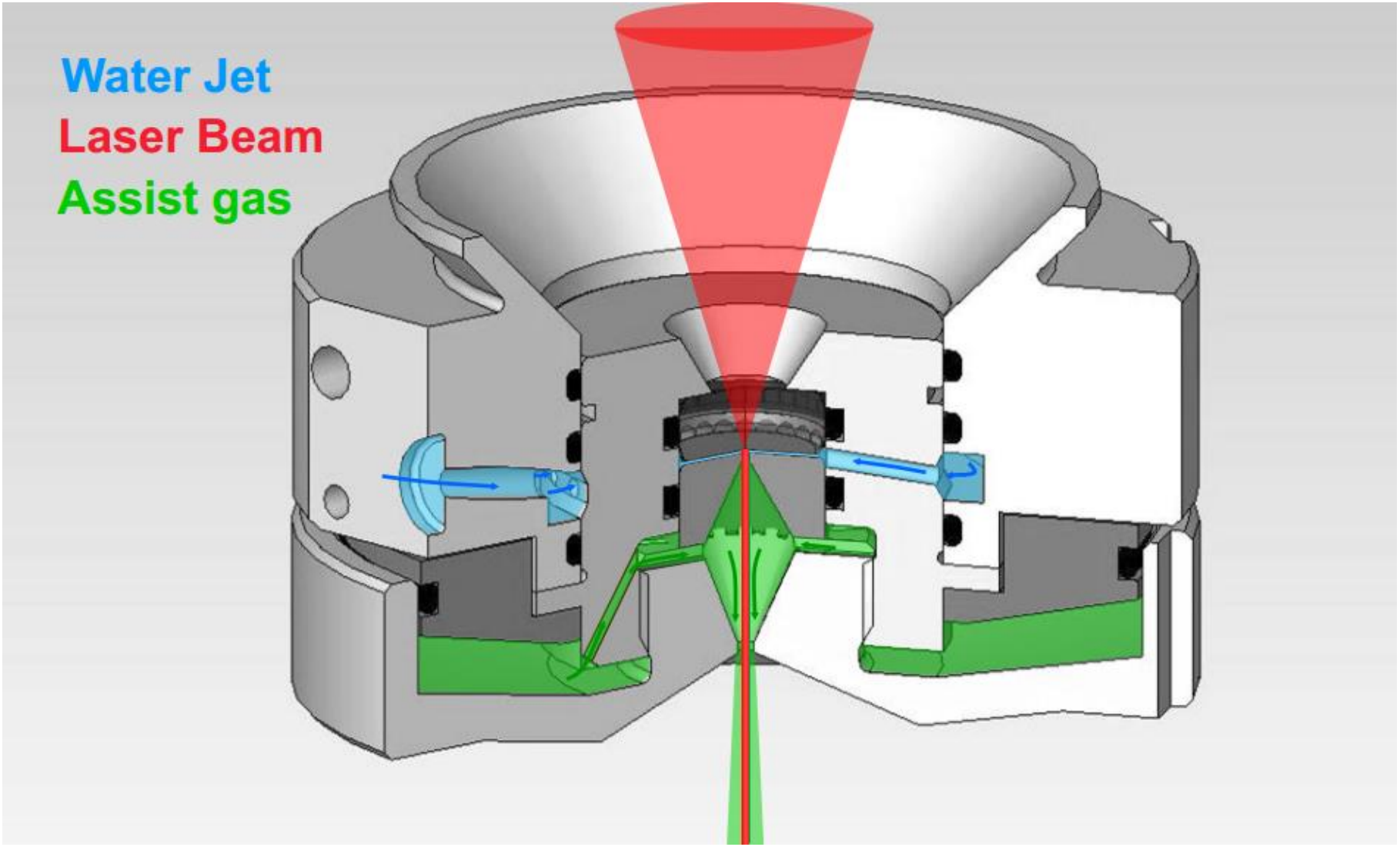


Ra=0.2µm

Laser MicroJet component parts



Coupling of laser, water and helium gas



Nozzle, jet, kerf and working distance sizes

Nozzle diameter (µm)	Water jet diameter (µm)	Kerf width (µm)	Jet length (Wd) (mm)
20	17	~21	20
25	21	~25	25
30	25	~32	30
40	33	~45	40
50	41	~60	50
60	50	~75	60
80	67	~100	80

The advantages of water

Contoured surfaces can be cut; no focus required within range of working distance (W_D)

Cuts are parallel sided, no taper as with dry lasers. The water takes the pulses to bottom of cut

Cuts can have high aspect ratio and can be very narrow – down to 20 microns. Gives high yield

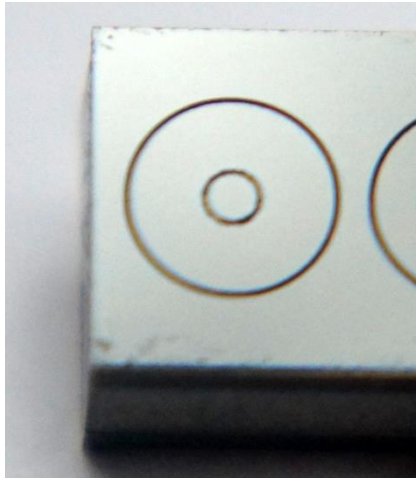
Water cooling minimizes HAZ, eliminates hot spots and thermal shock/cracking

Water gives a wet surface – molten debris does not stick and contaminate surfaces

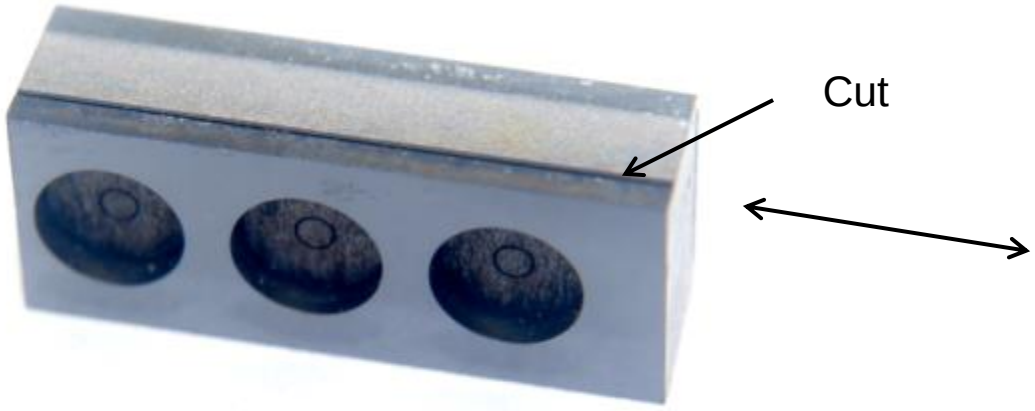
High kinetic energy of water jet expels debris, no burrs form on exit edges

Other industrial diamond applications of the wet laser:

Rotary glass cutter blanks



Step 1: cut into PCD layer



Step 2: cut within PCD layer parallel to surface

Released wheels:

- Wheel diameter = 2.8mm
- Thickness = 0.65mm
- Hole diameter = 0.8mm

Other industrial diamond applications of the wet laser:

Cutting rods from natural diamond

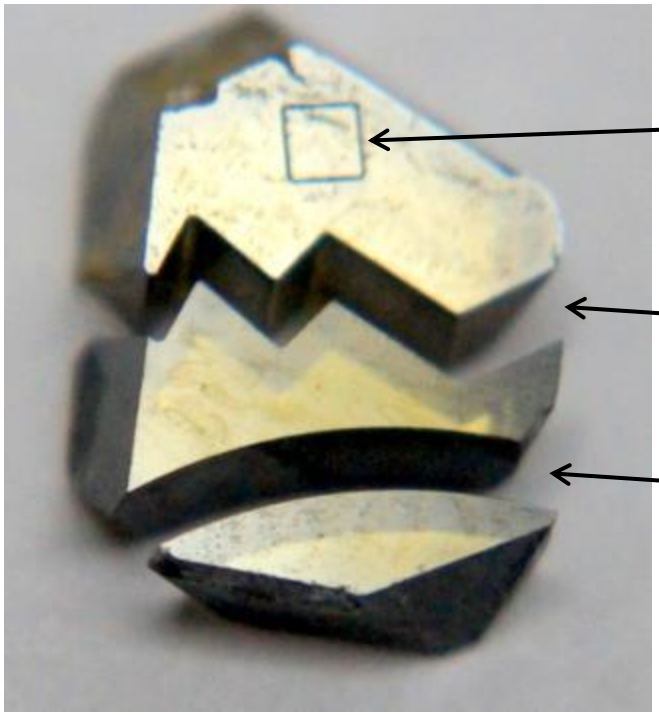
Diamond with 1.0mm hole
- parallel sided

1.0mm diameter rod/piston

Hole quality

Other industrial diamond applications of the wet laser:

Cutting HP/HT Monocrystal®/Monodite® type diamond



Cut time: ~ 4 minutes

Profile:
Cut time: ~ 11 minutes

15mm radius
Cut time: ~ 5 minutes

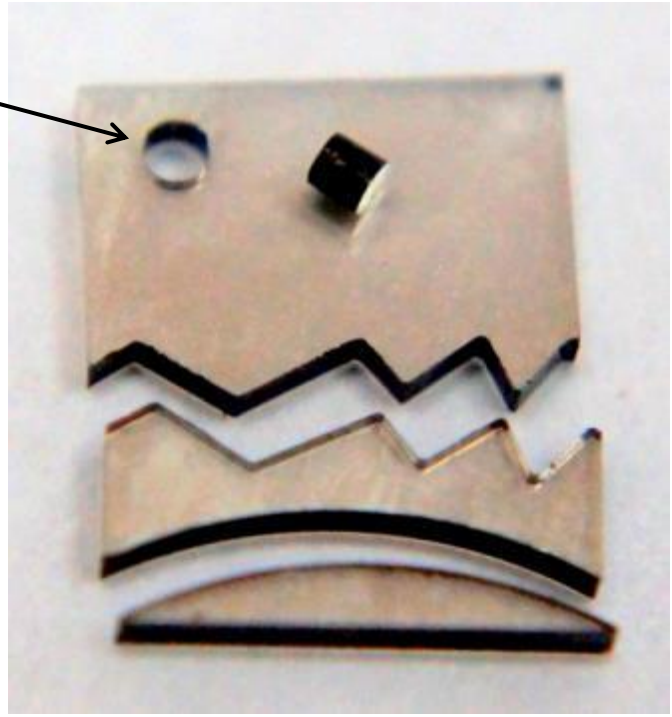
Thickness 1.2mm

®Registered trade mark of E6

Other industrial diamond applications of the wet laser:

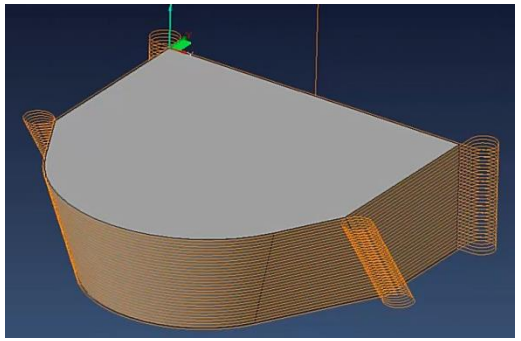
Cutting high purity, white CVD single crystal diamond

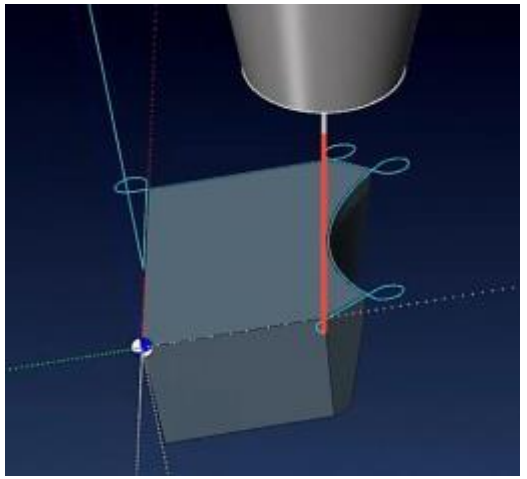
1mm hole



Thickness 0.87mm

MCS150 – 5 axis wet laser for diamond tool making





For cutting:

- All forms of diamond, PCD, CVD, cBN and PcBN
- 5 axis
- High precision (1um) linear motor drives, water cooled