New Laser Technology for Marking and Ablation

Daniel Seitz, 28.11.2017

Manager Application Development

COHERENT | rofin

Index

- **Introduction** (Location, Lab)
- **New laser sources for marking** (Rapid NX, Pico IR/SHG 10/50)
- **Application improvements** (Black marking, cleaning (metal, thin films), glass cutting, ceramic structuring..)
- **Software development** (5.3 incl. 3D, Wmof in 5.3)
- **2D/3D vision process** (line scanner, teach & match, pros)

Coherent Rofin AppsLab in Günding/Munich

Former Rofin marking division headquarter, ~180 employees, located northwest of Munich

Specializing in nanosecond lasers and sub-nanosecond laser marking/micro applications

- 4 labs, 6 employees, ~25 laser sources
- All flexible class 4 workplaces
- 2 workstations with x,y,z,u,v axis +3D scanner
- Wavelengths: 355nm, 532nm, 1064nm, 10.6µm
- Pulse durations: 10ps – 200ns
- Power levels: 100W (1064), 30W (532), 10W (355), 30W(10.6)

Coherent Rofin AppsLab in Günding/Munich

Lab equipment for process development / result verification

- 405nm laser scanning microscope (depth measurement, roughness determination)
- Various code readers (DMC, Barcode …evaluation, read out)
- Nano focus (large area topography)
- Color Eye (LAB color measurement)
- 3D printer (custom made fixtures)
- Saltwater spray test (corrosion resistance test)

New USP Laser Sources (Rails)

Short pulse laser sources for marking/micro

Powerline Pico 10 (1064 & 532 nm)

- Compact design, air cooled
- Up to 8 W IR, 3W SHG
- High efficiency amplifier
- All-in-one package

Laser Beam source	PowerLine Pico 10–1064	PowerLine Pico 10–532
Wavelength (nm):	1064	532
Average power (W):	8 @ 400 kHz	3 @ 400 kHz
Pulse frequency (kHz):	200 – 800	200 – 800
Pulse width (ps):	550 @ 400 kHz	450 @ 400 kHz
Beam quality:	TEM_{00}	TEM_{00}
M^2:	< 1.6	< 1.5
Energy per Pulse (µJ):	20 @ 400 kHz; 10 @ 800 kHz	7.5 @ 400 kHz; 3.5 @ 800 kHz
Peak power (kW):	20 @ 400 kHz	7.5 @ 800 kHz
Beam diameter (mm):	approx. 2	approx. 2
Divergence angle full radius (mrad):	collimated	collimated
Polarization:	random; > 100:1	linear; > 100:1
Power supply (V DC):	115 – 240 +/-10, 50/60 Hz	115 – 240 +/-10, 50/60 Hz
Operating temperature (°C):	15 – 35	15 – 35

Laser Marker	PowerLine Pico 10–1064	PowerLine Pico 10–532
Wavelength (nm):	1064	532
Pulse frequency (kHz):	200 – 800	200 – 800
Pulse width (ps):	550 @ 400 kHz	450 @ 400 kHz
Dimensions (W x D x H, mm):	167 x 631 x 285	167 x 631 x 285
Air flow (m3/h):	approx. 180	approx. 180
Field size (mm):	120 x120 or 240 x 240	120 x 120 or 240 x 240
Focus distance (mm):	193 (+/- 7) or 432 (+/- 25)	193 (+/- 7) or 432 (+/- 25)
Supply unit dimensions (W x D x H, mm):	19", 2 rack units	19", 2 rack units
Software:	VLM	VLM
Air flow 19" supply unit (m3/h):	approx. 80	approx. 80
Power supply (V):	115 – 240, +/- 10, 1 P/N/PE	115 – 240, +/- 10, 1 P/N/PE
Operating temperature (°C):	15 – 35	15 – 35

Short pulse laser sources for marking/micro

Powerline Pico 50 (1064 & 532 nm)

- High power version of Pico10
- Up to 40 W IR, 25W SHG
- Ps pulses (<500ps)

Laser Beam source	PowerLine Pico 50–1064	PowerLine Pico 50–532
Wavelength (nm):	1064	532
Average power (W):	40 @ 250 kHz	25 @ 250 kHz
Pulse frequency (kHz):	200 – 800	200 – 800
Pulse width (ps):	< 500 @ 250 kHz	< 500 @ 250 kHz
Beam quality:	TEM_{00}	TEM_{00}
M^2:	1,5	1,5
Energy per Pulse (µJ):	160 @ 250 kHz	100 @ 250 kHz
Peak power (kW):	> 320 @ 250 kHz	> 200 @ 250 kHz
Beam diameter (mm):	3	tbd
Divergence angle full radius (mrad):	< 1	< 1
Polarization:	linear; > 100:1 vertical	linear; > 100:1 horizontal
Power supply (V DC):	115 – 240 +/- 10%, 50/60 Hz	115 – 240 +/- 10%, 50/60 Hz
Operating temperature (°C):	15 – 35	15 35

Laser Marker	PowerLine Pico 50–1064	PowerLine Pico 50–532
Wavelength (nm):	1064	532
Pulse frequency (kHz):	200 – 800	200 – 800
Pulse width (ps):	< 500 @ 250 kHz	< 500 @ 250 kHz
Dimensions (W x D x H, mm):	360 x 980 x 212	360 x 980 x 212
Field size (mm):	variable	variable
Focus distance (mm):	variable	variable
Supply unit dimensions (W x D x H, mm):	2 HE^h x 482,6 x 400	2 HE^h x 482,6 x 400
Software:	VLM	VLM
Air flow 19" supply unit (m3/h):	70	70
Power supply (V):	115 – 240 +/- 10%, 50/60 Hz	115 – 240 +/- 10%, 50/60 Hz
Operating temperature (°C):	15 – 35	15 – 35

Ultra short pulse laser source for marking/micro

Rapid NX (1064nm)

- Seed burst mode, pulse picking
- Up to 10 W IR
- Ps pulses (<15ps)

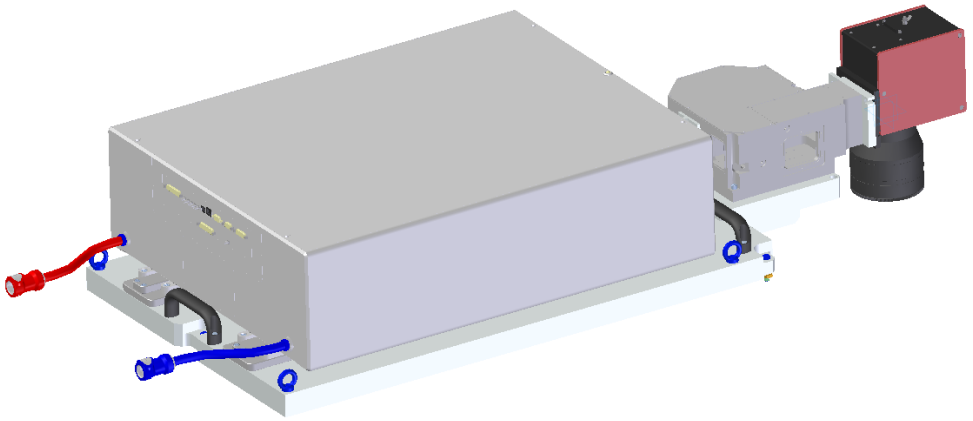
Laser head	PowerLine NX
Wavelength (nm):	1064
Laser power:	approx. 7 W @ 1 MHz
Pulse frequency:	50 kHz – 1 MHz
Beam quality M^2:	< 1.3
Ellipticity:	0.85 < 1.15
Pulse Energy:	50 µJ @ 50 kHz 7 µJ @ 1 MHz
Pulse width:	10 to 15 ps
Peak power:	7 W @ 1 MHz
Dimensions: (L x W x H, mm)	approx. 460 x 330 x 180
Weight (kg):	approx. 28 (laser source)

Supply unit (19”)	
Dimensions:	3U x 19“
Weight (kg):	approx. 20
Cooling:	water cooling chiller optional
Power supply:	115 – 240 V +/- 10%, 50/60 Hz
Power consumption (W):	100 – 240, < 500
Operating temperature (°C):	15° – 30
Air flow19“ (m^3/h):	80

Further Coherent sources coming soon

HyperRapid NX (355nm)

- 355nm
- 30W @ 400kHz
- Ps pulses (<15ps)

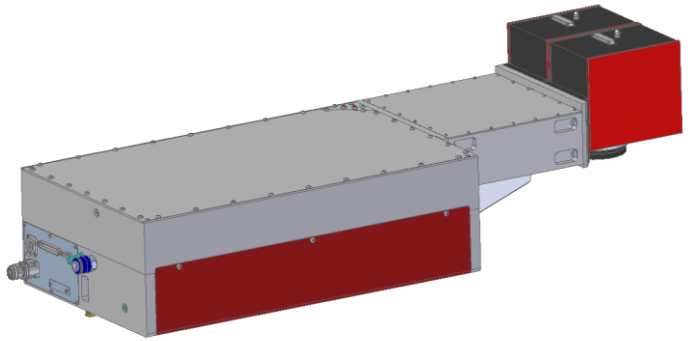


PL AVIA NX 20/40-355

- 355nm
- 40W/130kHz
- < 35 ns/130 kHz

PL AVIA LX 20-355

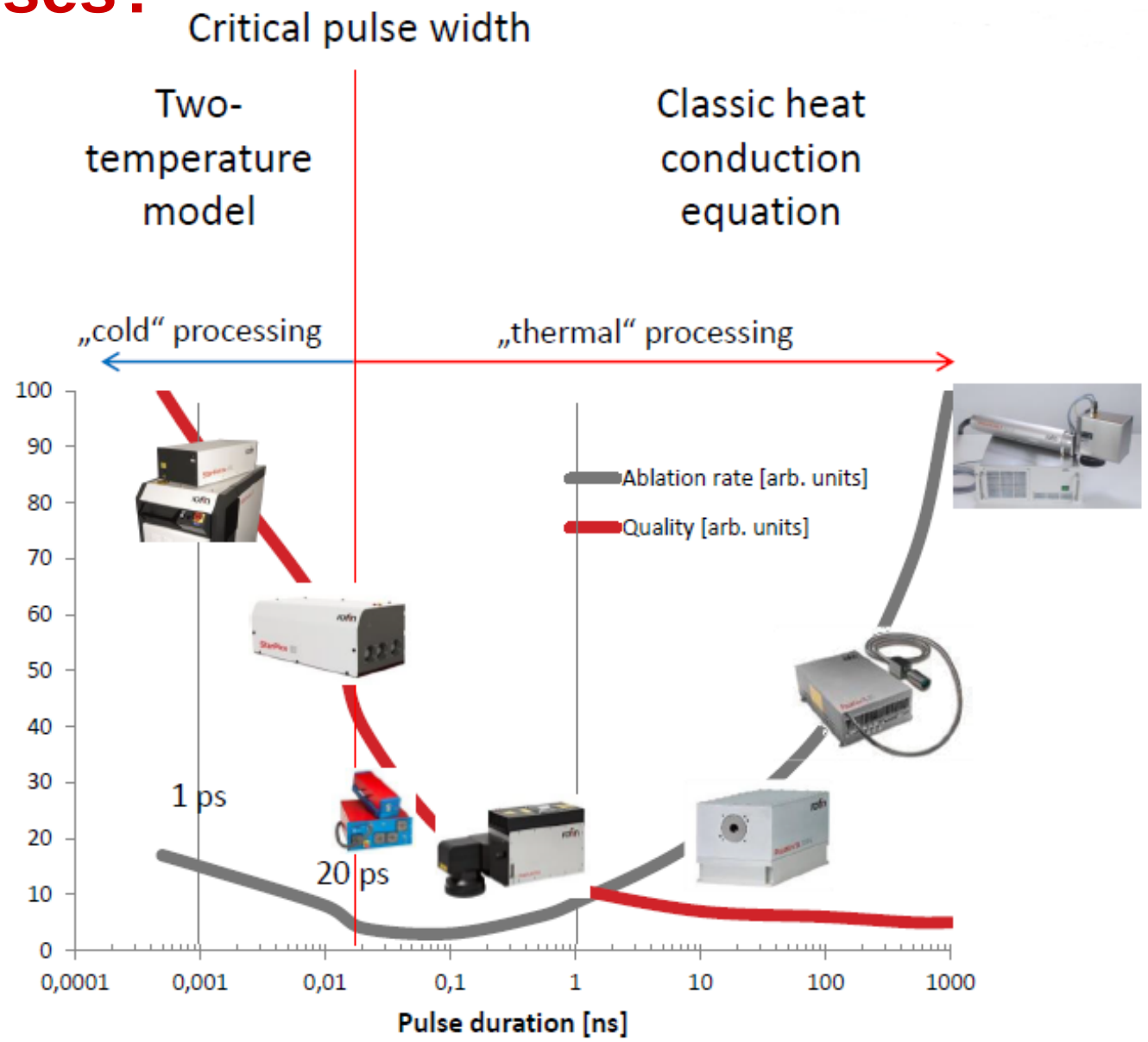
- 355nm
- 20W/50kHz
- < 30 ns/ 50kHz



Why shorter pulses?

Ablation rate,
Quality
[arb. units]

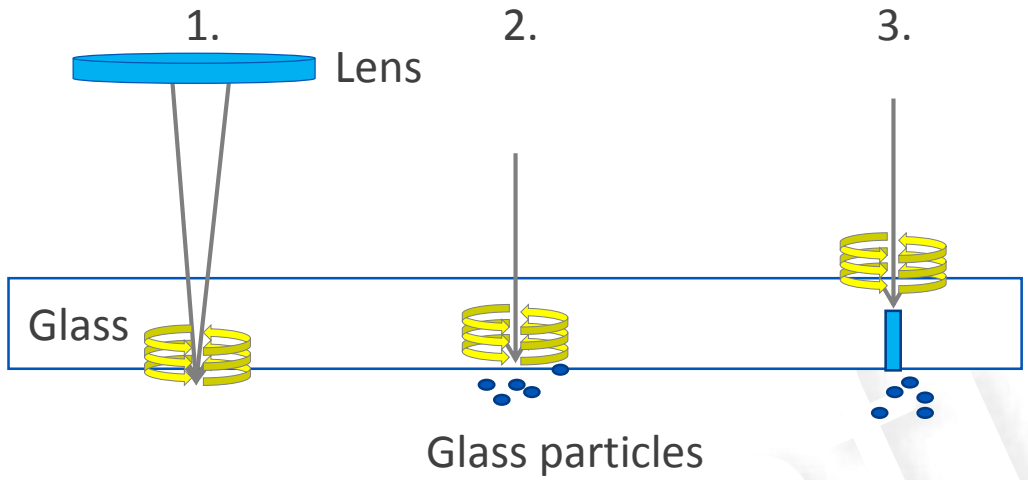
Depending on material and process quality:
100% ~ 10-20 mm³/min

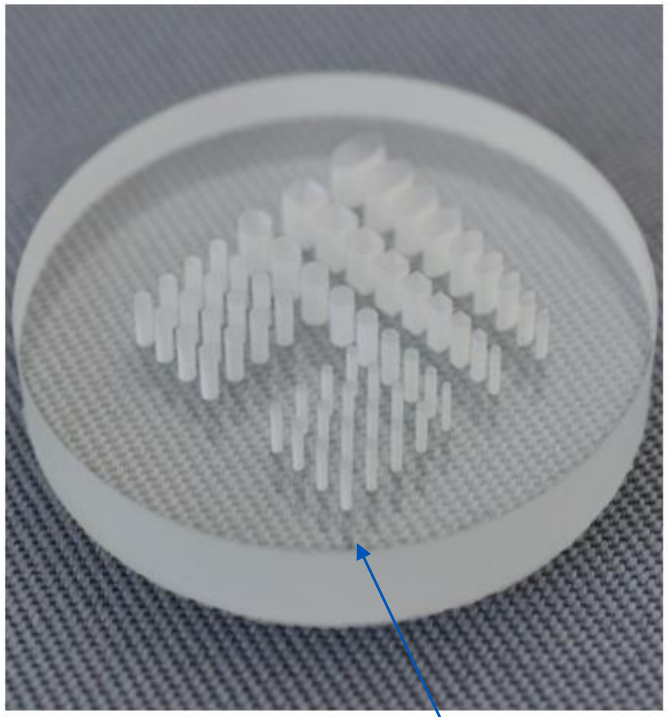


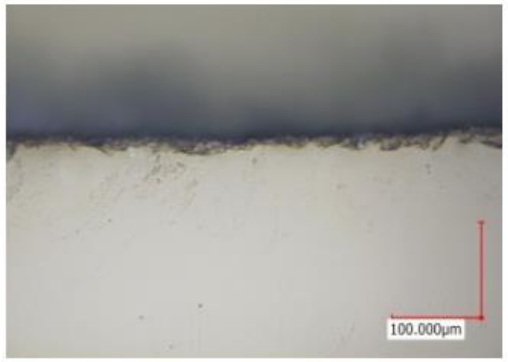
Application Improvements

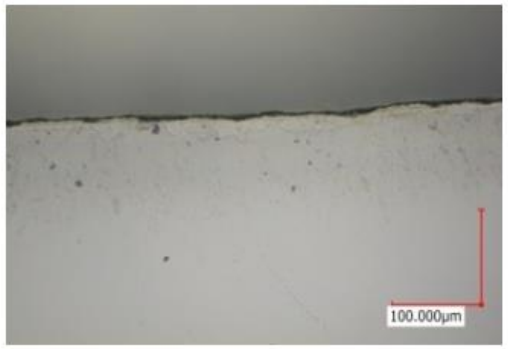
Bottom-up glass (transp. brittle material) cutting

Improved edge quality for bottom-up glass cutting process with short pulse lasers







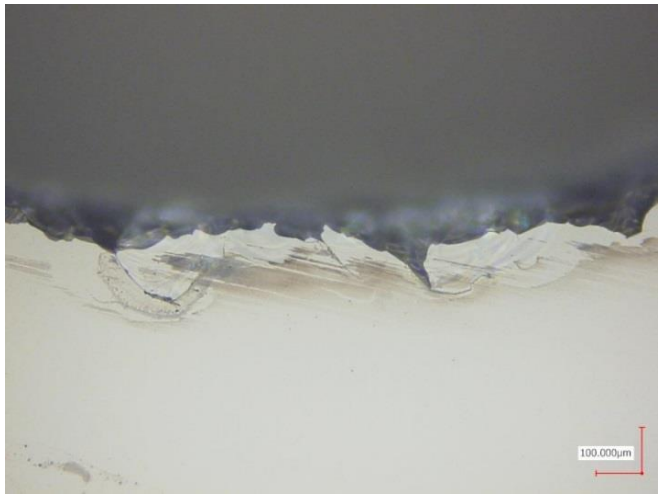


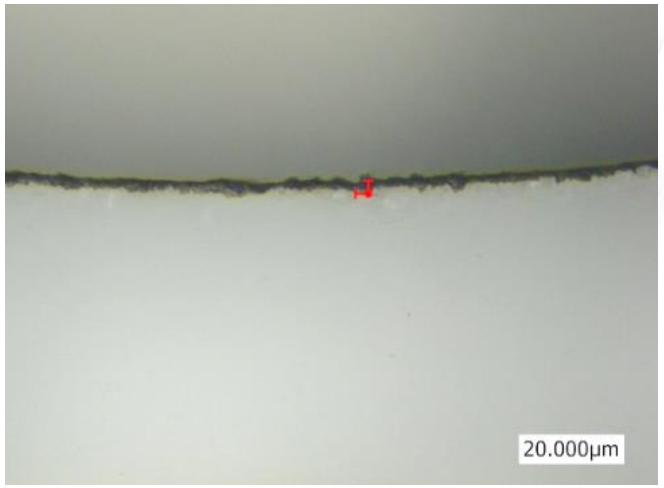
- 1: Focal plane is placed below substrate
- 2: Contour is executed repeatedly
- 3: Focal plane is shifted step by step through the glass substrate from bottom to top (either mechanical or optical z-axis)

Aspect ratio up to 1:20

Glass cutting, quality vs. cycle time

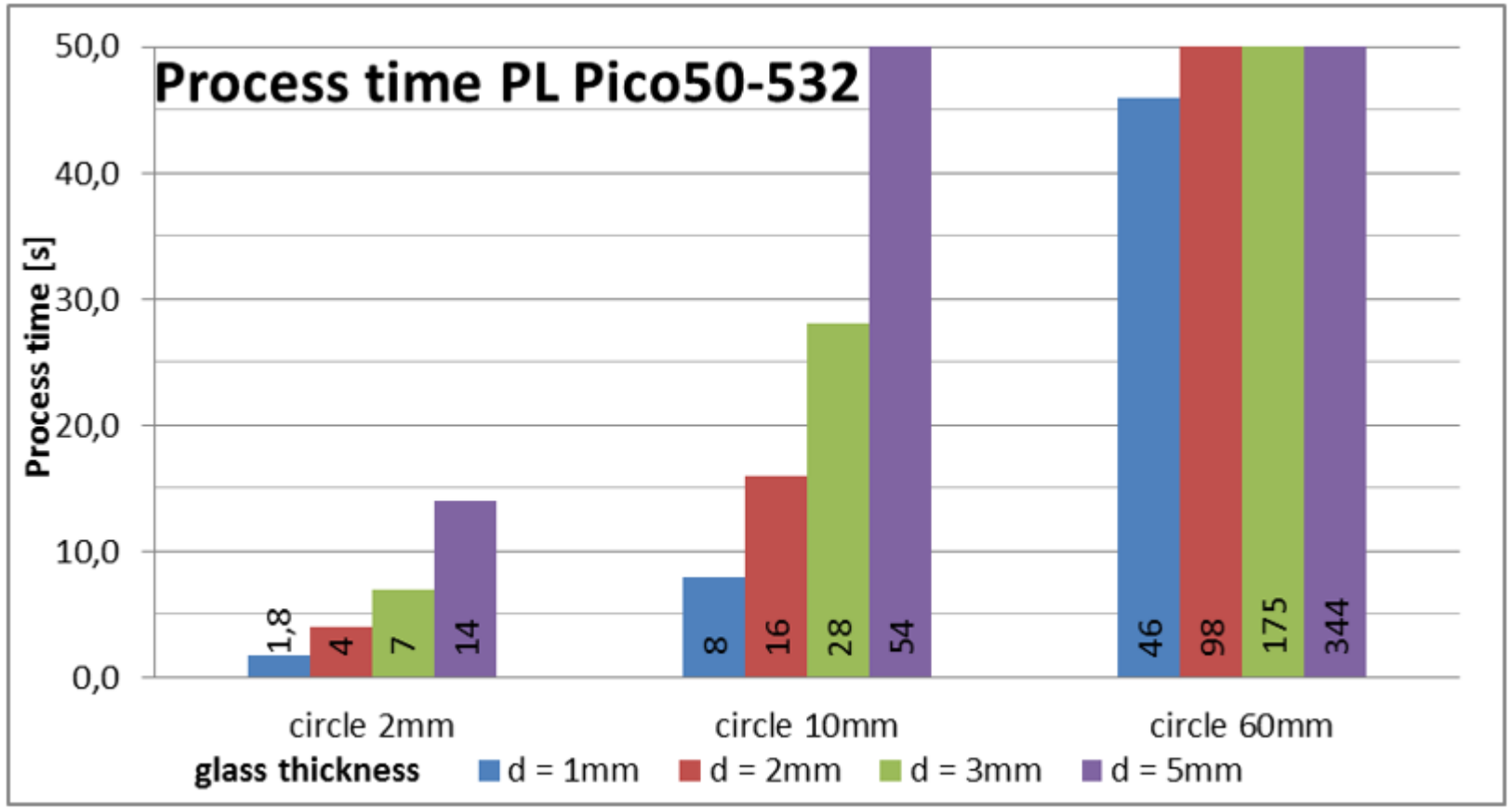
Laser parameters can be optimized for quality or execution time.



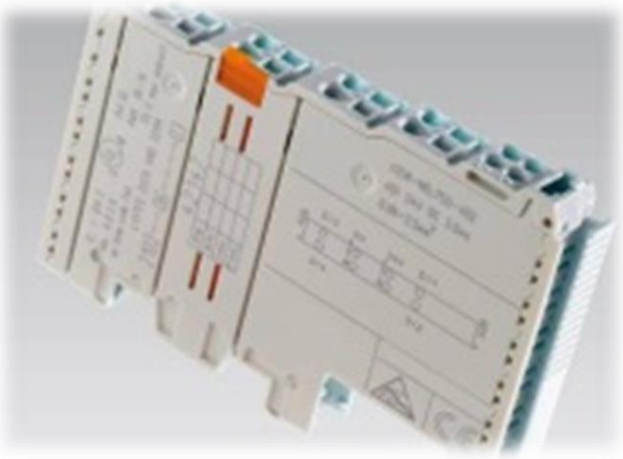


P

PL



Allows wavelength change for polymer marking



PL E20 THG

PL Pico 10-532

Industry standard: ns-UV lasers (e.g. Rofin E UV5)

Process info:

- high speed marking,
- very low cycle times required (~1-2 sec./part)
- 355nm needed for contrast on polymers

New process: ps-SHG lasers (Rofin Pico10-532)

- Increased process speed
- Substitution of UV laser, 532nm instead of 355nm
- Sufficient contrast
- Reduced cost of ownership (less maintenance, higher lifetime)

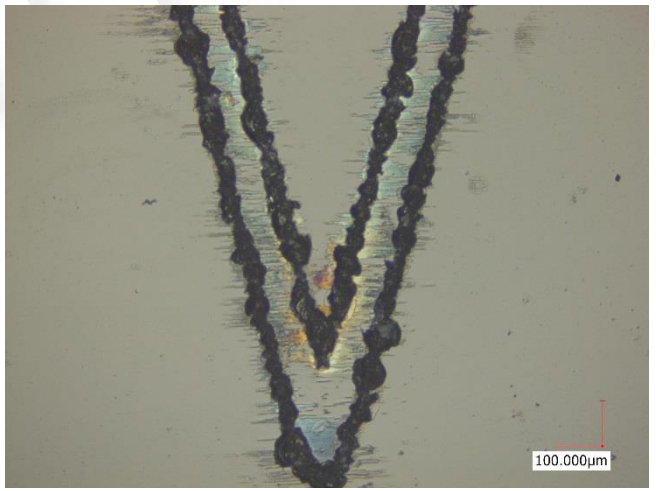
…and high power for brittle material marking

Industry standard: ns-UV lasers (e.g. Rofin E20 THG)

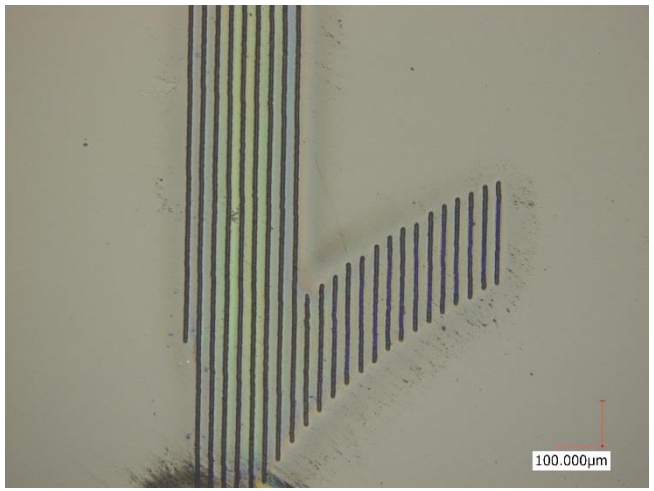
Process info: slow, large chipping

New process: ps-SHG lasers (e.g. Rofin Pico50-532)

- Increased process speed (up to 15x faster)
- Substitution of UV laser
- Short pulses improve quality drastically

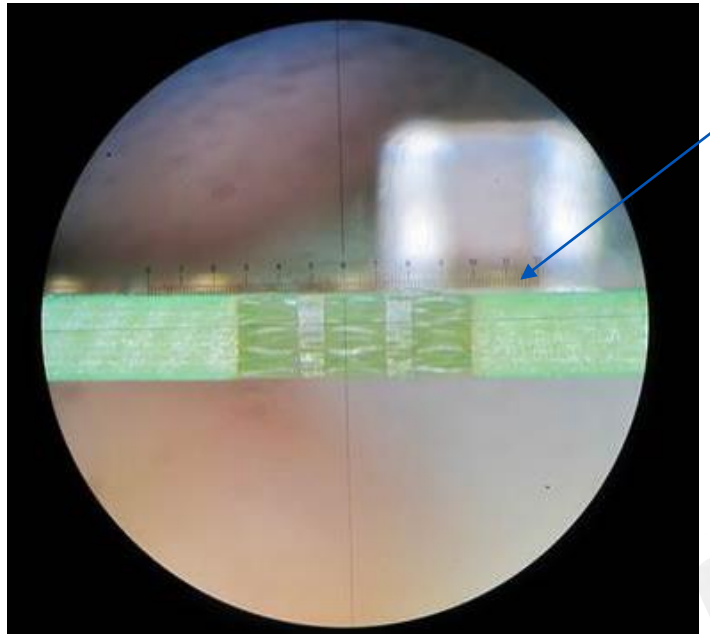


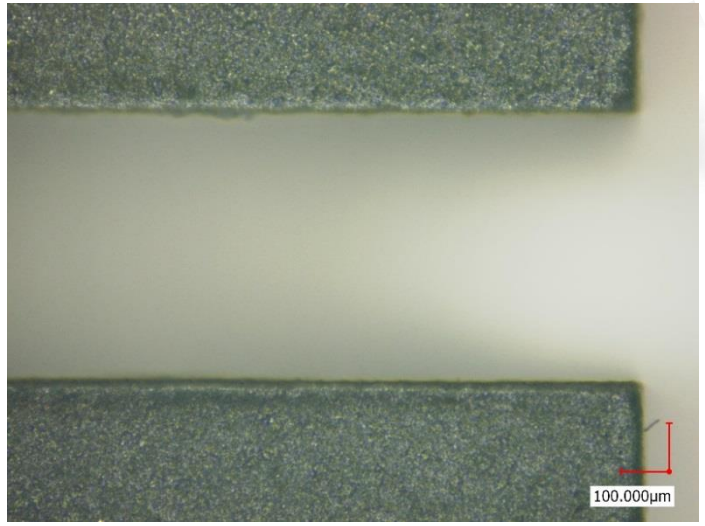
PL E20 THG



PL Pico 50-532

PCB cutting





Industry standard: ns-UV or SHG lasers (e.g. Rofin E UV10, E25 SHG)

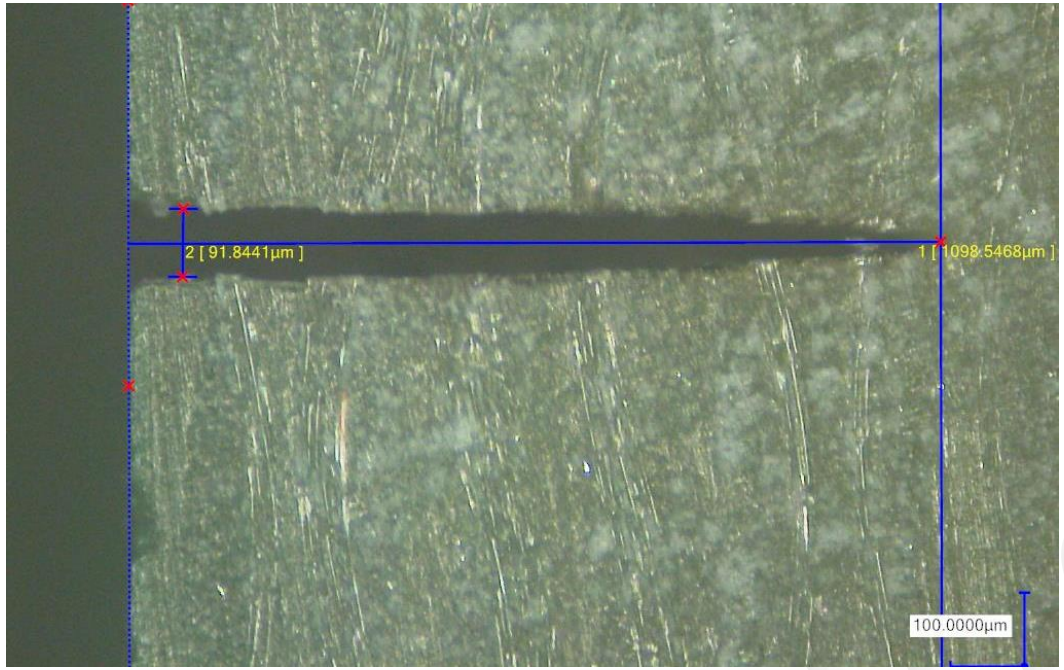
Process info:

- Slow process speed (<10 mm/s)
- Large HAZ, carbonization, particles
- Discoloration of PCB substrates

New process: ps-SHG lasers (Rofin Pico50-532)

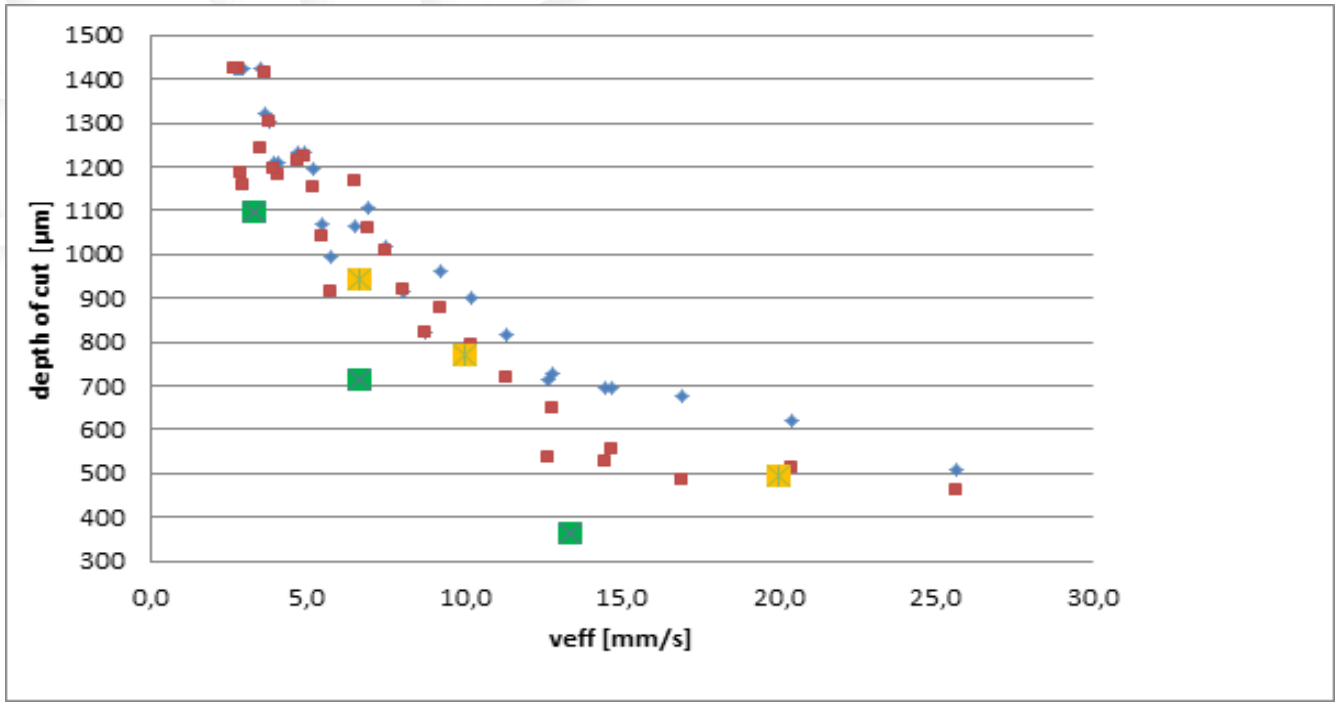
- Similar or increased process speed
- Substitution of UV laser, 532nm instead of 355nm
- Low HAZ
- Reduced particles & carbonization

PCB cutting

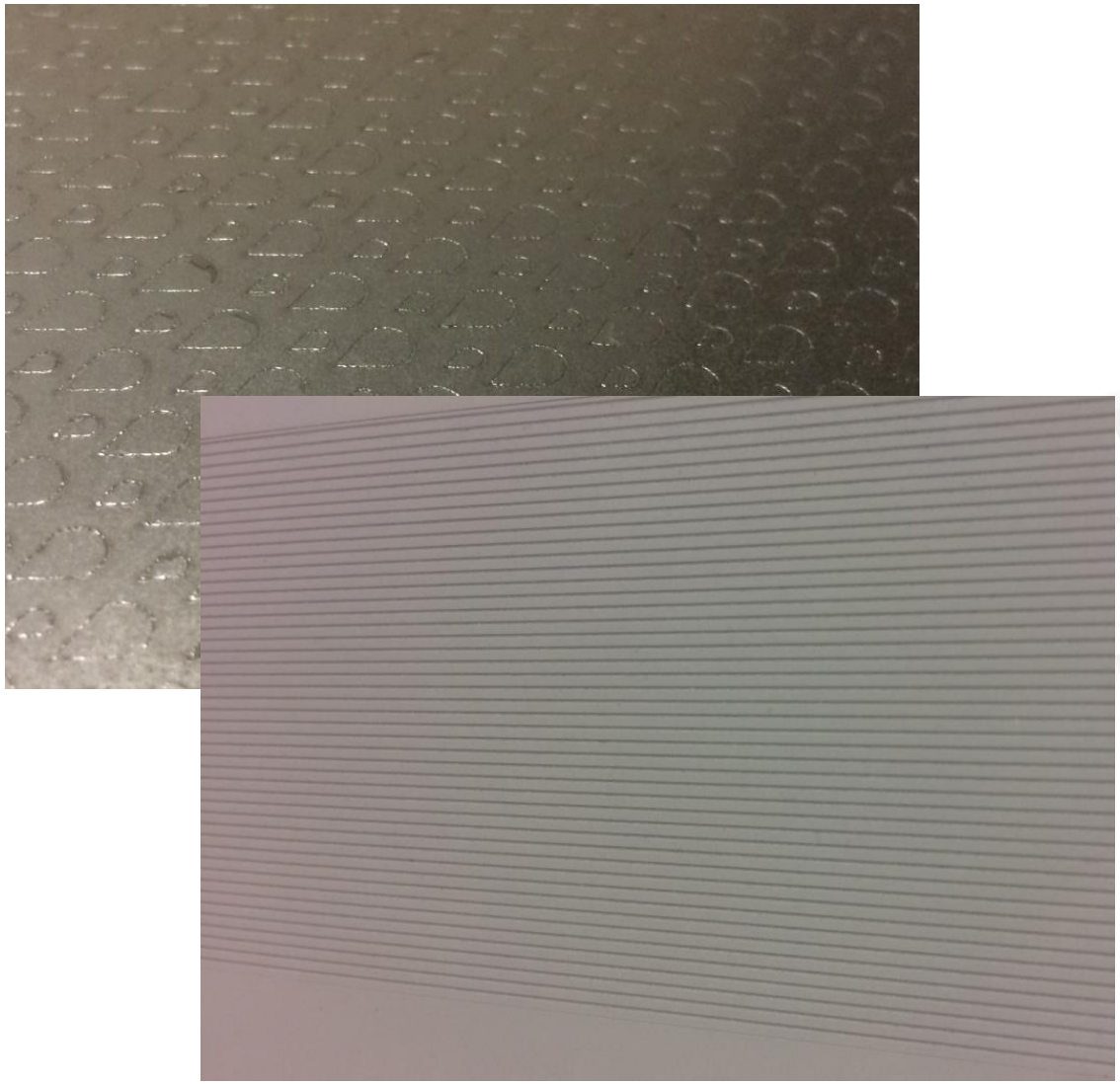


Process info:

- Up to 2mm PCB thickness possible
- Effective cutting speed up to 30 mm/s
- Nearly debris free cuts
- Full cut, half cut or depaneling possible



Ceramic structuring



Industry standard: -

Process info:

- high speed marking,
- very low cycle times (~1-2 sec./part)
- 255nm needed for contrast on polymers

New process: ps-SHG lasers (Rofin Pico10-532)

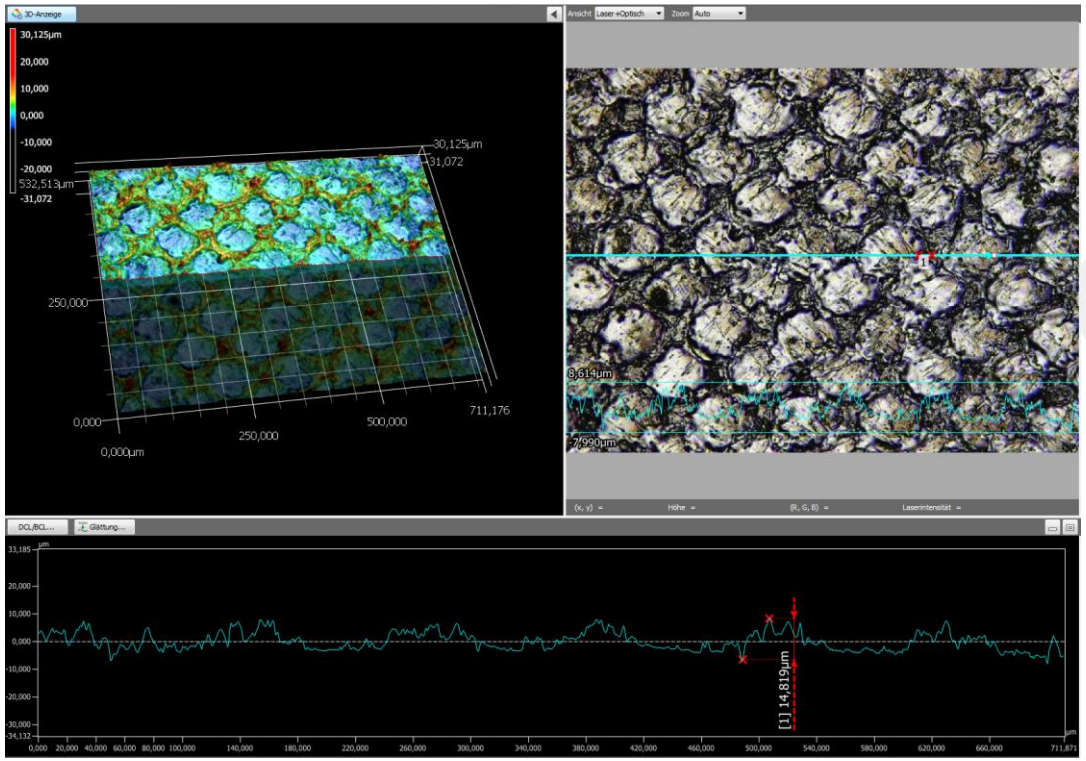
- Similar or increased process speed
- Substitution of UV laser (532nm) instead of 355nm
- Sufficient contrast
- Reduced cost of ownership (less maintenance, higher lifetime)

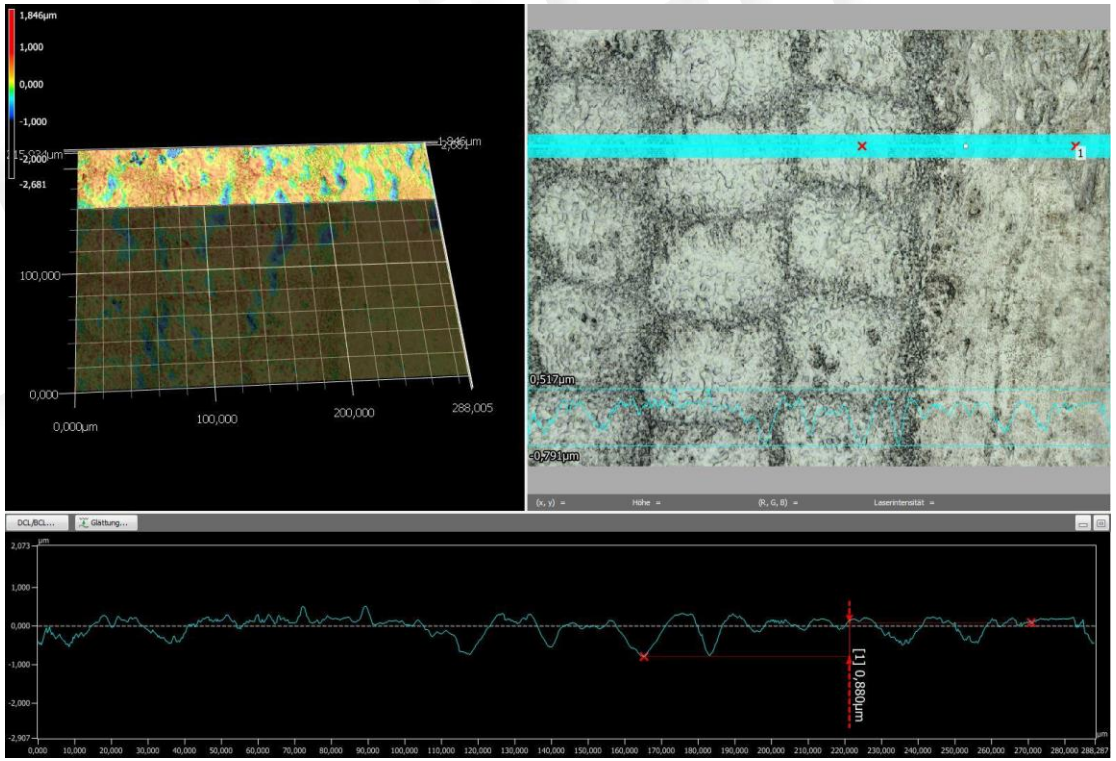
High speed surface cleaning of metals

PL Pico 50 (IR/SHG) ideal solution due to:

- High repetition rate / pulse energy
- Low ablation rate on metals, heat input and recast

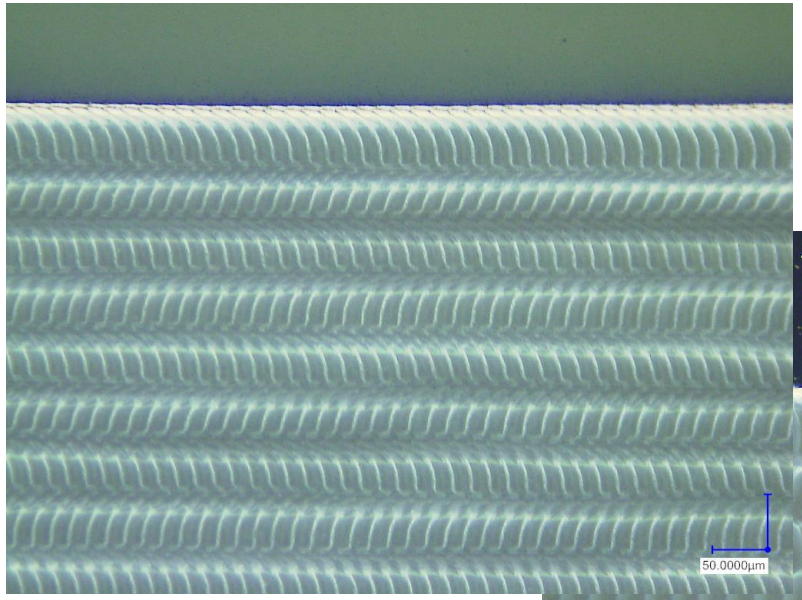
Up to 15 cm²/s cleaning rate



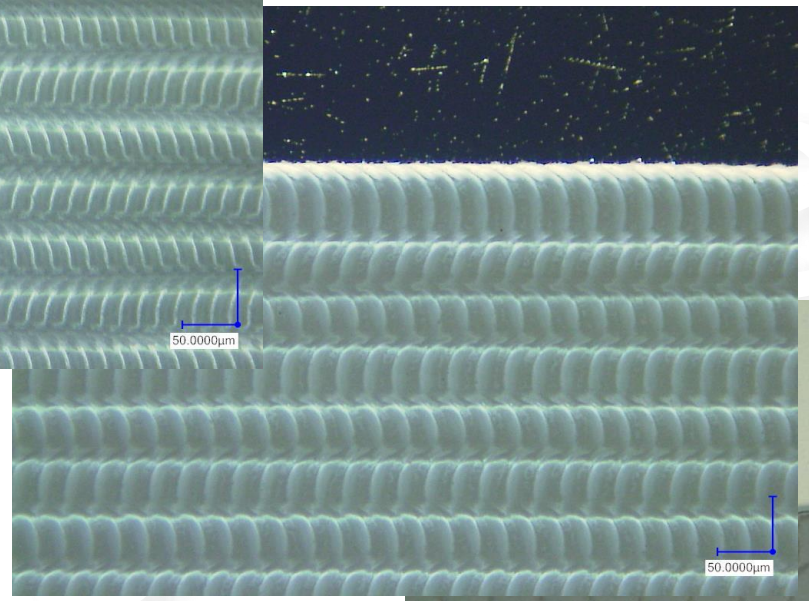


PL F20 vs. PL Pico 50-532: Cleaning of aluminium housings for electronic devices

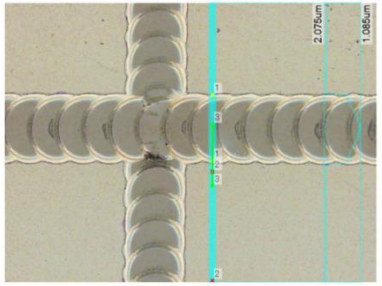
High speed surface cleaning of glass

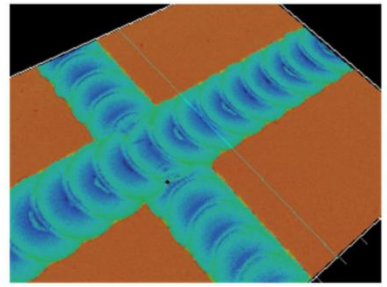


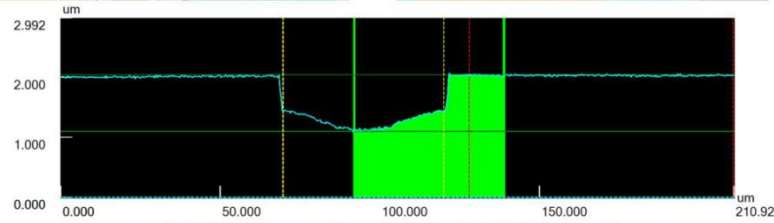
2.5 cm²/s cleaning rate



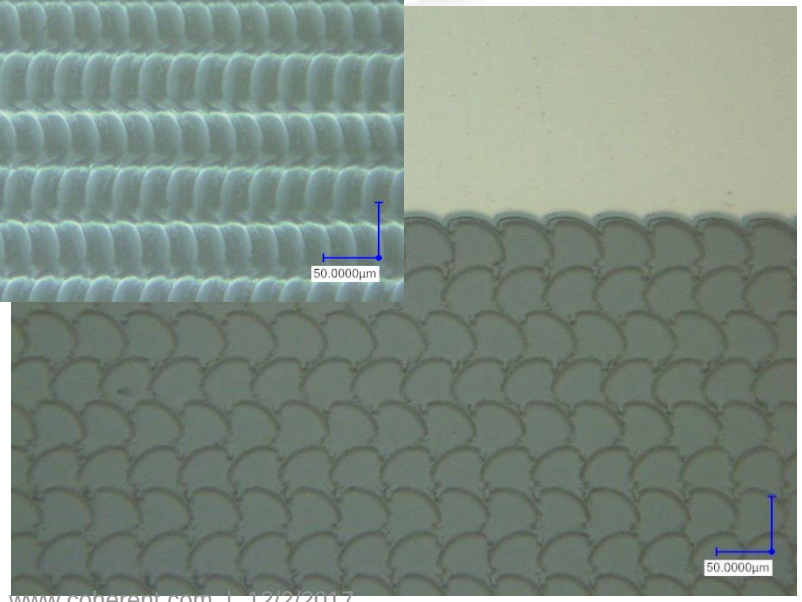
4 cm²/s cleaning rate







Profile1	Horz. dist.	Hght. diff.	Hght. ave.
Seg.1	50.234um	0.018um	1.269um
Seg.2	82.486um	0.028um	2.032um
Seg.3	46.809um	0.940um	1.550um



8.5 cm²/s cleaning rate

Thin film ablation with PL Pico 50-1064

Black marking of metals

PL F20 Varia

PL Rapid NX

Industry standard: ns Fiber lasers, DPSS (PL F20, E25)

Process info:

- Classic surface “annealing”, laser → heat → oxidation
- Shiny/glossy mark, visible color changes (dependent on viewing angle)
- Parameter settings depend on material, surface finish...

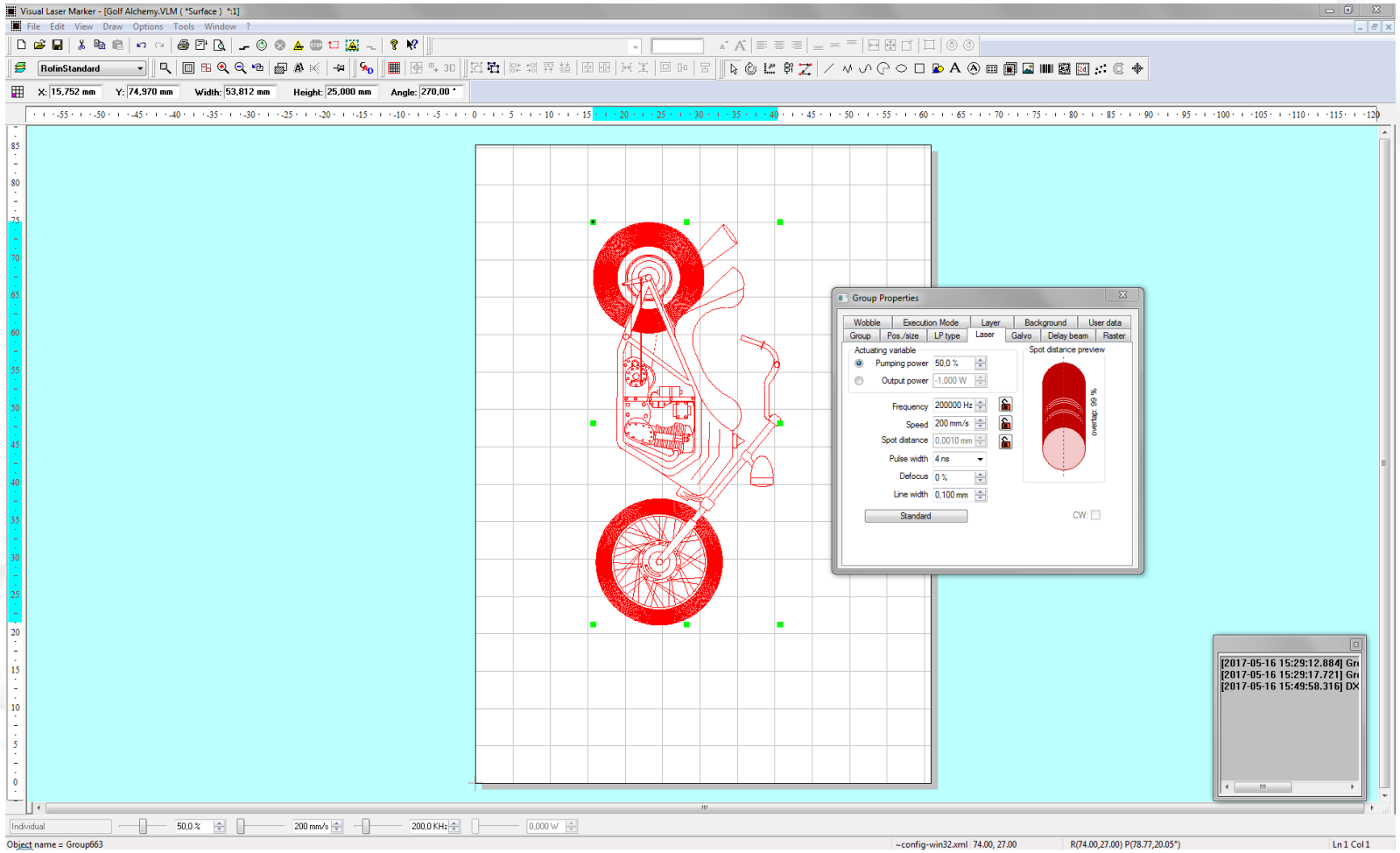
New process: ps-IR lasers (Rofin PL Rapid NX)

- Extremely high contrast achievable.
- Mat, angle independent mark
- At least 50% faster compared to fiber laser annealing
- Stainless steel, titanium, aluminium (copper, brass)
- Very good corrosion resistance properties

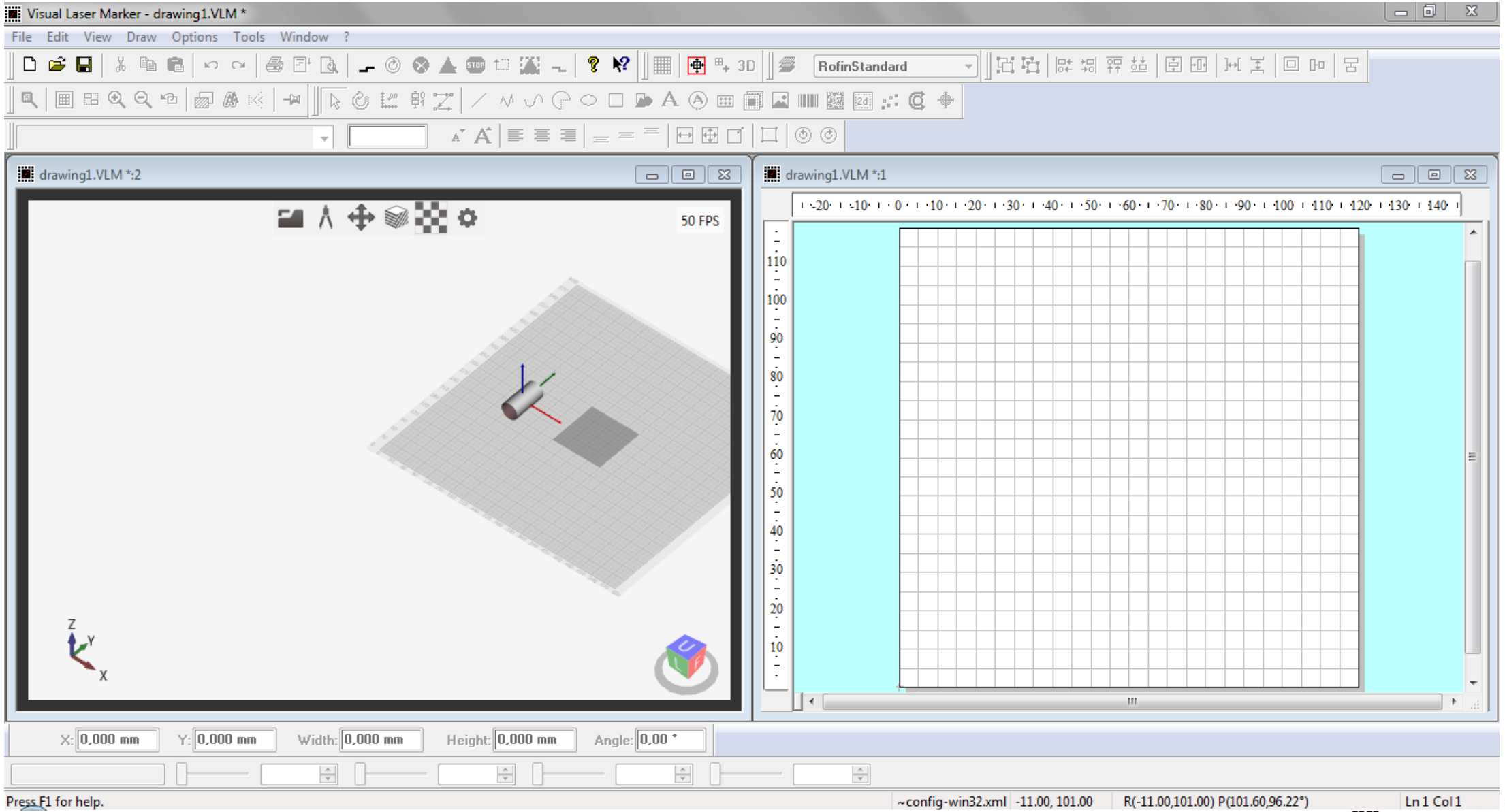
Software Development

VisualLaserMarker software version 5.3

Newly developed user interface

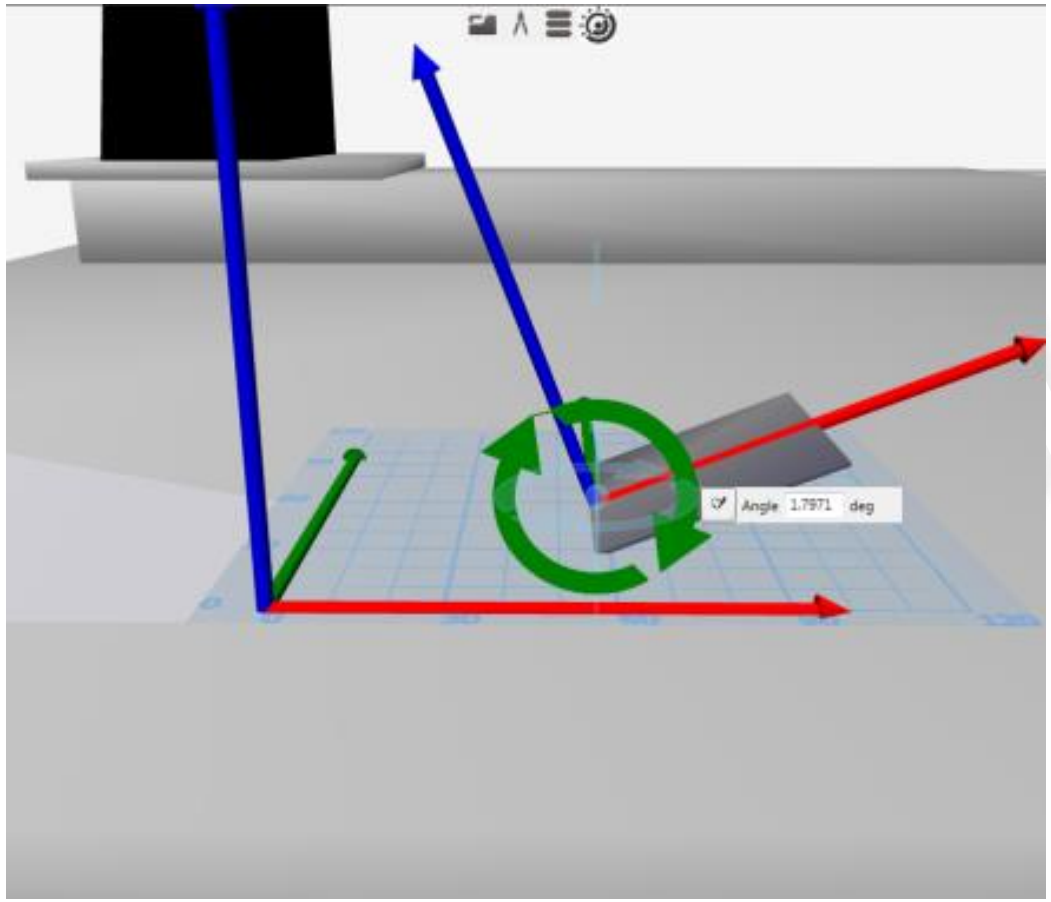


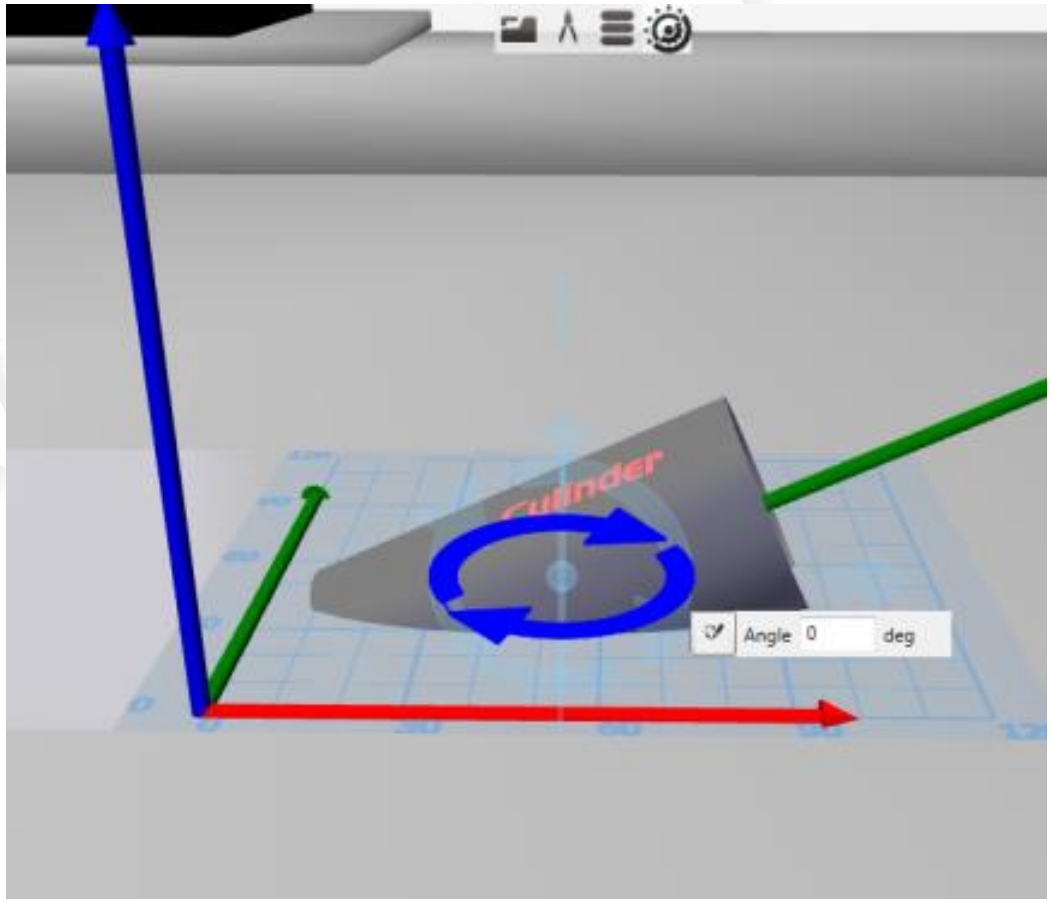
VisualLaserMarker software version 5.3



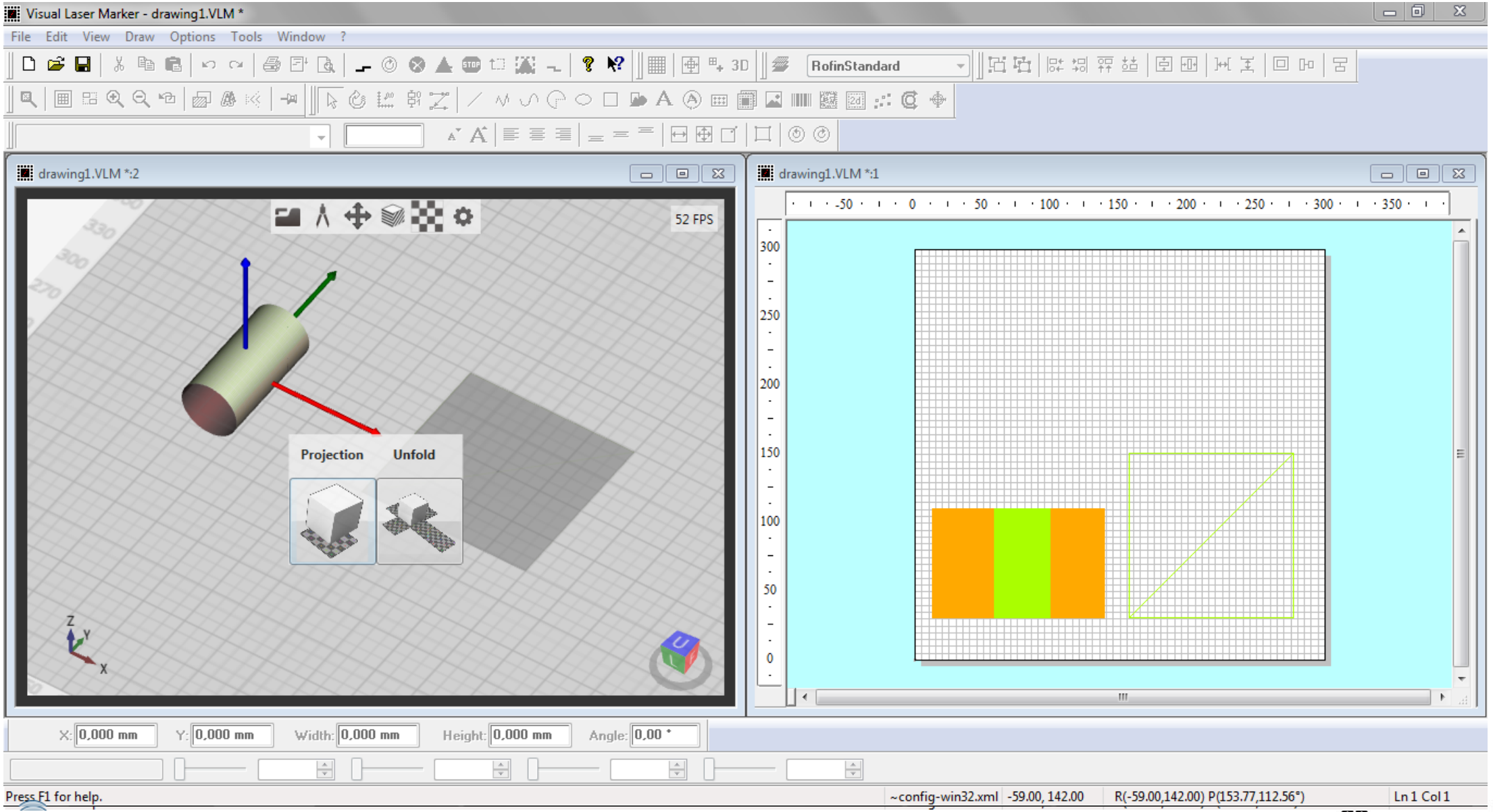
VisualLaserMarker software version 5.3

Newly developed user interface



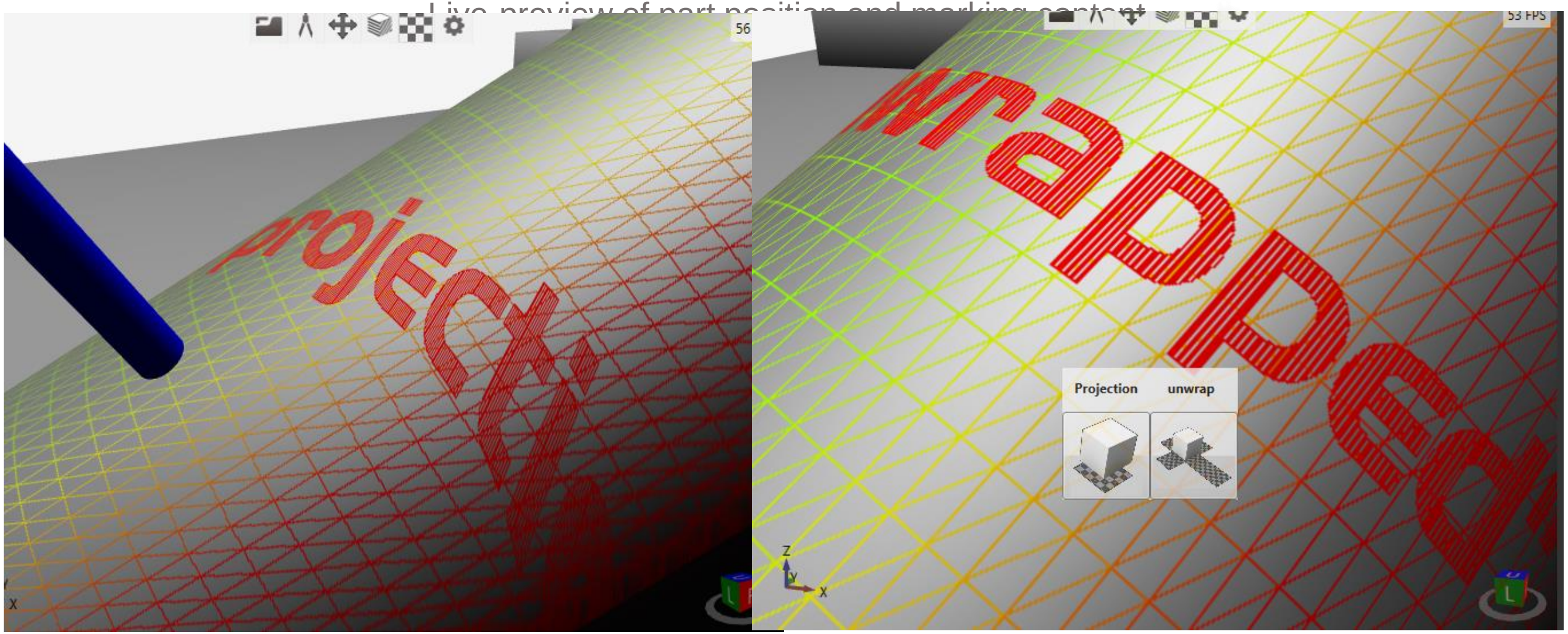


VisualLaserMarker software version 5.3

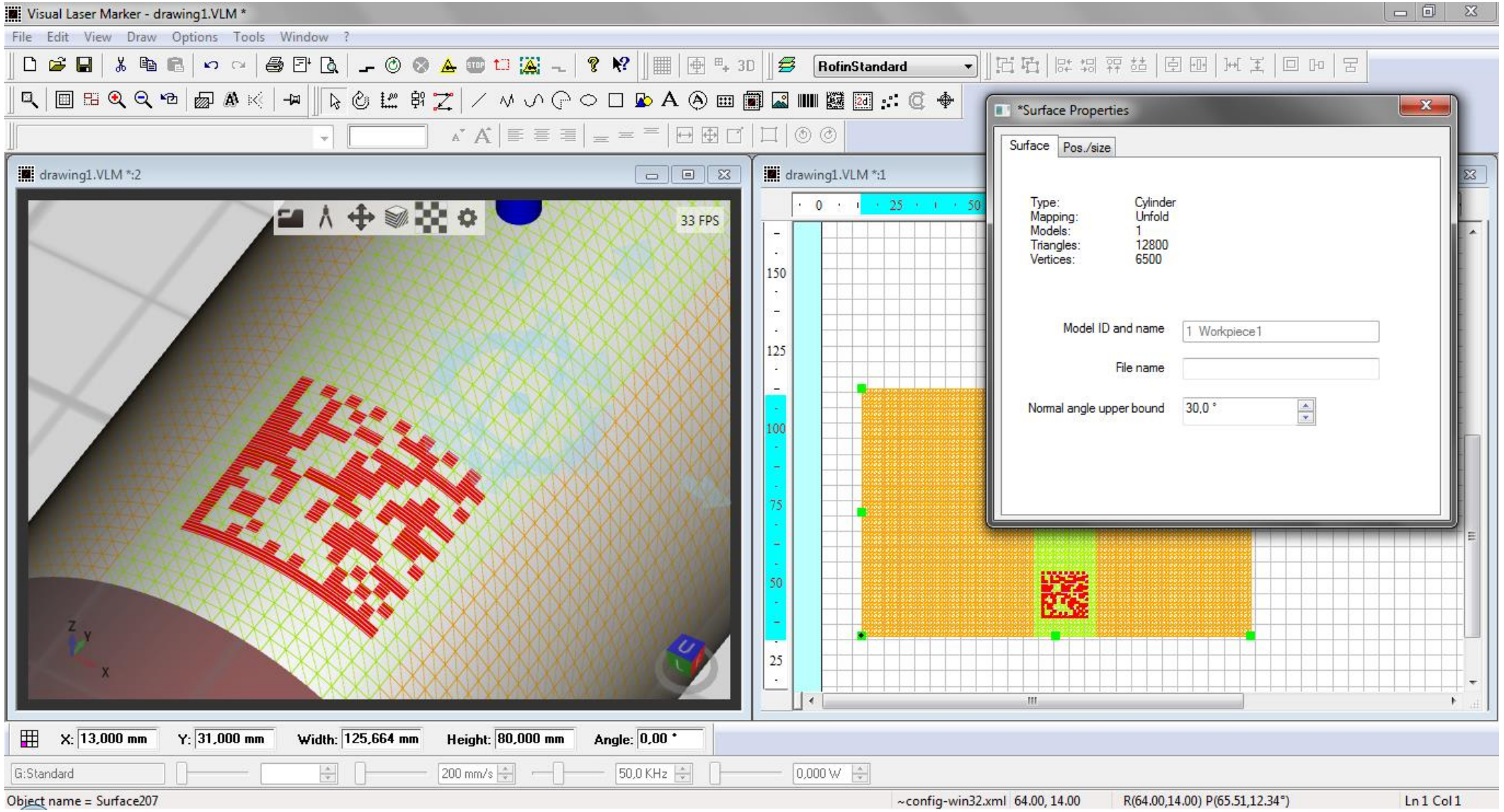


VisualLaserMarker software version 5.3

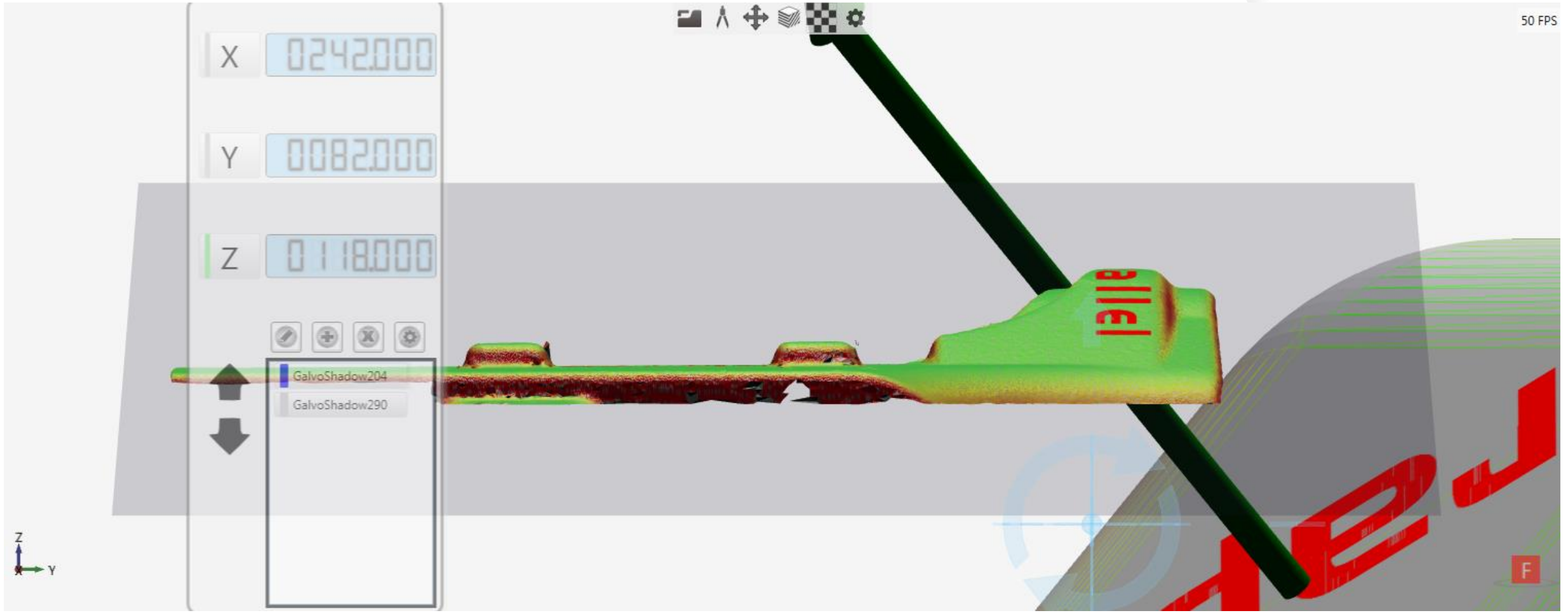
Live preview of part position and marking content



VisualLaserMarker software version 5.3

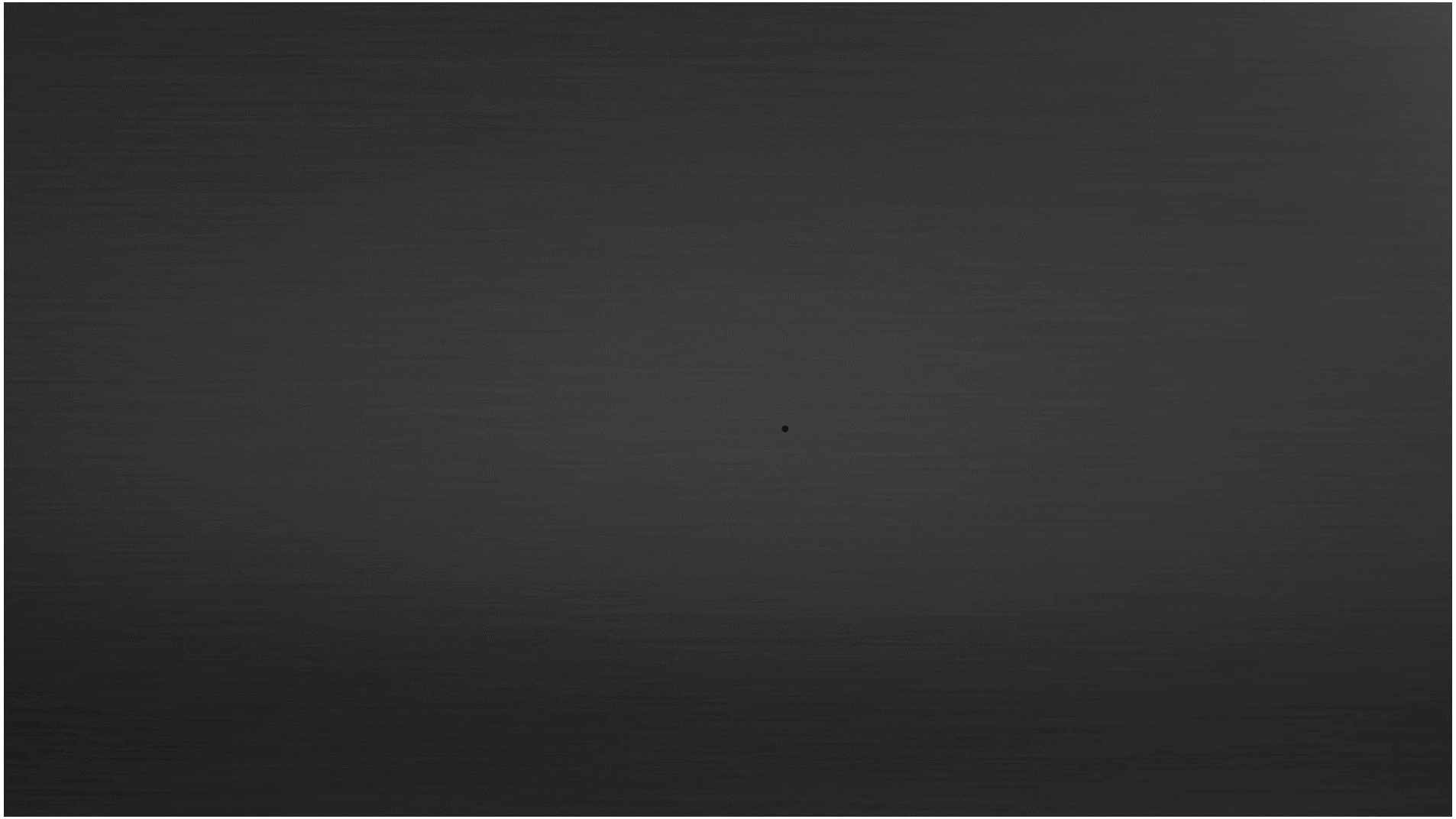


VisualLaserMarker software version 5.3



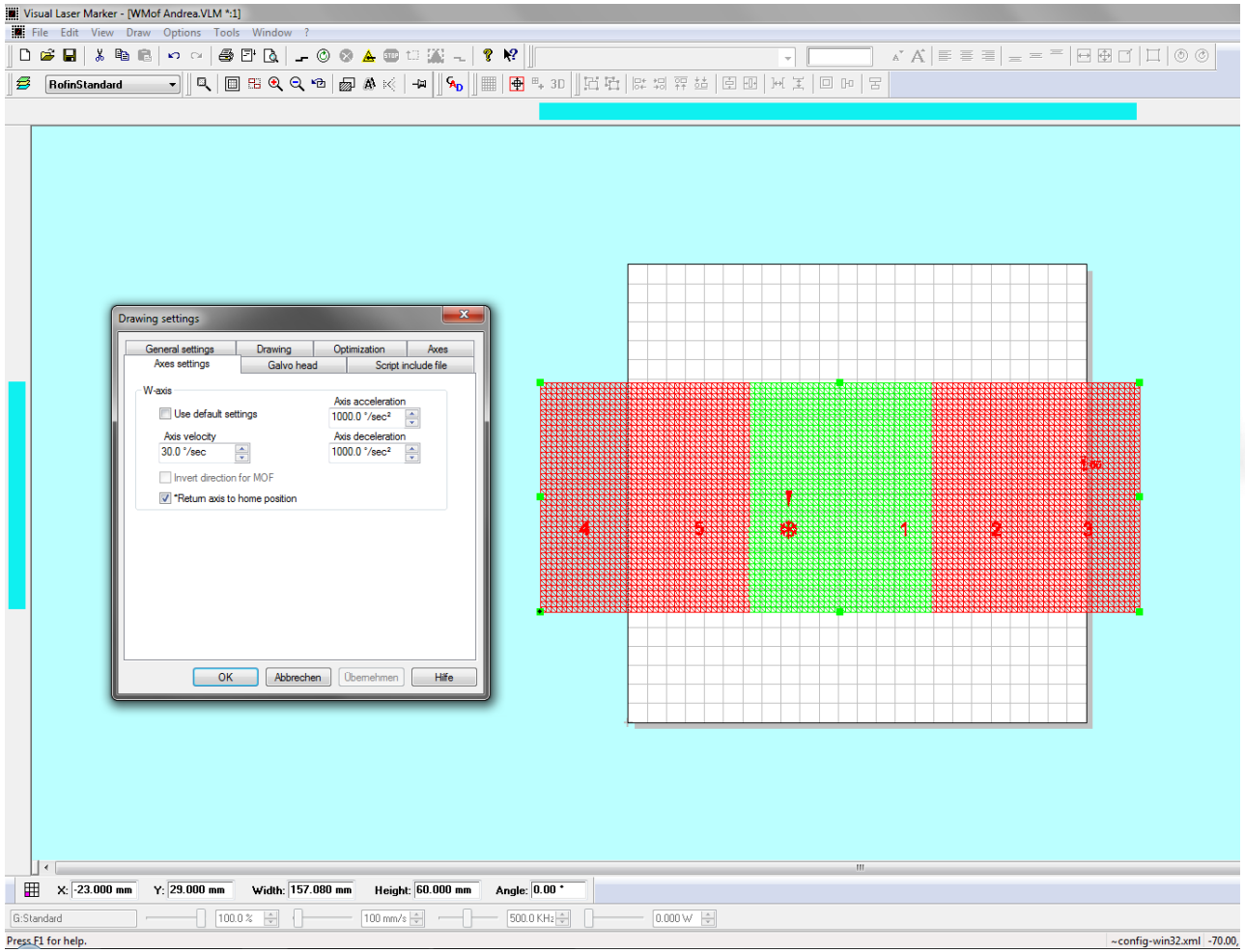
VisualLaserMarker processing of 3D surfaces

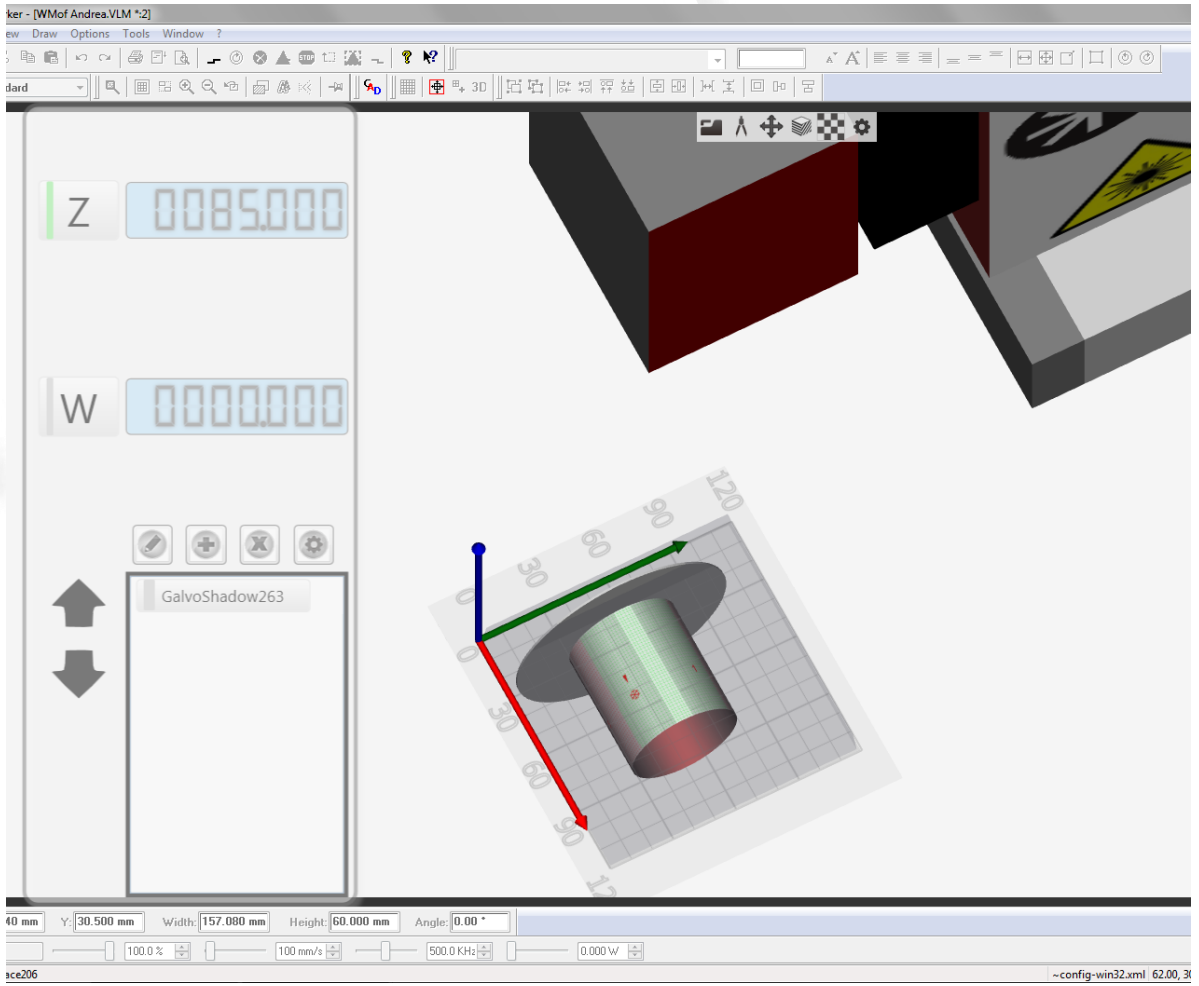
Demonstration of workflow



Marking on the fly in version 5.3

Completely revised user interface for improved usability and simple layout verification



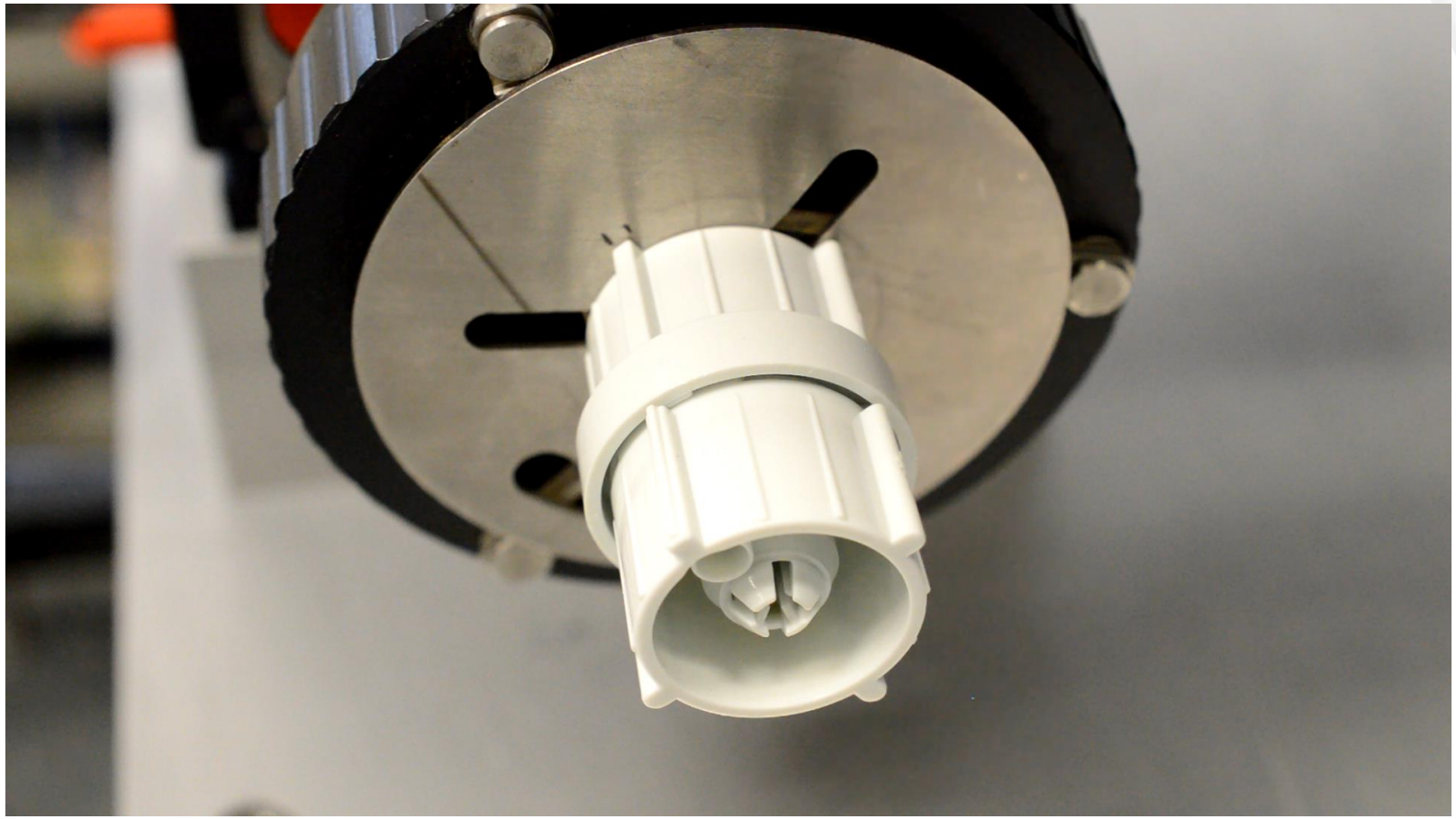


Marking on the fly in version 5.3

Reduced cycle time due to simultaneous rotation and marking…

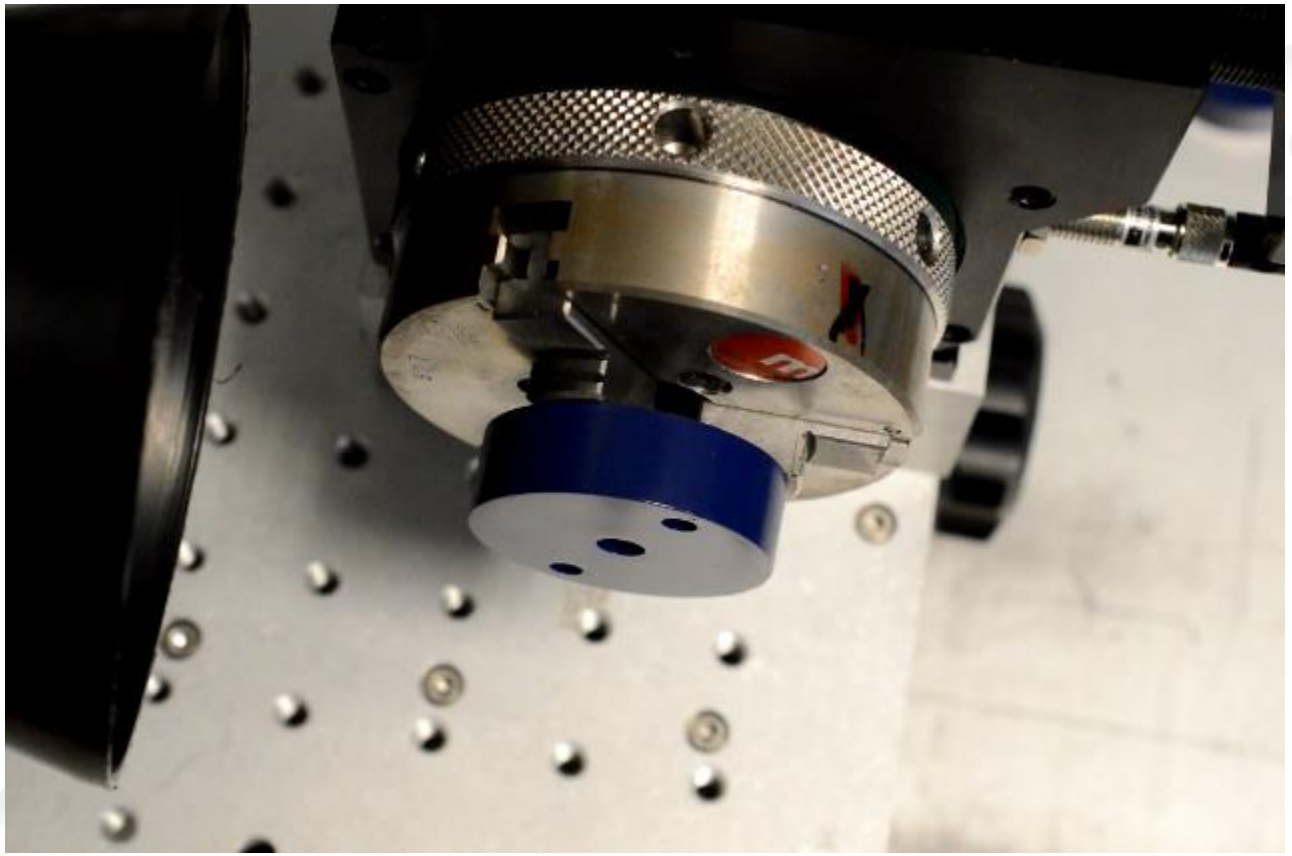
Marking on the fly in version 5.3

…while maintaining the quality



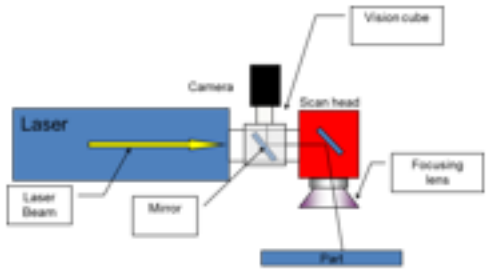
Marking on the fly in version 5.3

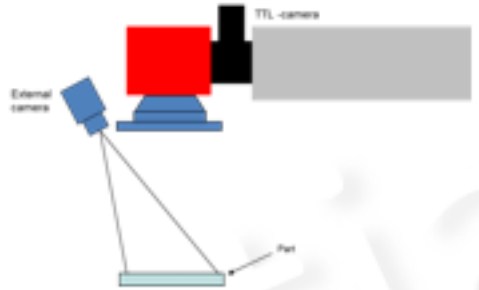
For comparison: classic step and repeat marking



2D/3D Vision Process

2D Vision: Integrated solution available





Vision Systems

Through-the-lens (TTL)

External

Cognex (In-Sight, Dataman

ID, OCR

V60

Alignment

Inspection

ID, OCR

Integrated version*

Alignment

Inspection

ID, OCR

Crosshair

Alignment (manual)

Cognex (In-Sight, Dataman

ID, OCR

V60

Alignment

Inspection

ID, OCR

Integrated version*

Alignment

Inspection

ID, OCR

SmartView

Alignment (manual)

Combination

Combination

*integrated in laser software

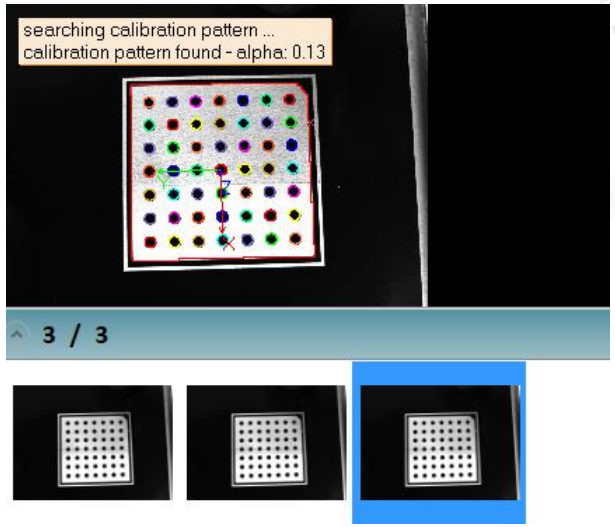
available

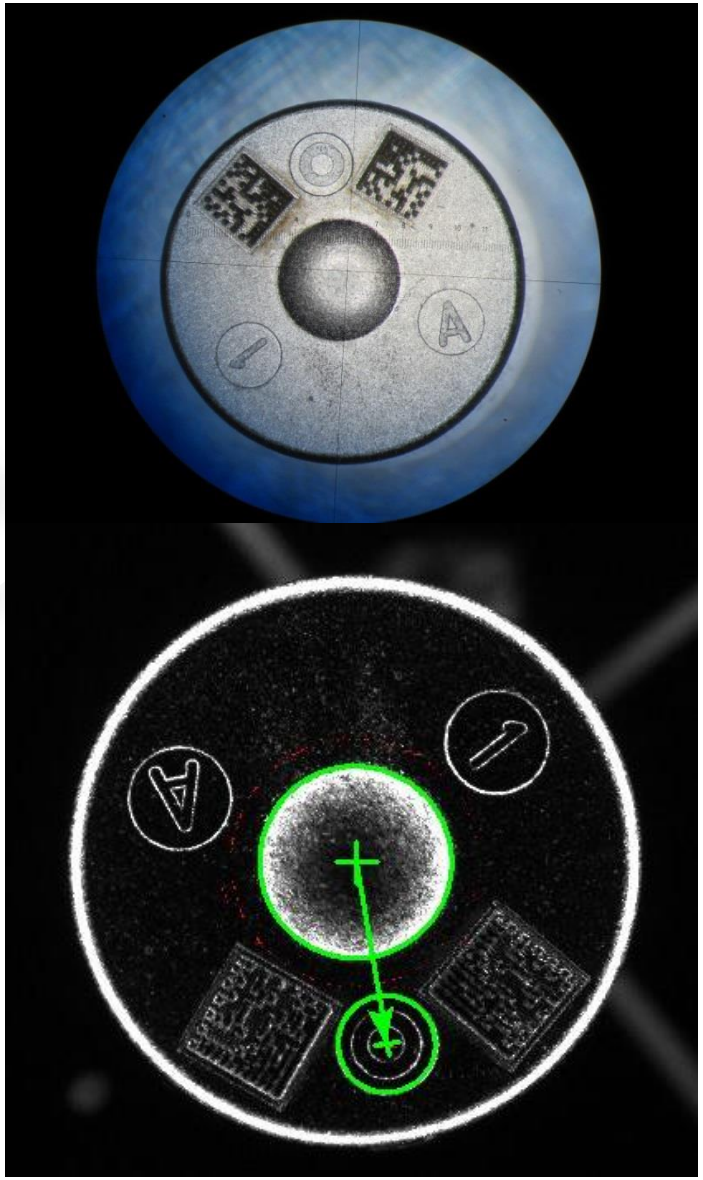
In progress

COHERENT | rofin

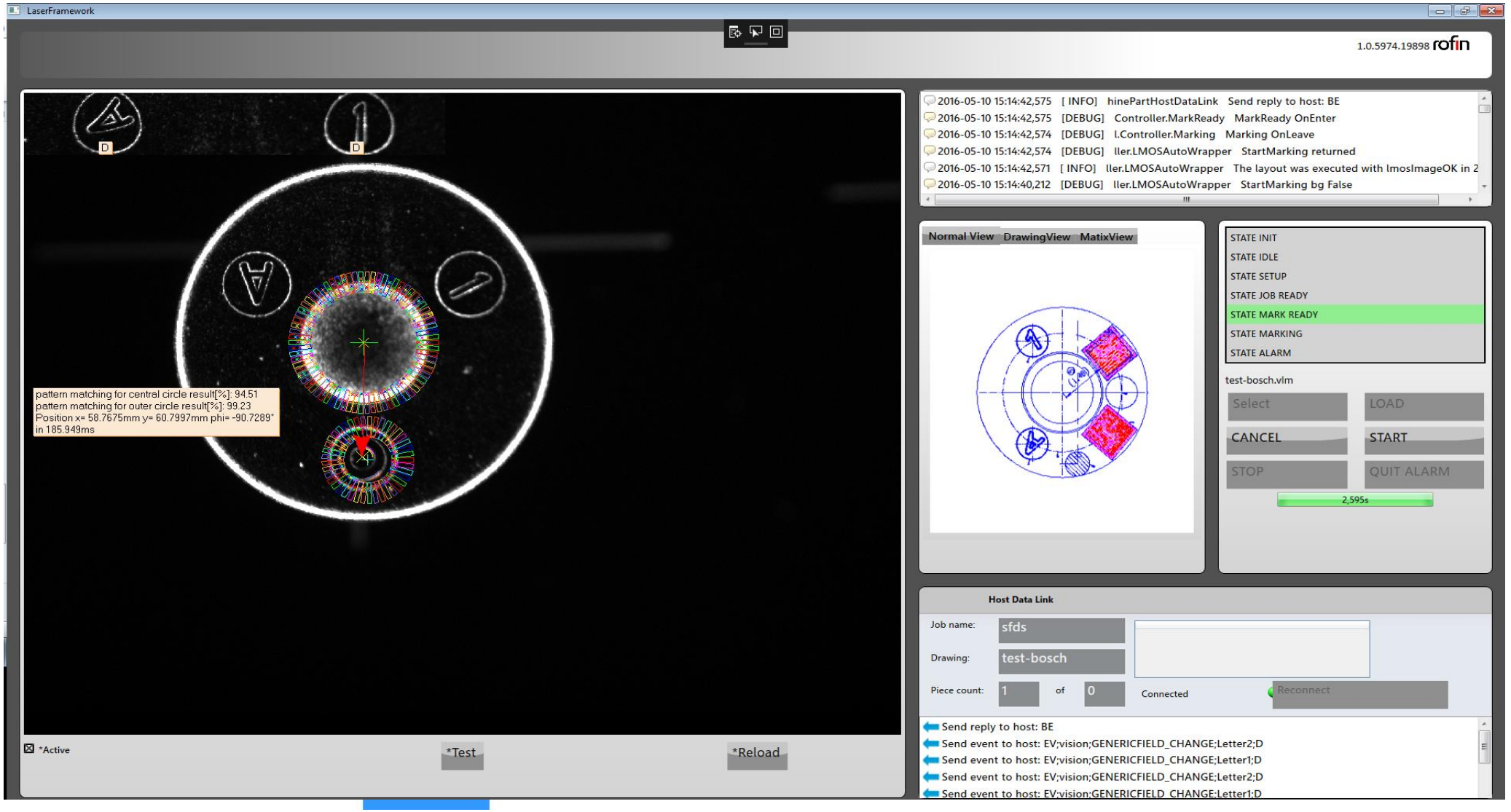
2D Vision: Integrated solution available

- User friendly vision task integration
- For TTL or external camera
- Easy vision task definition
- One software interface for the customer
- No further external tools required
- Includes calibration procedure

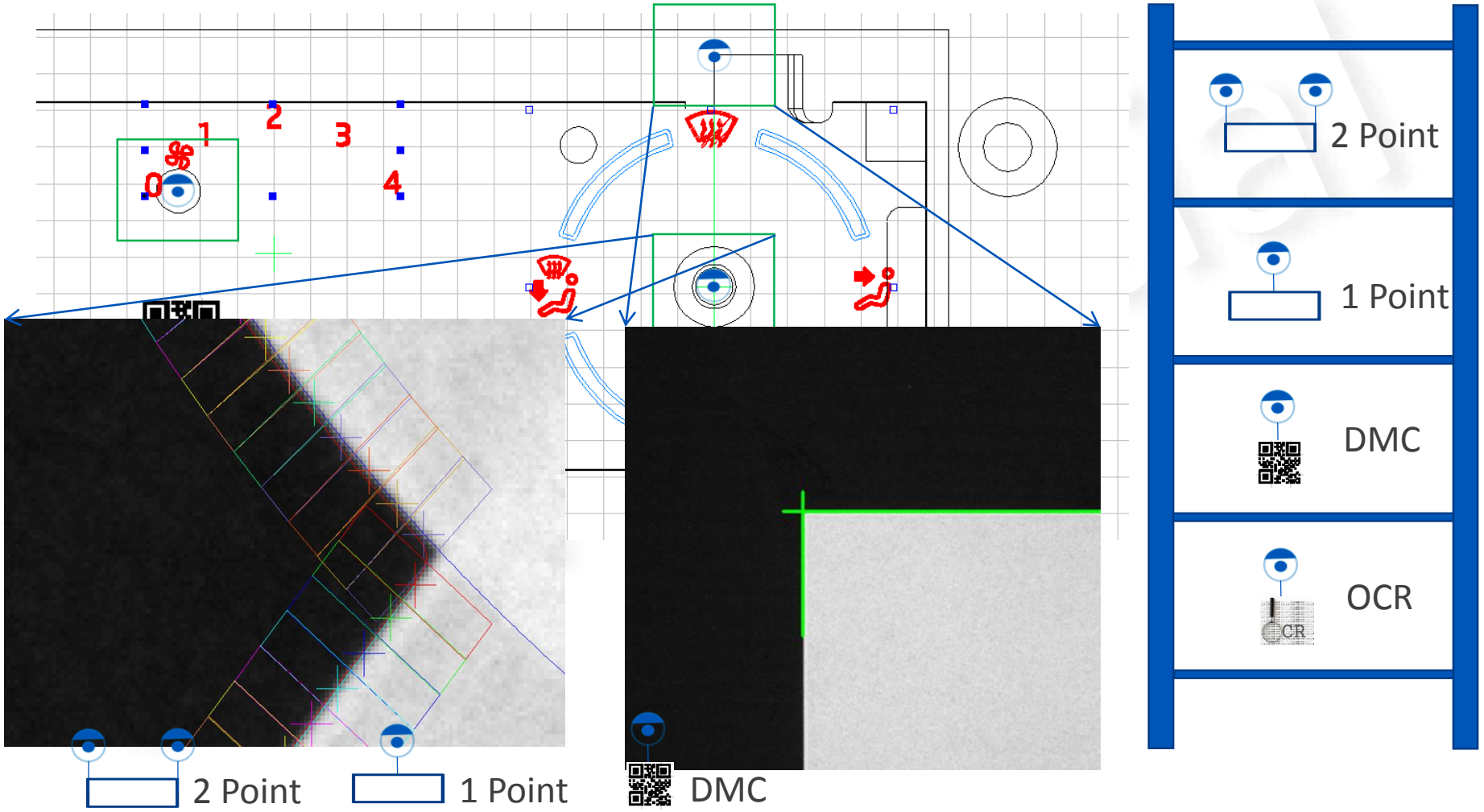




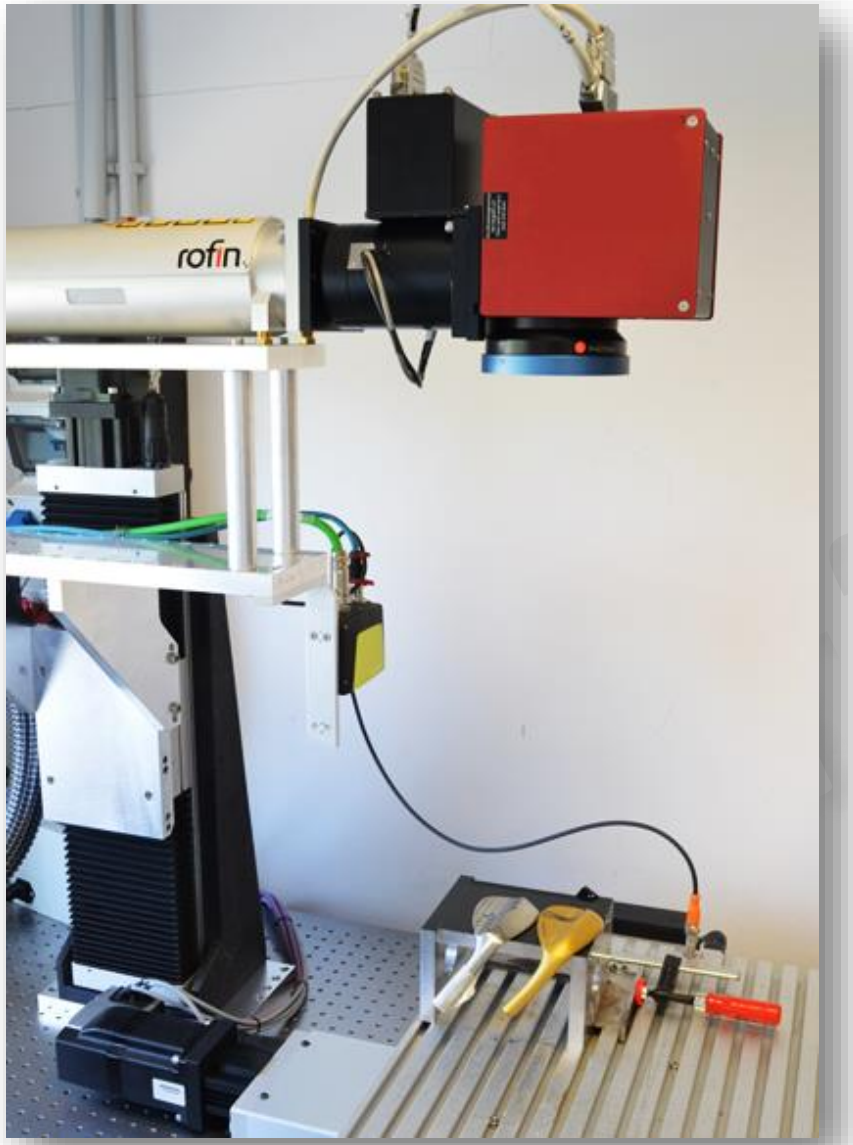
2D Vision: Integrated solution available

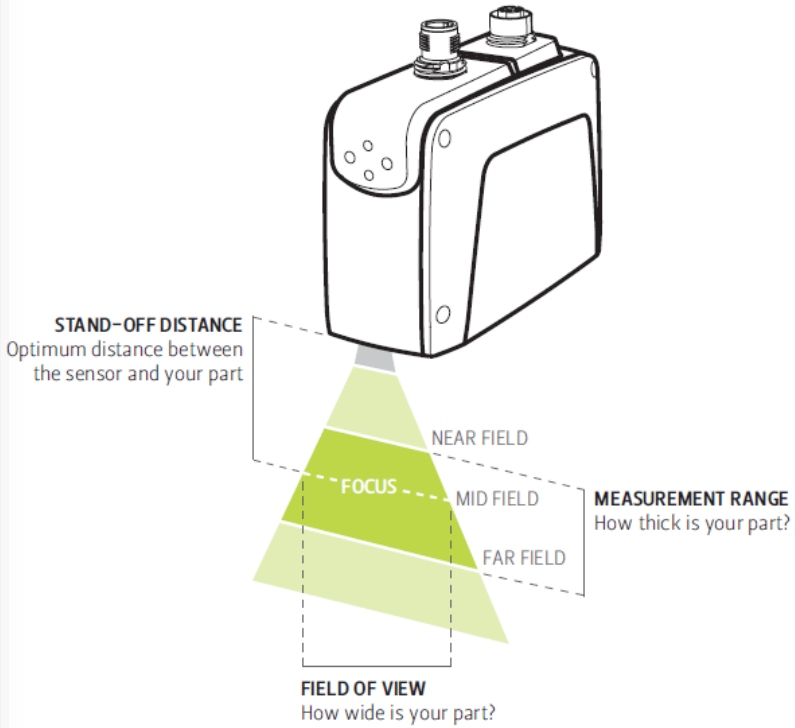


2D Vision: Integrated solution available



3D Vision: Implementation of 3D-scanners in VLM





1920 points @ 100 mm or 36 mm scan width

- Typical scan rate: 150 Hz up to 4 kHz

3D Scanner 100

- scan width: 100 mm
- scan depth: 100 mm
- stand-off dist.: 150 mm
- lateral resolution: 56 um
- vertical resolution: 8.5 um

3D Scanner 30

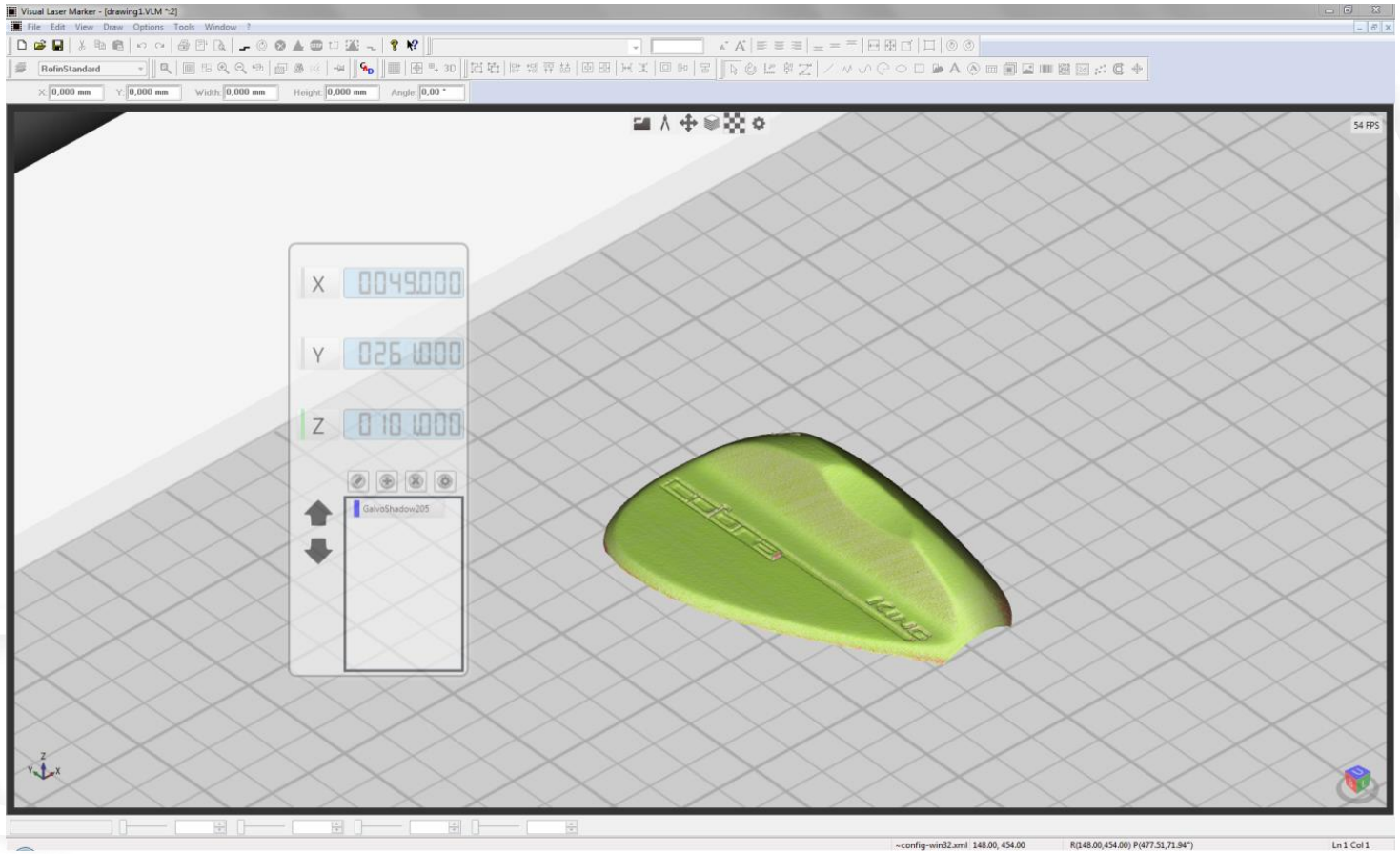
- scan width : 36 mm
- scan depth : 16 mm
- stand-off dist.: 60 mm
- lateral resolution : 19 um
- vertical resolution : 1.6 um

660nm or 450nm scanner wavelength

Image: Smartray

3D Vision: Implementation of 3D-scanners in VLM

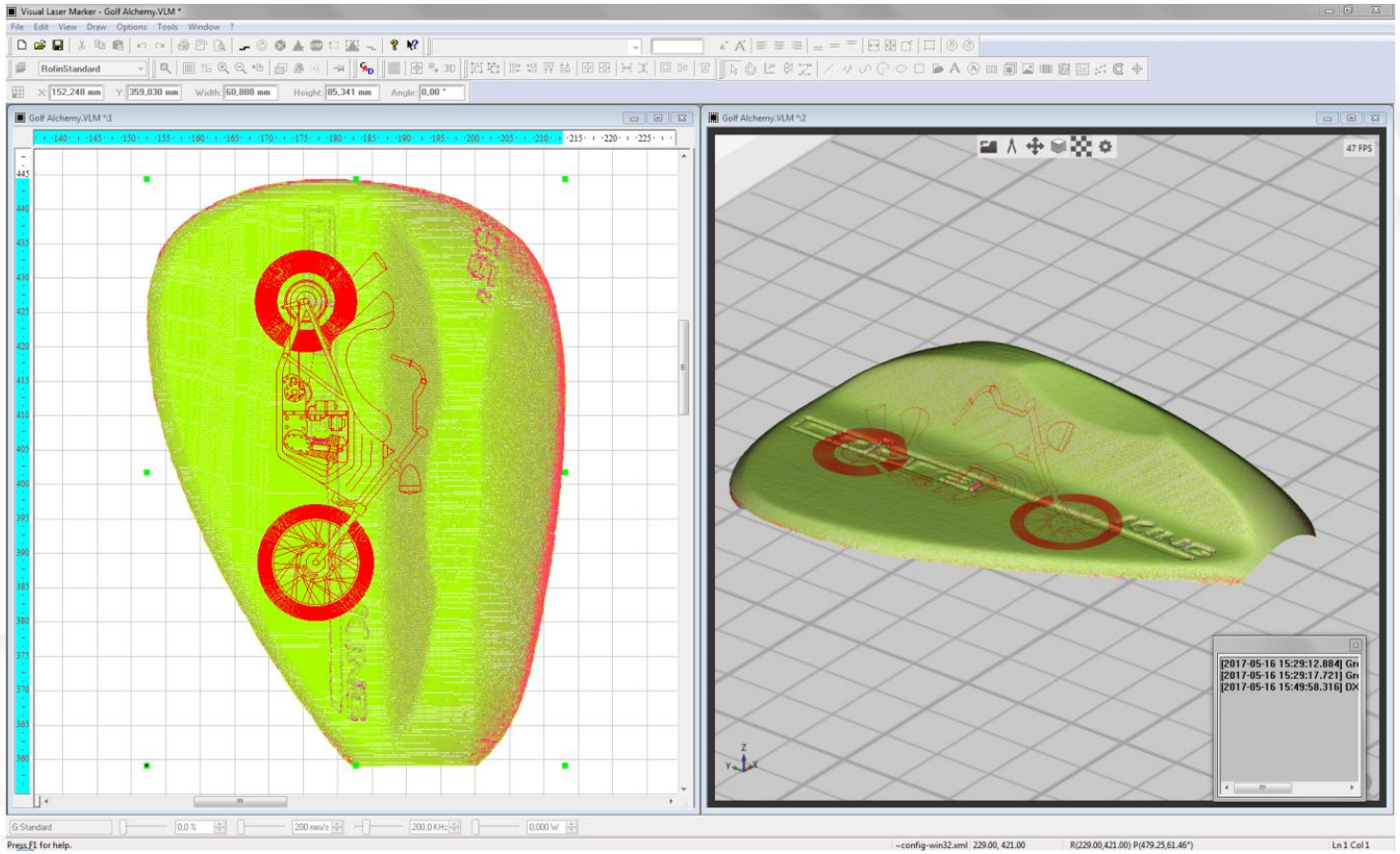
Capture and import 3D point cloud into VLM



A visualization of the 3D workspace allows proper positioning of available axis. The z-range of an FFM is superimposed to show coverable areas. A false color image shows the angle of incident of the laser beam to the surface of the workpiece.

3D Vision: Implementation of 3D-scanners in VLM

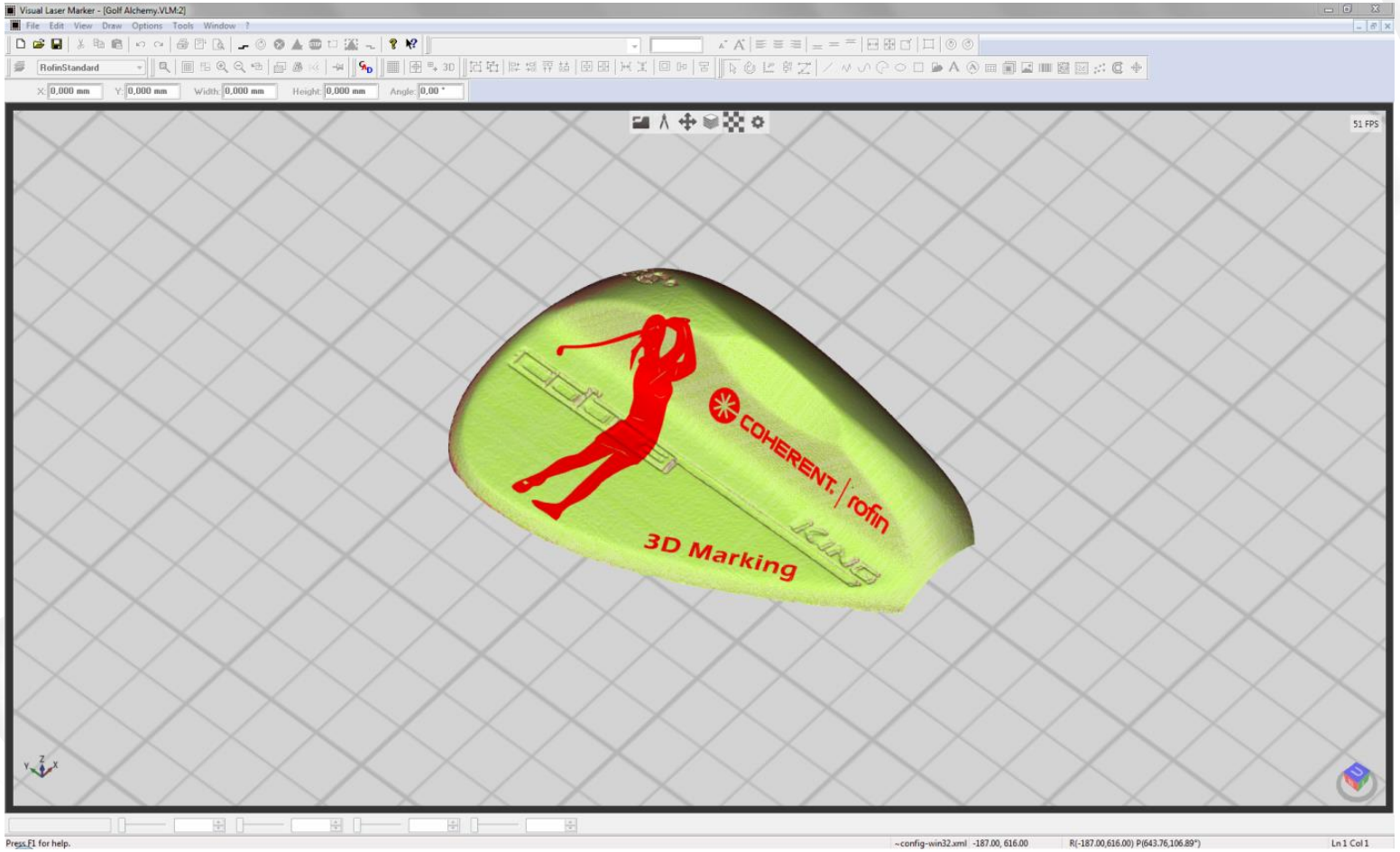
Capture and import 3D point cloud into VLM



A visualization of the 3D workspace allows proper positioning of available axis. The z-range of an FFM is superimposed to show coverable areas. A false color image shows the angle of incident of the laser beam to the surface of the workpiece.

3D Vision: Implementation of 3D-scanners in VLM

Add drawing content to surface, laser mark



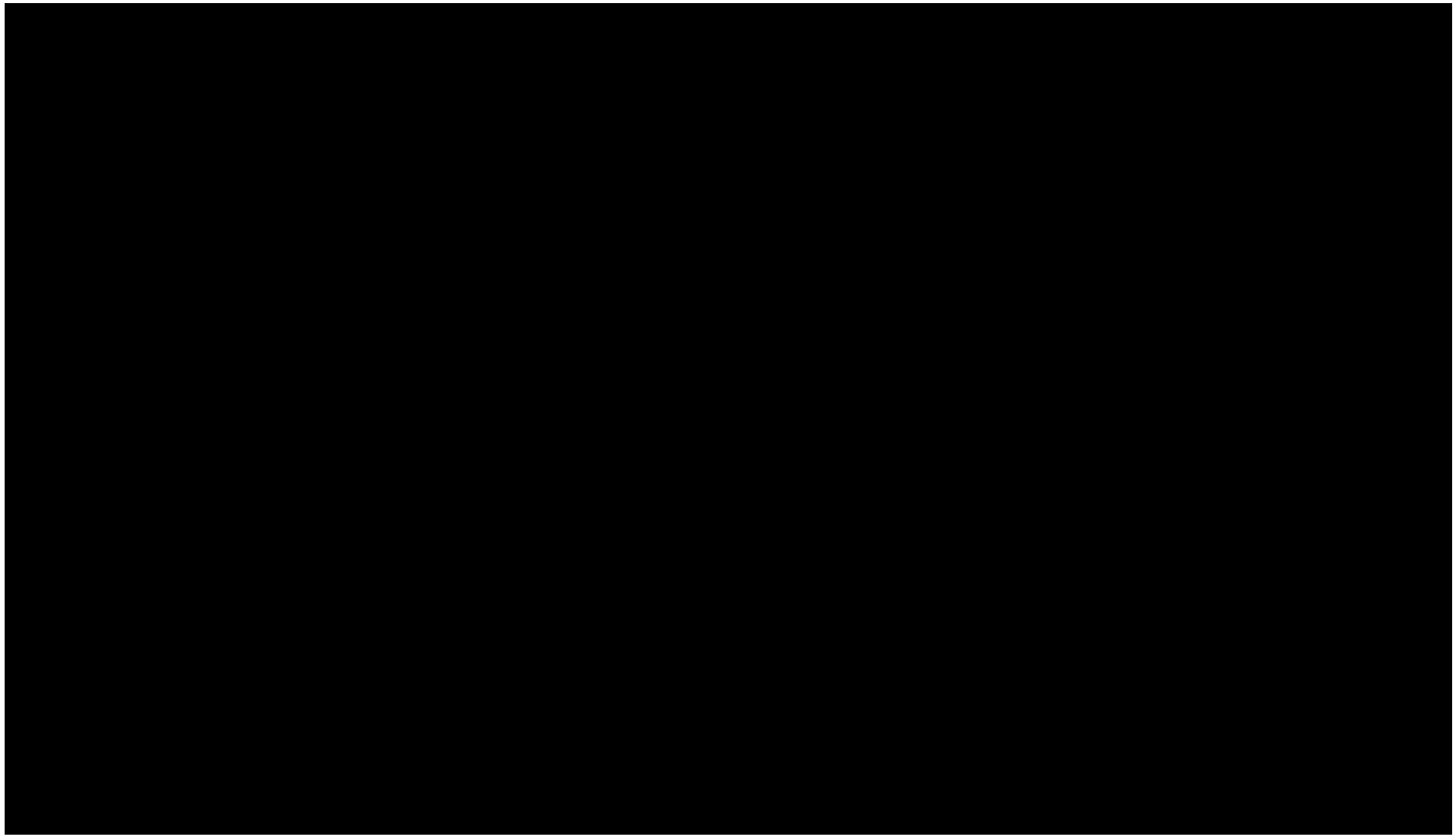
The marking content is then attached to the 3D workpiece, a real time preview allows easy placement of drawing elements.

3D Vision: Implementation of 3D-scanners in VLM

Add drawing content to surface, laser mark

The marking content is then attached to the 3D workpiece, a real time preview allows easy placement of drawing elements.

3D Vision: How-to VLM demo



www.coherent.com

www.rofin.com