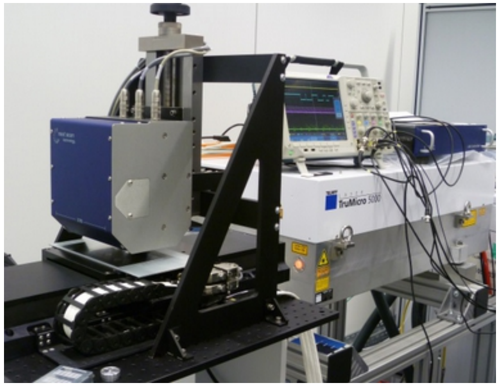
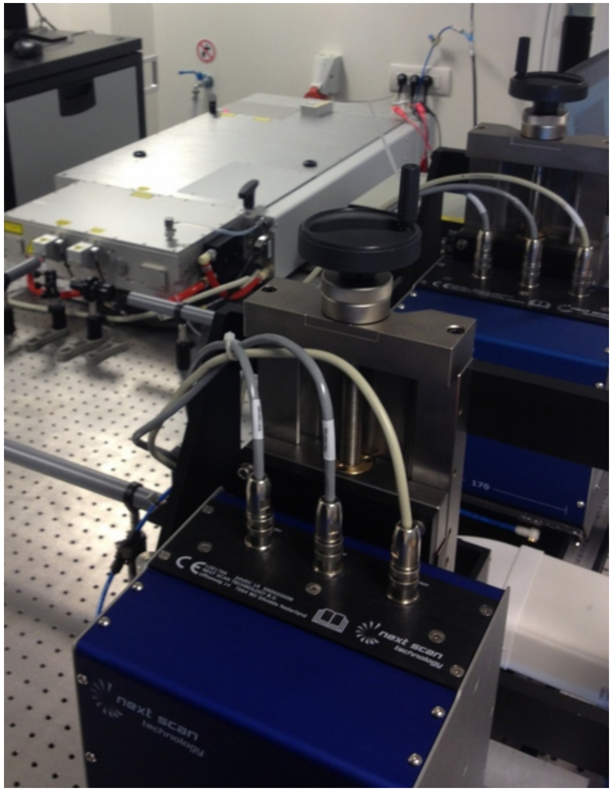
Polygon Scanners – Capabilities, Applications and System integration considerations

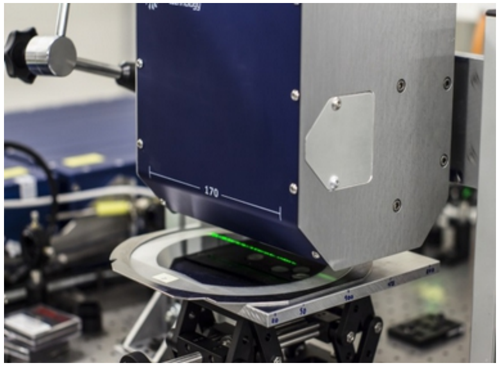
Lars Penning

CEO Next Scan Technology

Innovating and leading polygon scanner technology





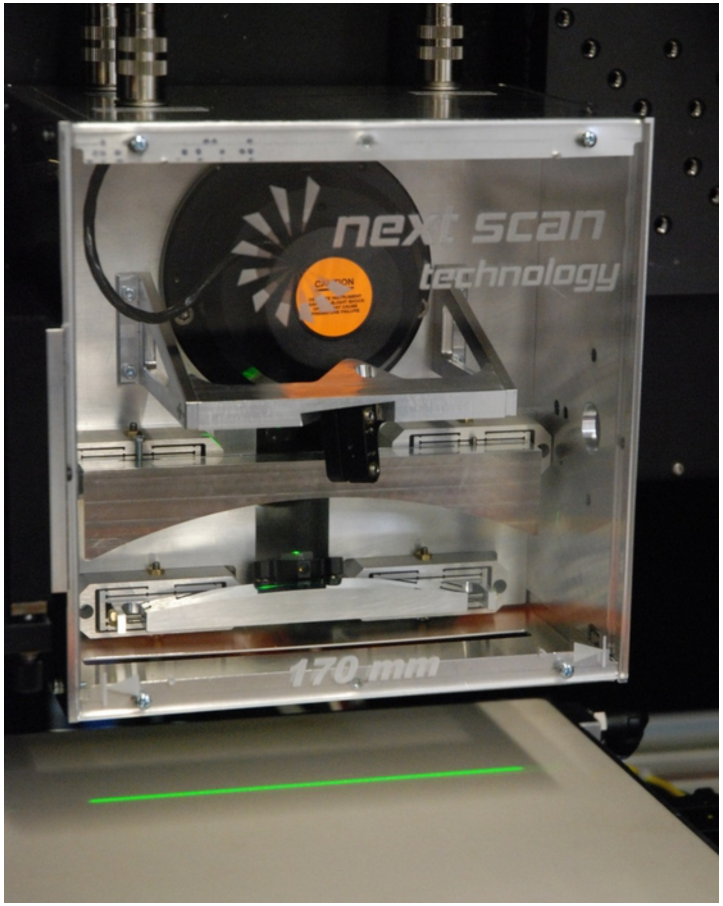


Introduced polygon scanner system at WOP11

Next Scan Technology was the first to introduce polygon based scanner systems to the laser micro-machining market.

Technology is similar to desktop laser printers, however, tailored for:

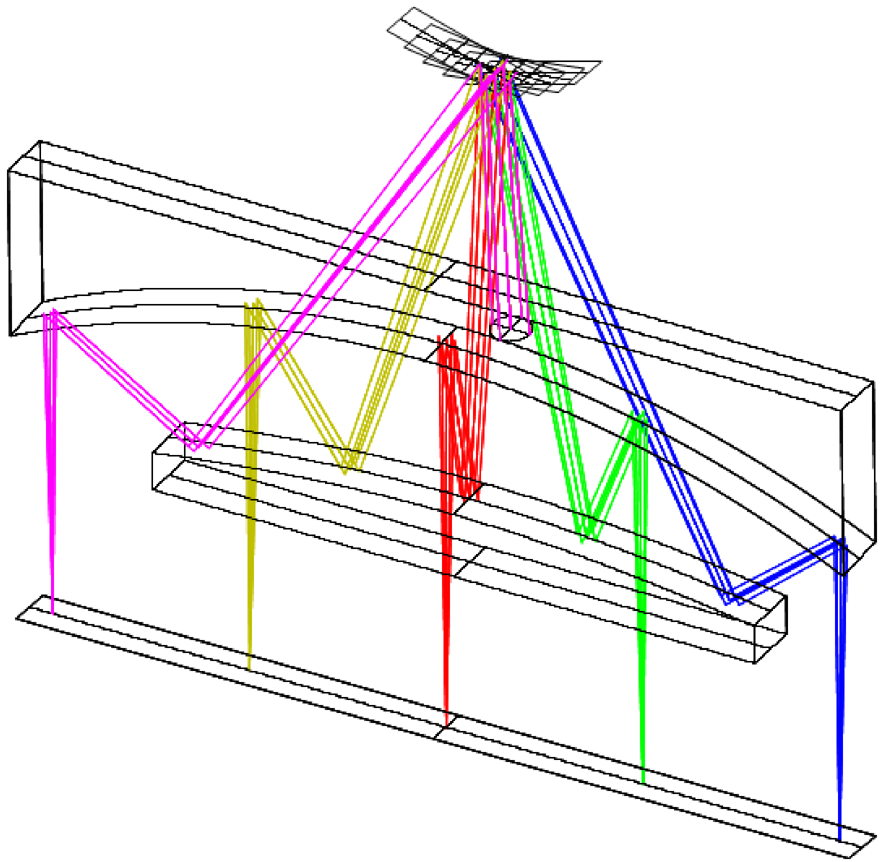
- **Very high laser pulse power handling**
- **Very high resolution and accuracy**
- **High quality spot size**
- **Sophisticated USP laser/scanner synchronisation**



Patent pending two mirror optics

- **Dual wavelength coating both IR and GR wavelengths, or specific UV version.**
- **High precision optics, very low distortion, line straightness ± 10 µm**
- **Constant round spot size along scanned path down to 8 µm @ 355 nm**
- **Full telecentric up to 300 mm**

⇨ Constant material-light interaction



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Next Scan Technology 2013:

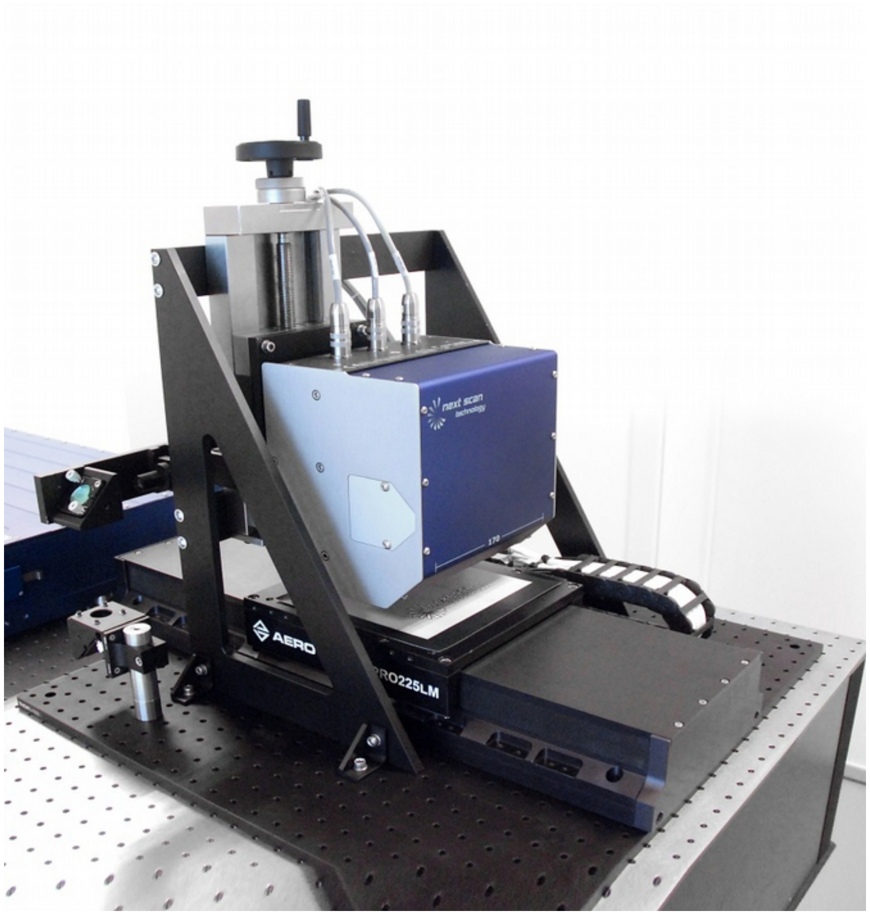
Commercial release LSE170

First commercially available polygon based scanner system on the market.

One box pre-aligned optical system.

Laser scan controller for easy integration by integrators and machine builders.

Proces Development kit for instant process development start.



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Introduction LSE170HNA and LSE300

LSE170 HNA

- **170 mm scan width**
- **Half the spot size of LSE170**

LSE300

- **300 mm scan width**
- **Same spot size as LSE170**

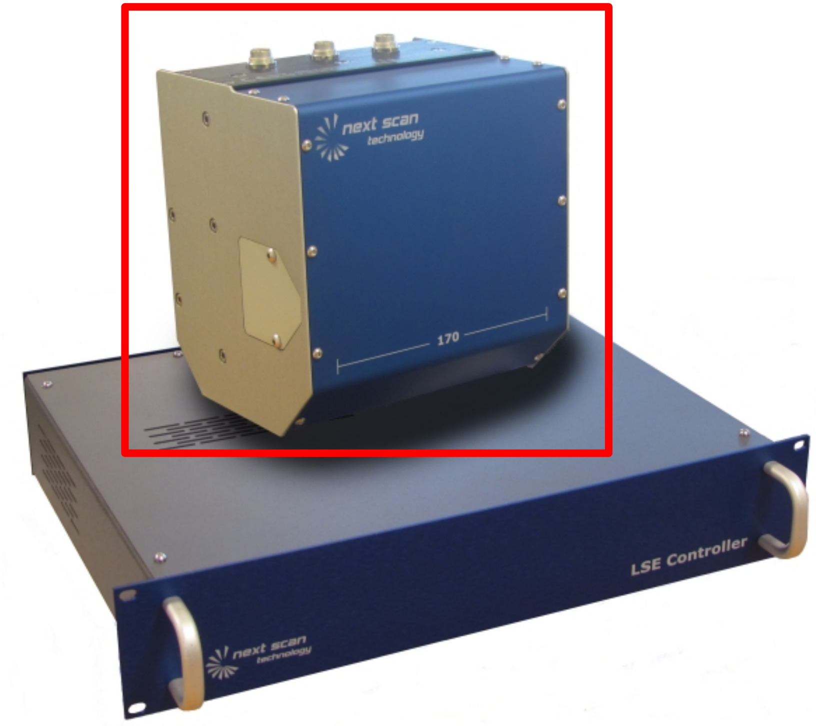
Both systems can be delivered with

SuperSync and TrueRaster options.

Polygon scanner system – two parts

LSE scanner head

- Polygon and drive motor
- Input beam shaping optics
- Telecentric f-theta optics



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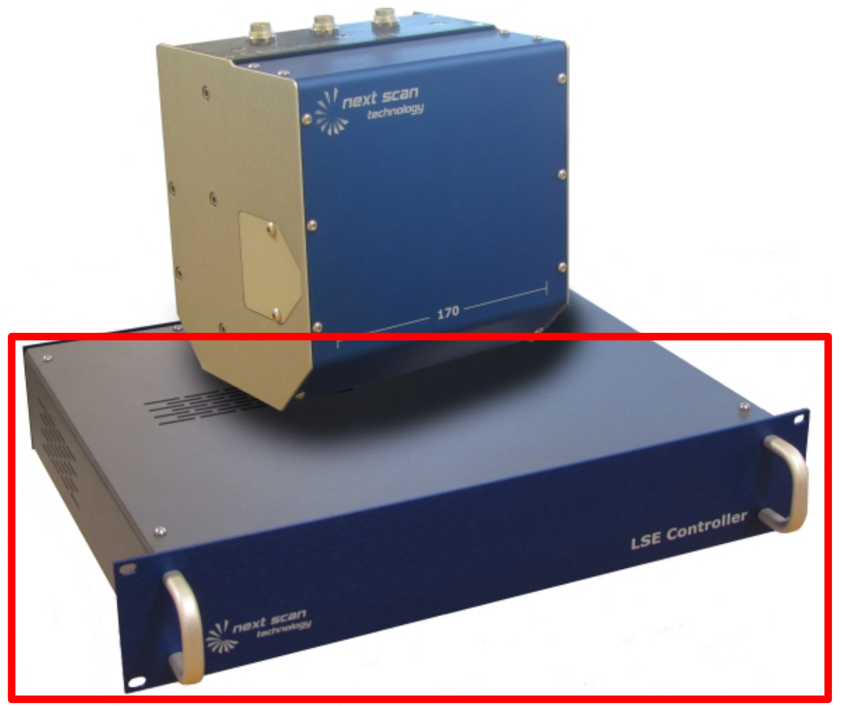
LSE controller

- **Polygon speed control**
- **Ethernet communication port**
- **Linear transport interface**
- **Laser (SuperSync) interface**



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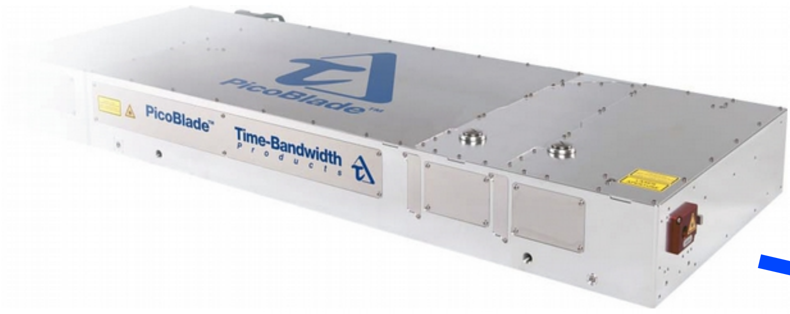
Typical set-up

CW or nano-,pico- or femtosecond pulsed laser source



LSE controller synchronises laser, scanner, stage and pattern data transfer

Scribe data stream

Stage or R2R by customer

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Vector versus Raster scanning

Vector scanning

- Beam path fully programmable in 2D
- Scan speed may vary along path
- Mechanical start/stop per vector, speed is inertia limited, low inertia mirrors required
- Can be programmed in raster mode
- Processing time depends on nr of features

Often best fit for line mode patterns

Limited in speed

Raster scanning

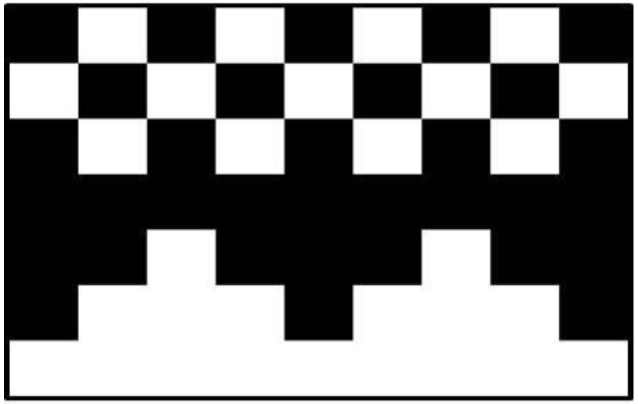
- Beam path is a semi fixed line pattern
- Scan speed is constant along path
- Constant motion device, high inertia needed for constant speed
- Hardware implementation of raster scan mode
- Fixed processing time but complexity for free

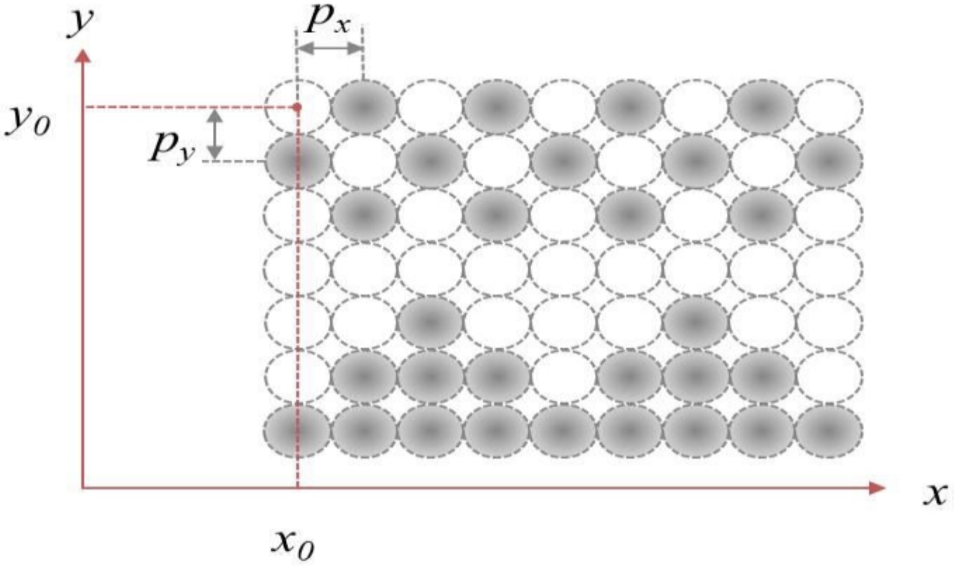
Best for dense patterns

High writing speeds possible

Laser pulse on grid position is controlled by monochrome bitmap

- Each laser pulse will be positioned on a pre-determined position which is the (user programmable) grid
- A rectangular region (bitmap, white is laser pulse) is formedby equally spaced parallel lines (line spacing)





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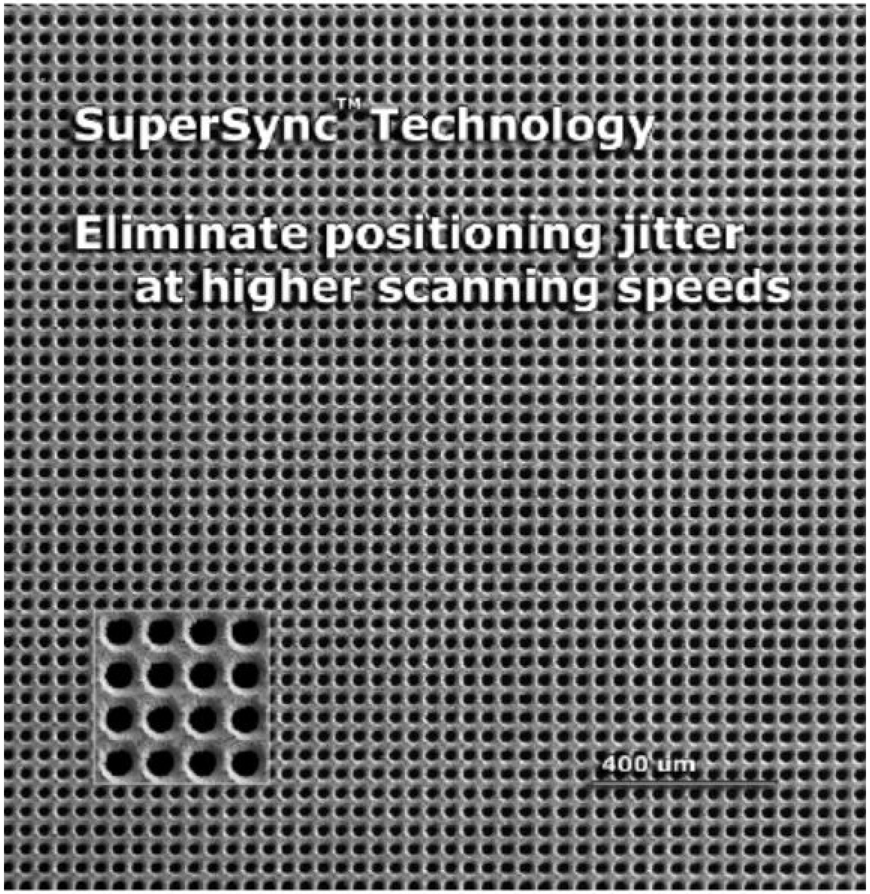
Percussion type drilling at very low 'pulse' rate

- **Scan speed to separate the holes**
- **Application example**

  - 400 Khz PRR
  - 250 um spot spacing through
    100 meters/sec is 400 lines/sec
  - 100 passes per hole is 4 lines/sec
  - 170 mm board is 600 holes per line

> 2.000 holes per second

Works with lower rep-rate lasers !



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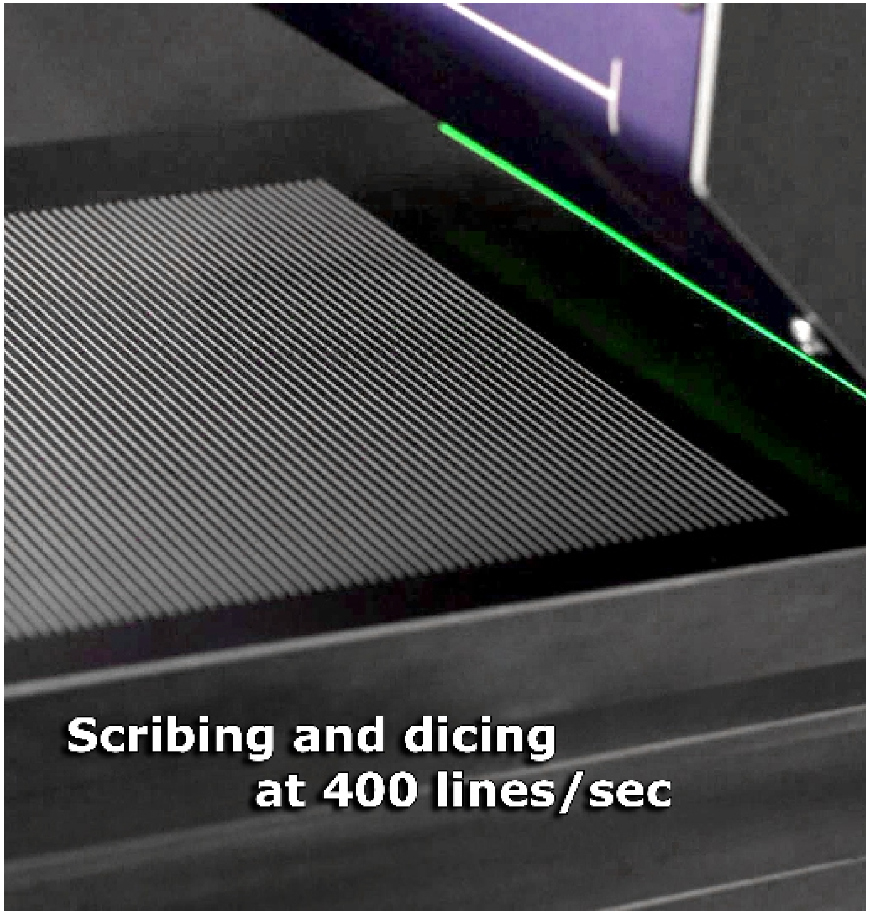
Scribing, grooving and dicing

- **Speed set by PRR and spot spacing**
- **Linear stage in stepping mode or moves at constant speed.**

Application example

- 2 MHz PRR
- 25 um spot spacing
- 50 meters/sec (200 lines/sec)
- 40 passes/kerf
- 3 kerfs/second



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Surface texturing

Apply any texture in same time!

- **100 meters/sec is 400 lines/sec**
- **Linear speed stage is 1 cm/s at 25 um**
- **Surface speed is 17 cm²/sec at 4 MHz**
- **Multi-pass for 'deeper' structures**

Applications:

- Thin film patterning
- High density marking
- Volume ablation (holes/slots/pockets)
- Additive printing (LIFT, STL)
- Laser cleaning/annealing

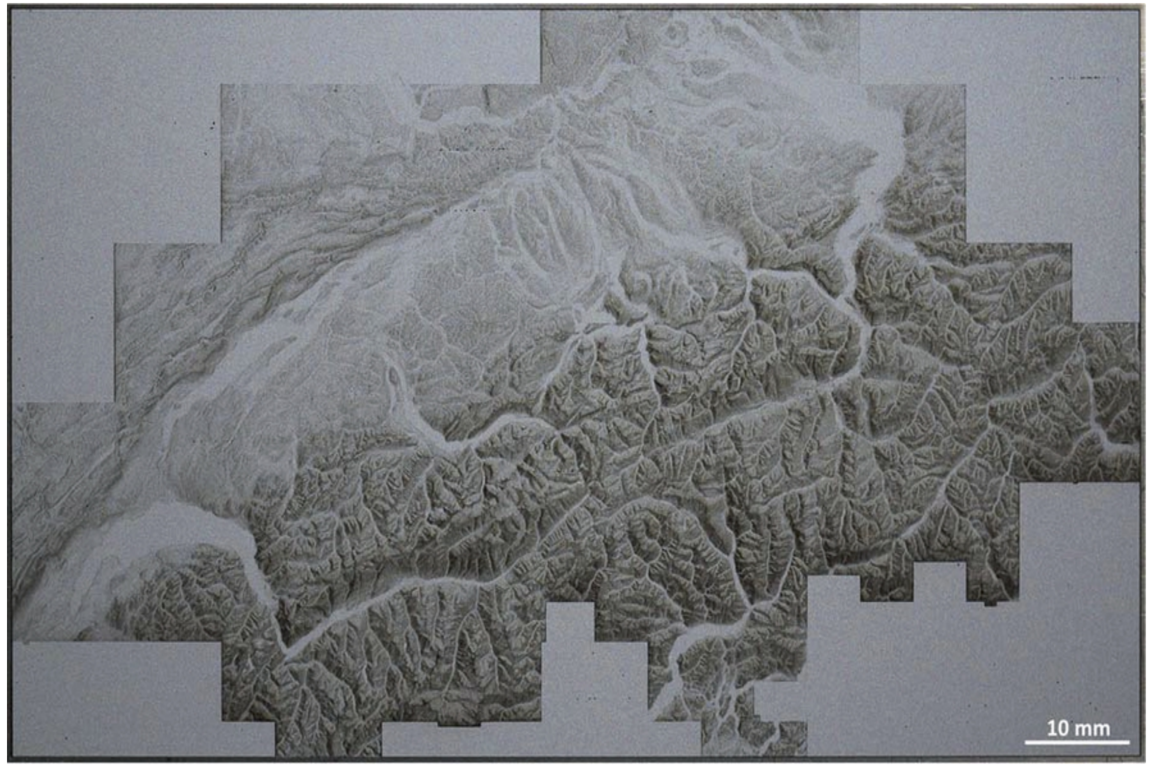
Stainless steel engraving

This work was supported by the

FP7 project APPOLO

Bern University of Applied Sciences

B. Neuenschwander/B. Jäggi/M. Zimmerman



Dimensions 108 x 65 mm

14.5 um spot spacing (1.750 dpi)

4.1 MHz rep-rate*- 25.6 W

Scan speed 59,5 m/s

24 seconds per layer

2233 layers

Scanning strategy: start point dithering/averaging

Maximum depth about 100 um

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Modularity: only add the complexity on a real need basis

Do I need Laser pulse synchronisation?

What if my laser's rep rate laser is too low ?

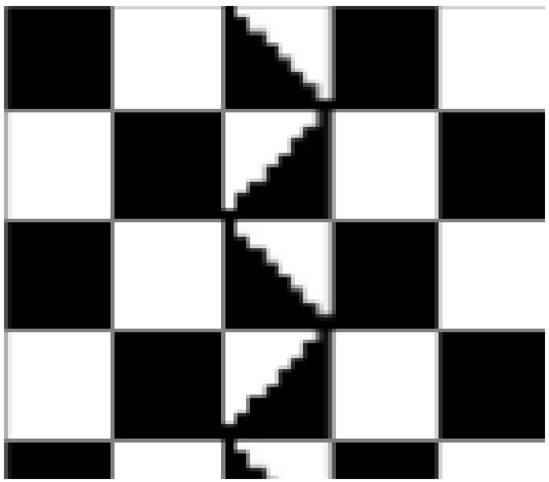
Do polygon facet errors harm my application ?

Repeatability is not enough, I need higher accuracy !

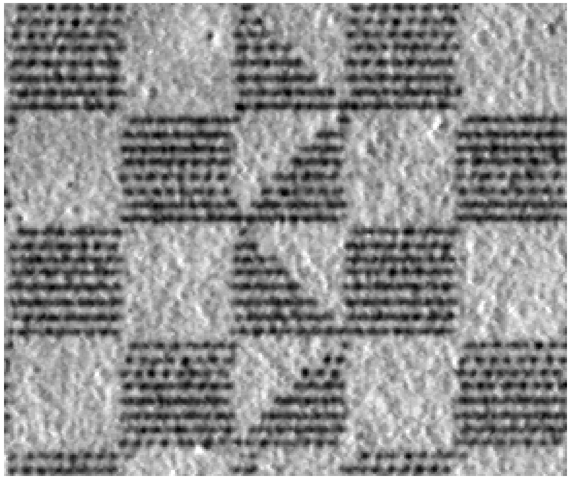
Proprietary SuperSync technology realises repeatable dot position

1 MHz @ 100 m/s scan speed is a 100 µm spot positioning error !!!

- **SuperSync laser/scanner electronic synchronisation reduces jitter to few microns.**

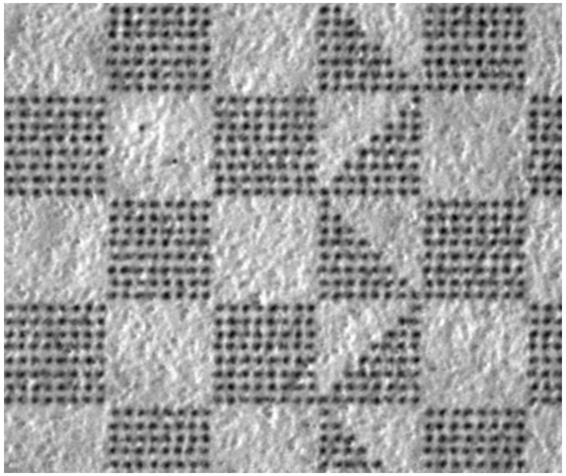


Bitmap pattern



No SuperSync™

Multi-pass operation at 100 m/s (10 passes)



SuperSync™

Multi-pass operation at 100 m/s (10 passes)

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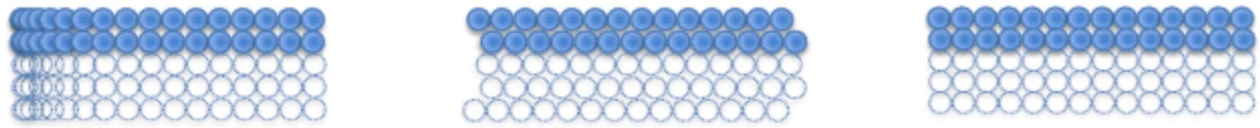
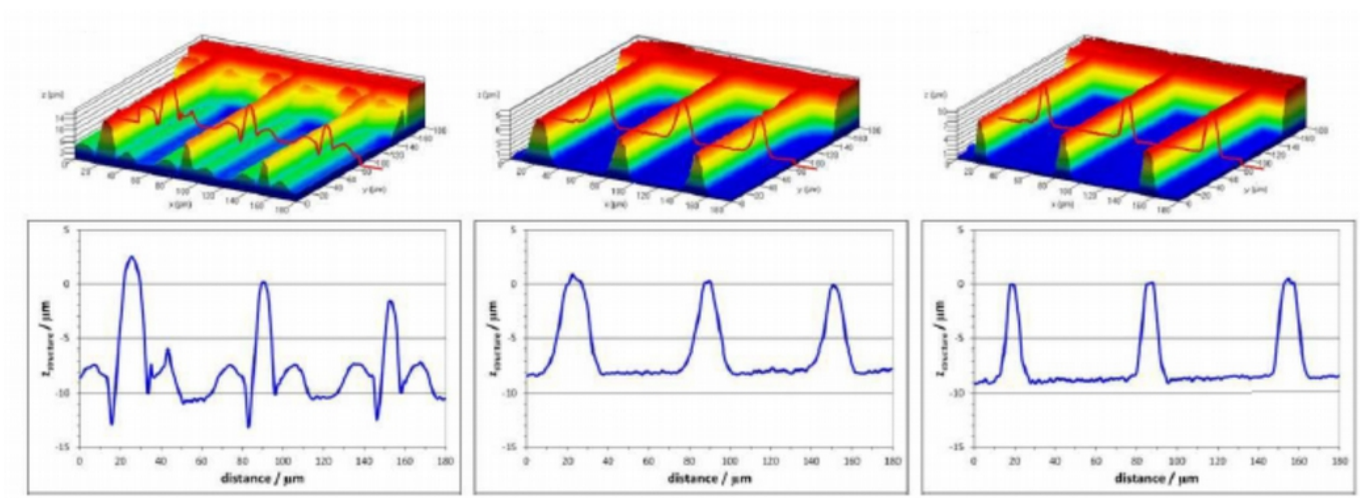
Processing quality versus laser/scanner synchronisation

"acceleration" problem | Sky writing | Synchronized



Uncontrolled processing quality at ramp up/down	**Improved quality at constant speed with existing timing jitter**	**Highest quality at constant speed through eliminated timing jitter**



Courtesy Bern University Applied Sciences: Research by B. Neuenschwander/B. Jäggi/M. Zimmerman

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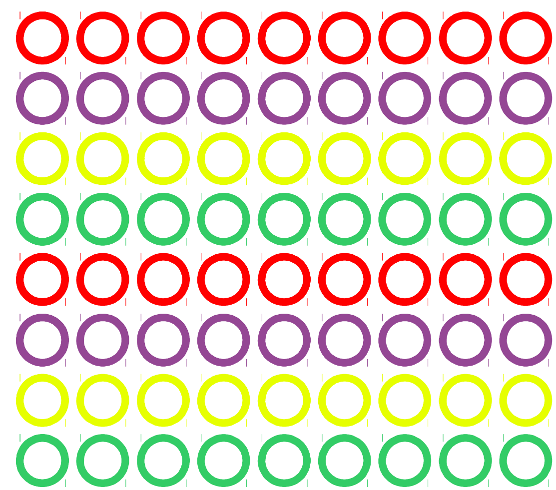
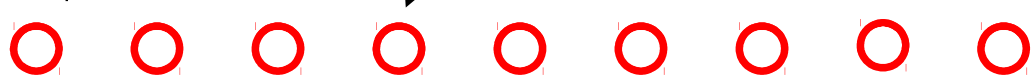
Dot interleaving mode

- **In dot-interleaving mode, the spot spacing is larger than the spot size (no overlap), so no heat accumulation**

Bitmap data:



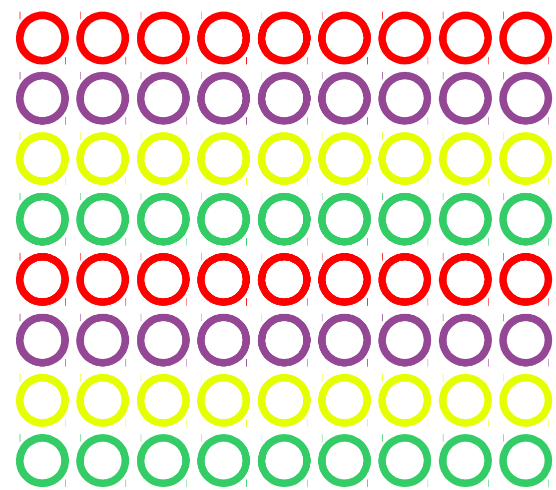
Scribed line pattern:



Dot interleaving mode

- In dot-interleaving mode, the spot spacing is larger than the spot size (no overlap), so no heat accumulation
- Successive lines in the bitmap are used to fill the gap between the laser pulses of the former passes.

Bitmap data:



Scribed line pattern:

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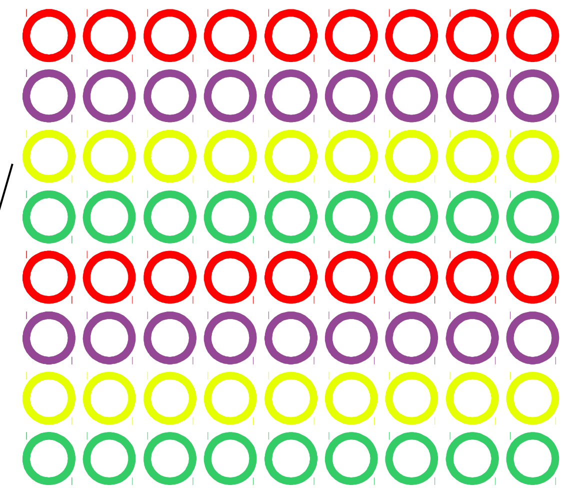
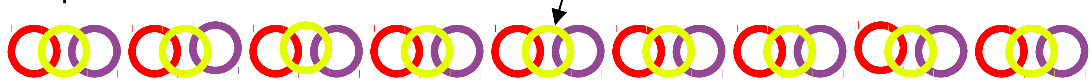
Dot interleaving mode

- **In dot-interleaving mode, the spot spacing is larger than the spot size (no overlap), so no heat accumulation**
- **Successive lines in the bitmap are used to fill the gap between the laser pulses of the former passes.**
- **Overlapped regions are scribed with minimal one scan line time spacing**

Bitmap data:



Scribed line pattern:



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Dot interleaving mode

- In dot-interleaving mode, the spot spacing is larger than the spot size (no overlap), so no heat accumulation
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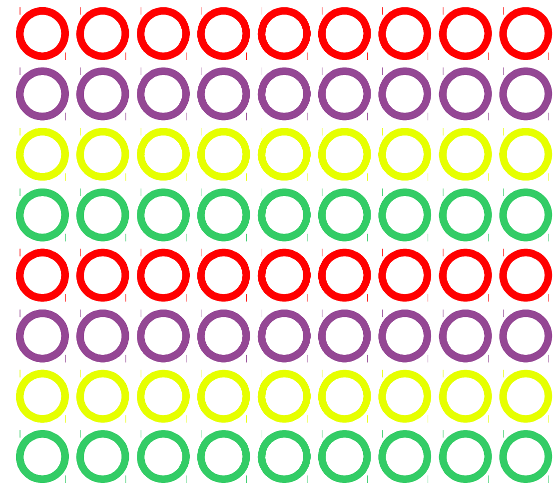
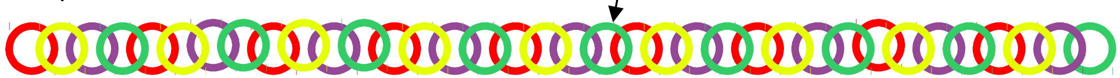
Reduces thermal heating

Bitmap data:

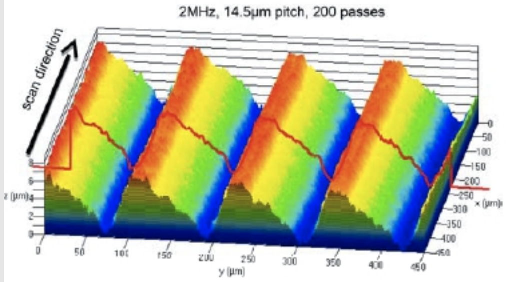


Scribed line pattern:

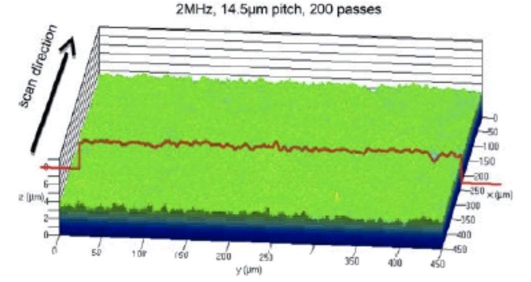


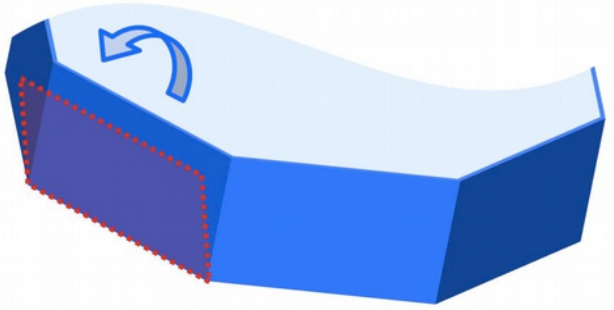
Avoiding Facet error related artifacts

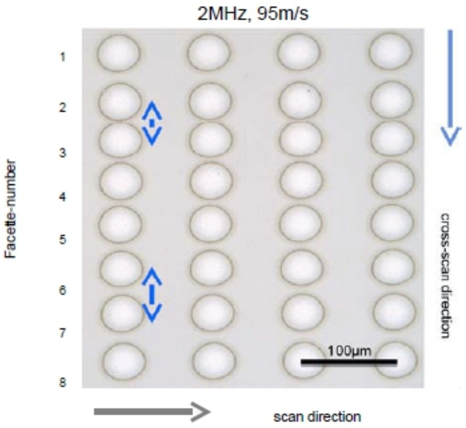
- Pyramidal error affects processing quality when using **small** spot sizes



- Start layers with different facet as first line: averaging pyramidal error







No need for complex correction

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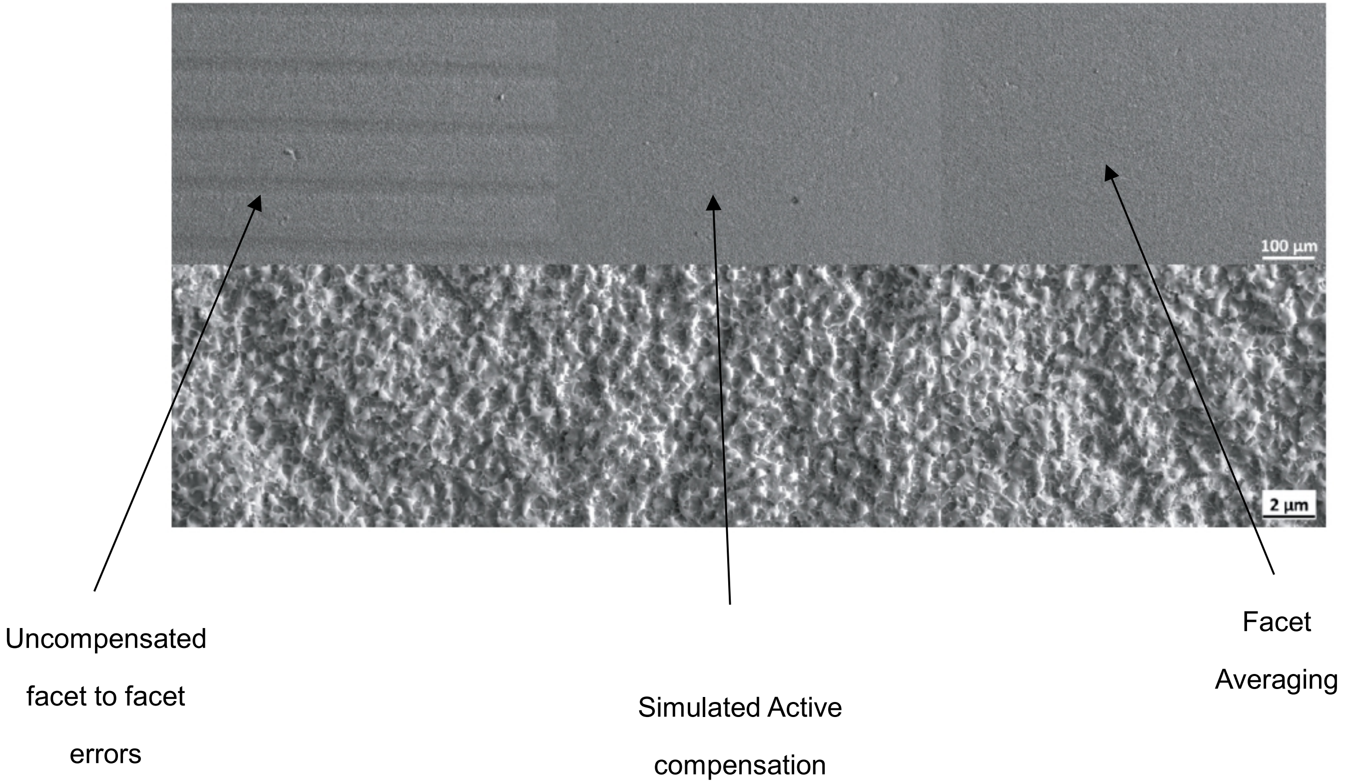
Layerwise multi-pass processing: Surface quality

Ablation at 2 MHz in stainless steel with 200 layers



WOP15- Ultrafast Laser Beam Deflection and Transportation

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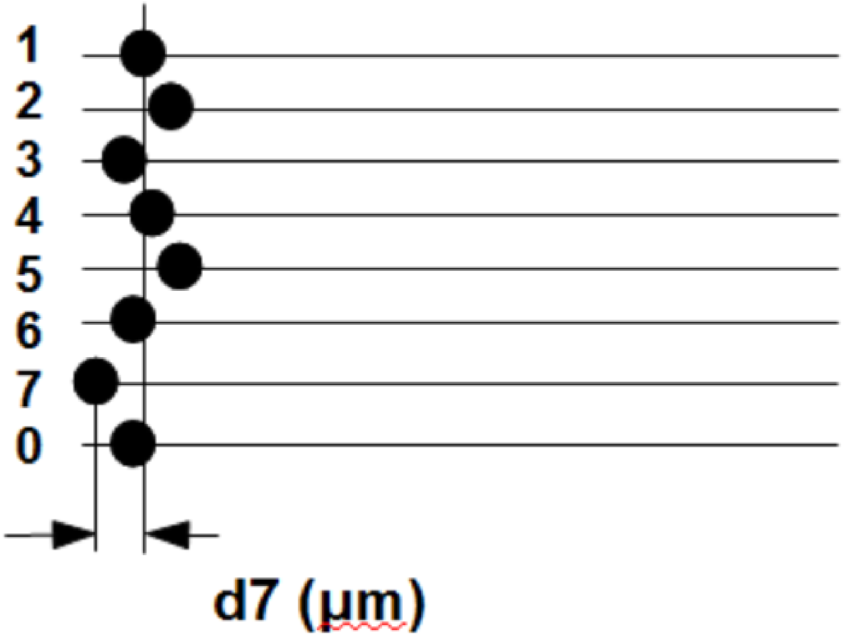
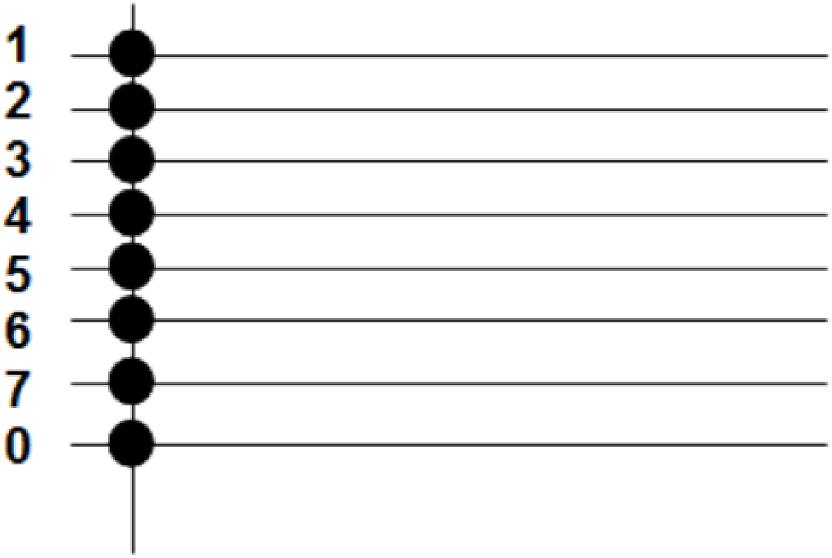
Facet start correction (in-scan)

Before correction → **After correction**





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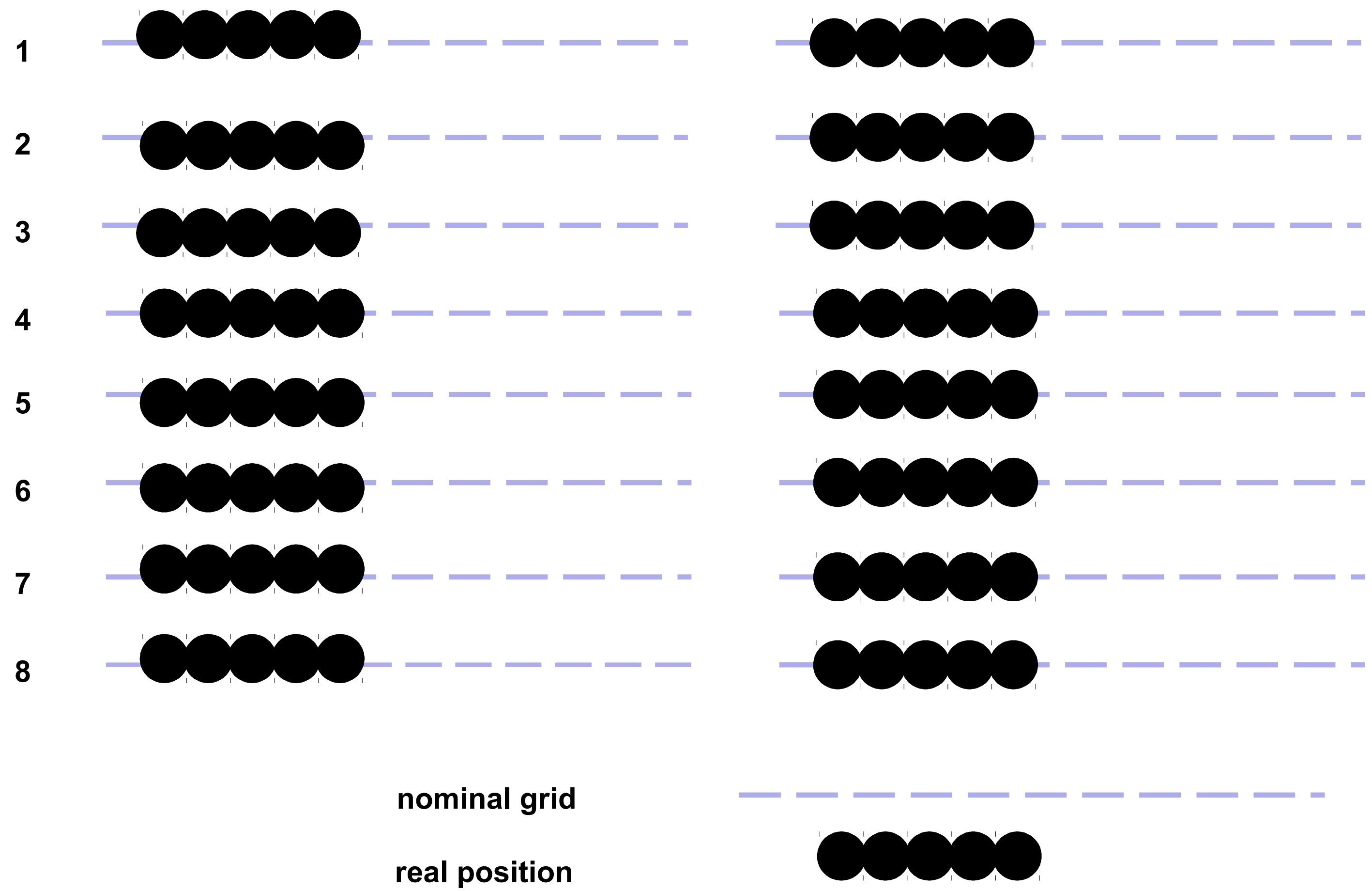
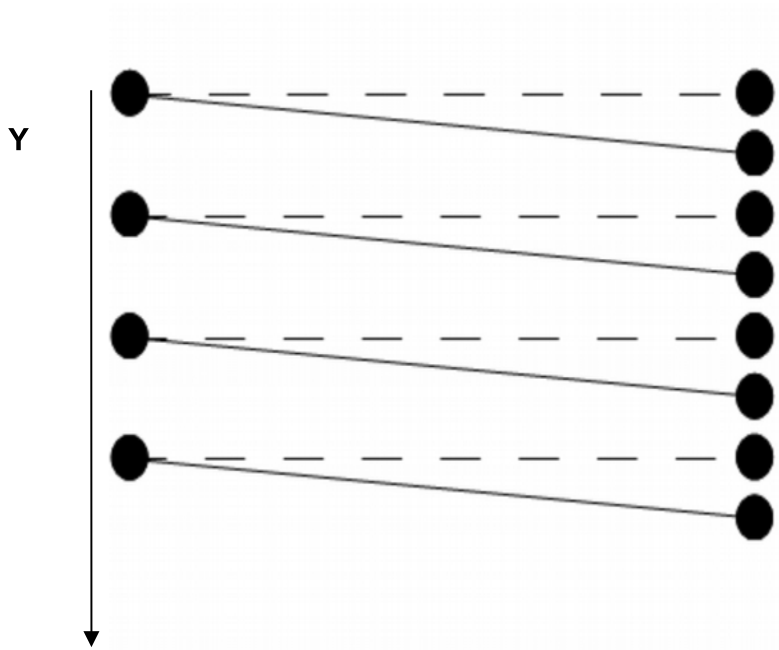
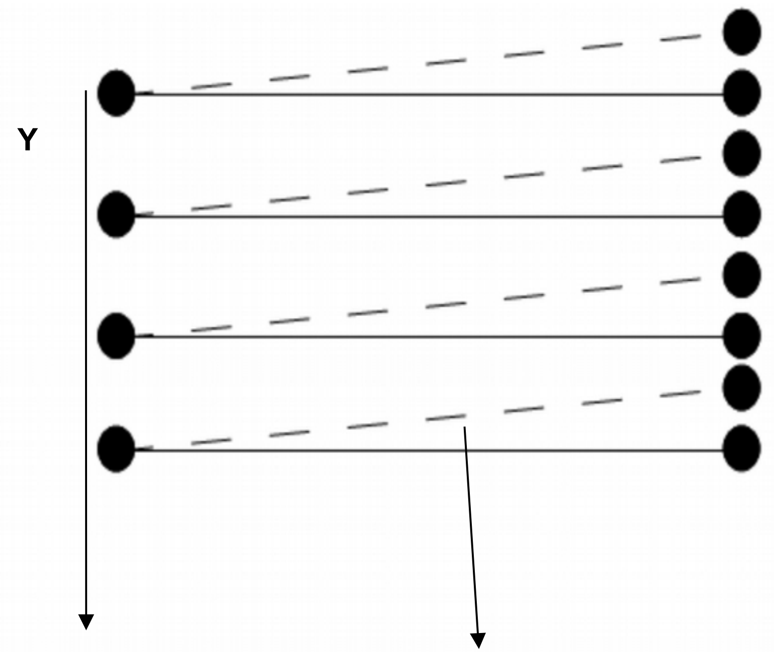
Scanner facet error elimination



Electronic Parallelogram distortion





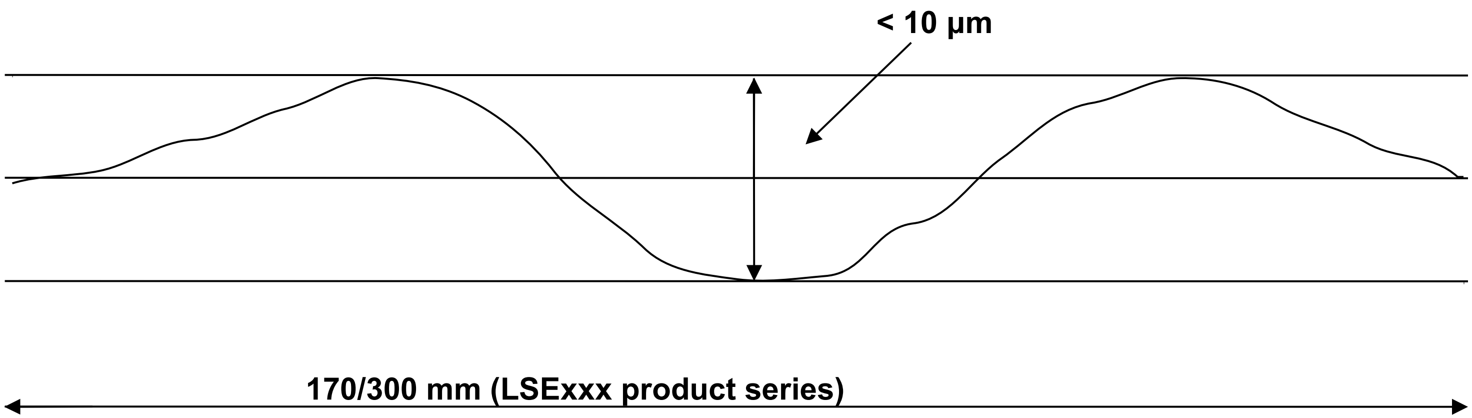
— — — = stationary line

——— = real scribe

Tilt scan head mechanically

versus stage direction (LSExxxSTD)

Scan Line Bow



A repeatable Line bow is caused by f-theta 'lens' distortion

current line straightness is ± 10 µm ,

plus mirror manufacturing and alignment tolerances

TrueRaster Technology flattens line bow through calibration line

Distortion and reduces the line bow i.e. enabling a high line straightness

NEW TrueCalib

TrueRaster has built-in real time drift compensation

Drift is measured 60-400 times/sec and compensates accordingly

This drift compensation also takes care of laser pointing stability

(small changes in laser beam input angle versus scanner housing

also move focused spot in focal plane)

Thank you for your attention

Come and see our products in hall 2 booth 423

LSE170HNA and LSE300STD development is supported by EU FP7 programs:

RAZipol

and

appolo

Questions ?

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