



Water jet guided laser: towards near net-shape machining



The Fusion of Water and Light

Lasers in Manufacturing 2017



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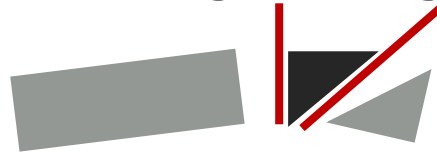
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jdiboine@synova.ch

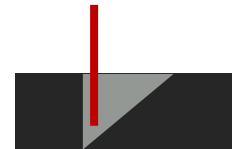
Coming up:

A. Technology, Machine and Applications

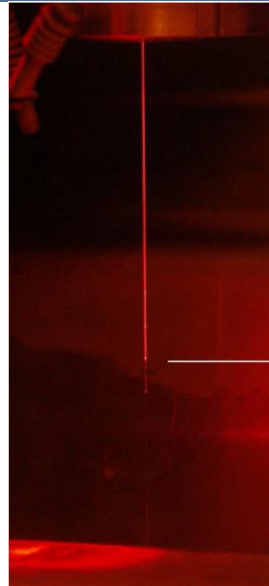
B. Near net-shape machining: cutting approach



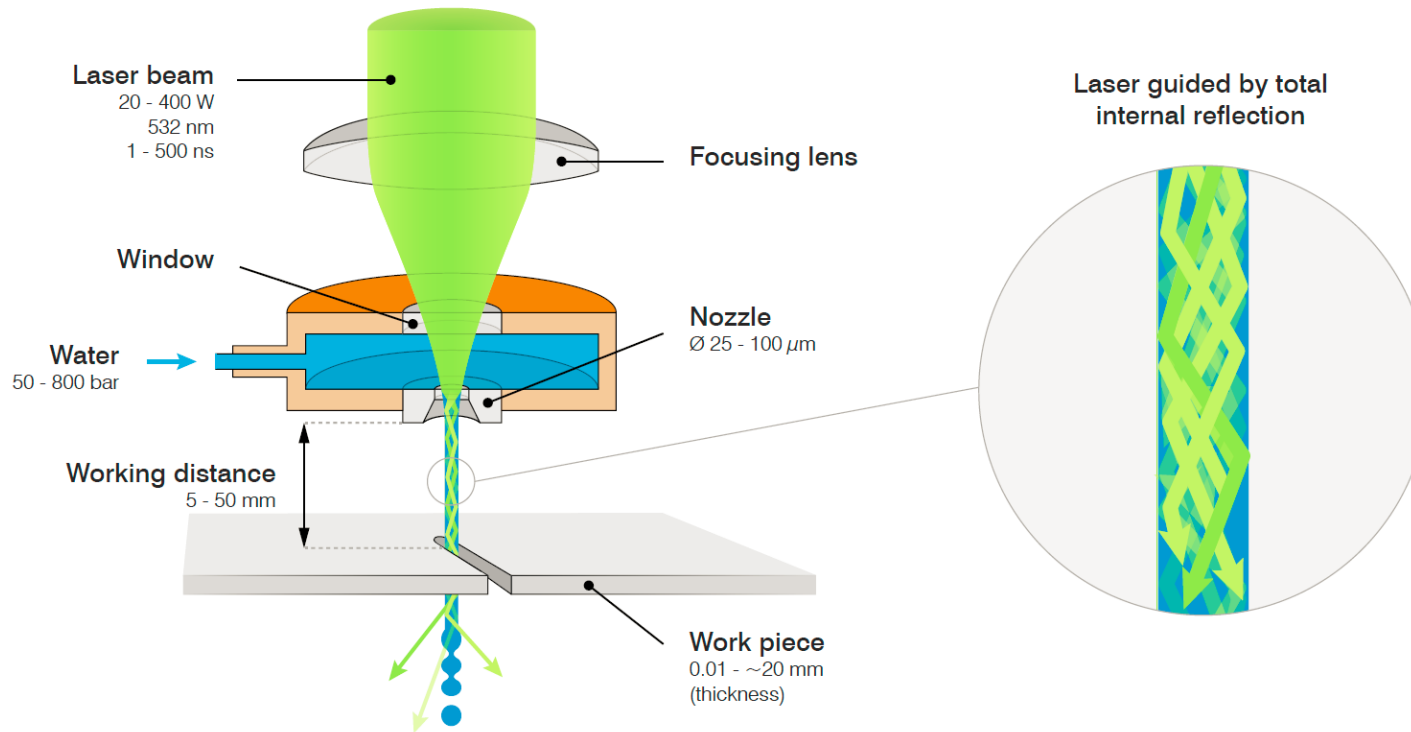
C. Near net-shape machining: milling approach



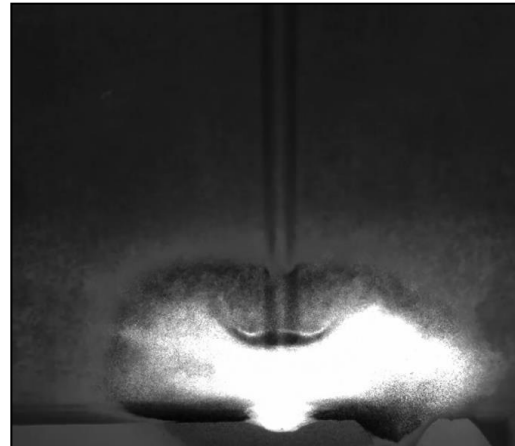
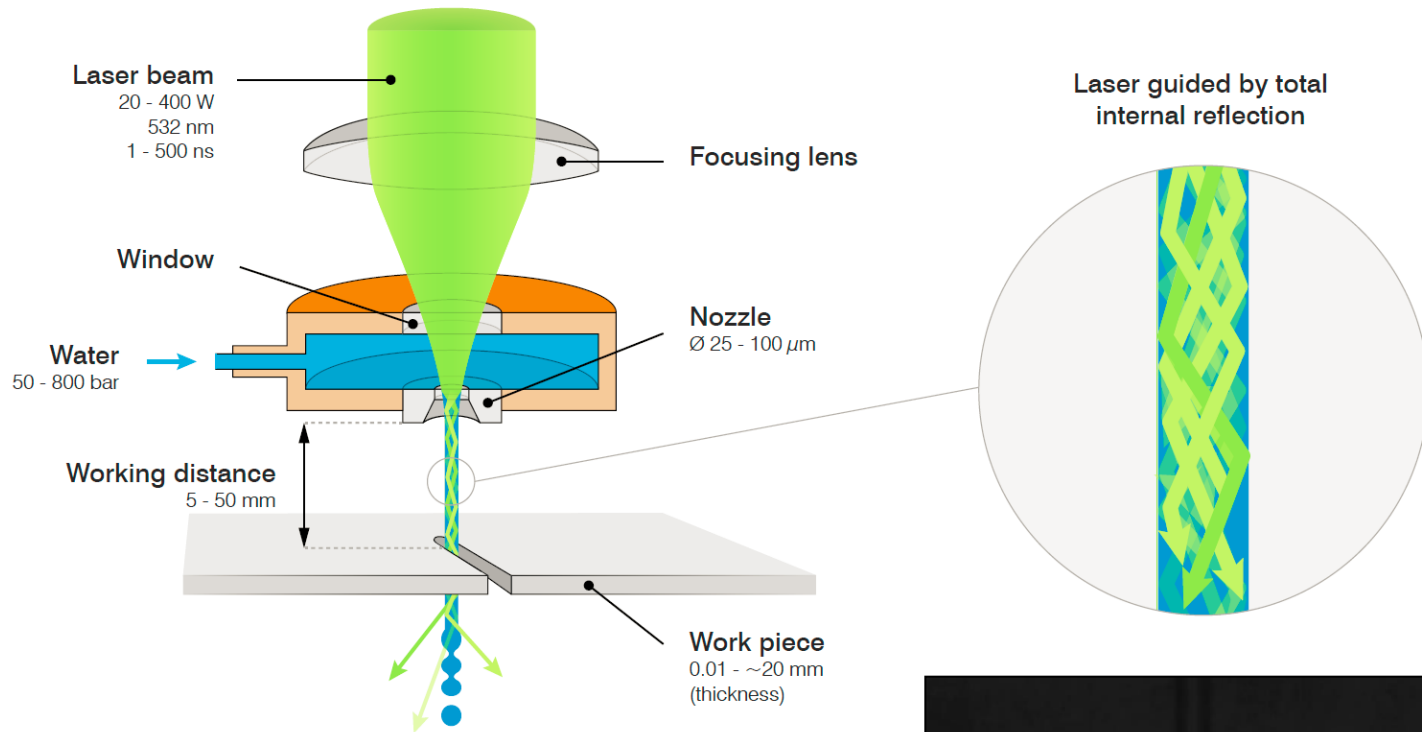
D. Closing words & Acknowledgements



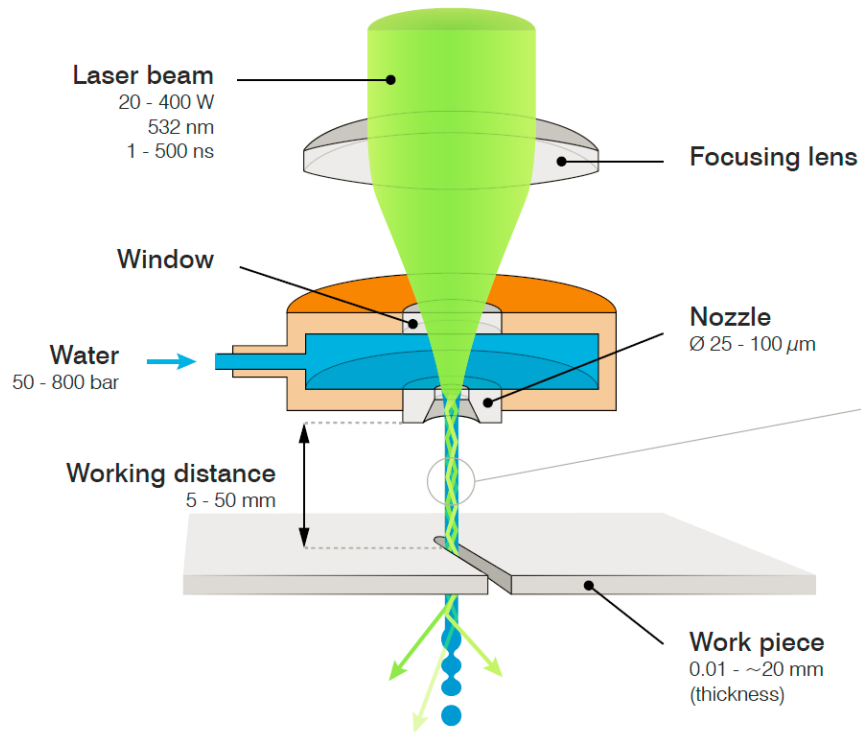
A. Water jet guided laser



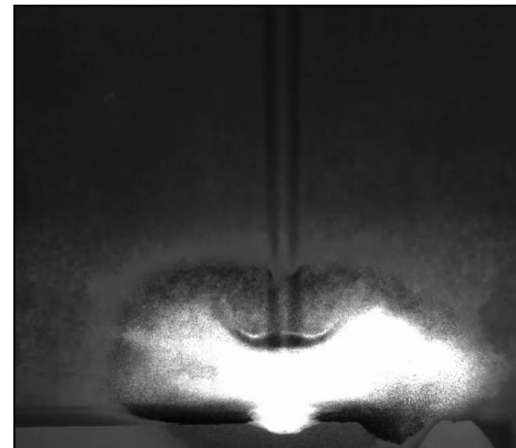
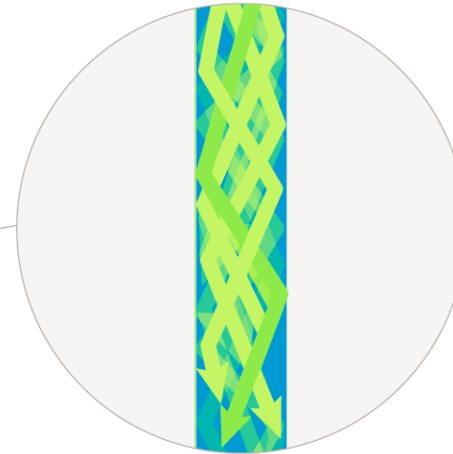
A. Water jet guided laser



A. Water jet guided laser



Laser guided by total internal reflection



LASER MICROJET



No focus adjustment,
long working distance



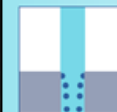
Parallel cuts



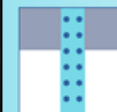
High aspect ratio



No heat affected zone
(water cooling)



No deposition



No burrs



A. Synova & Partners machine line-up



LCS-300

3 axis

- Most versatile system
- Watch, medical,

Main system in operation



LCS-50

3-5 axis compact

- Diamond roughing, shaping
- PCD/Co cutting tools

New generation precision



MCS-300 & 500

5 axis

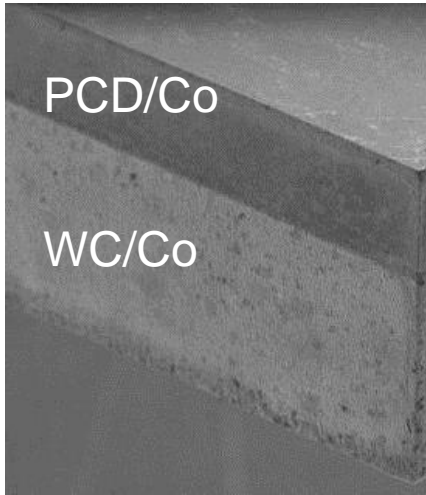
- Large industrial parts
- 24/7 lights-out production

Geared for industry



A. Fields of application

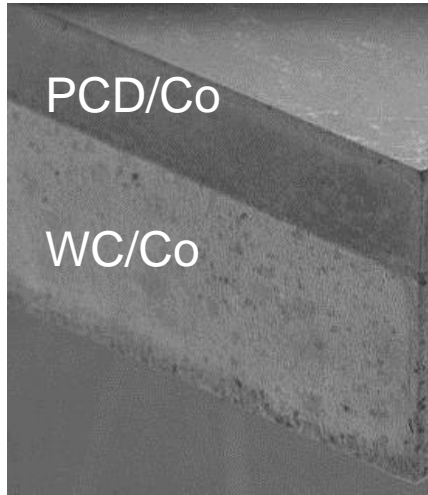
Hard materials



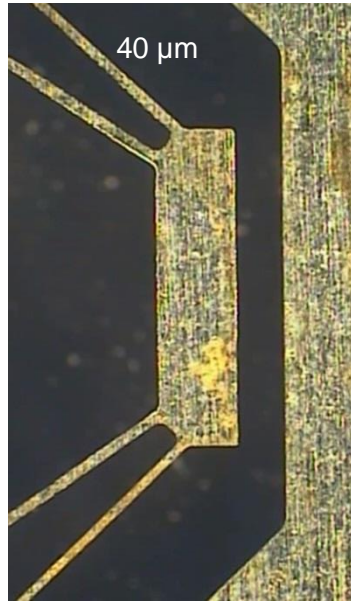
- Cutting tools
- PCD/Co
- MCD
- PcBN

A. Fields of application

Hard materials



Micro-Machining

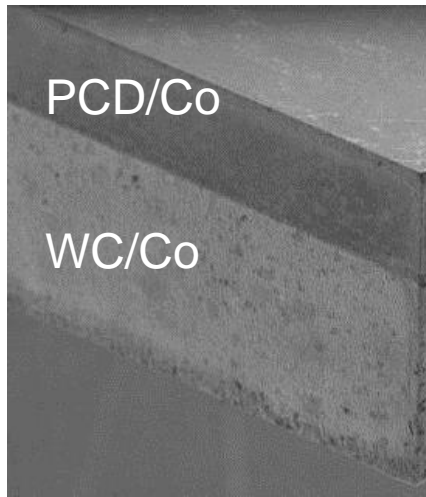


- Cutting tools
- PCD/Co
- MCD
- PcBN

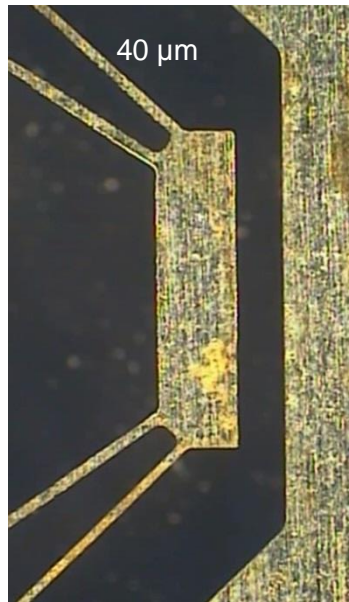
- MEMS
- Watch
- Medical (NiTi)

A. Fields of application

Hard materials



Micro-Machining



Industrial



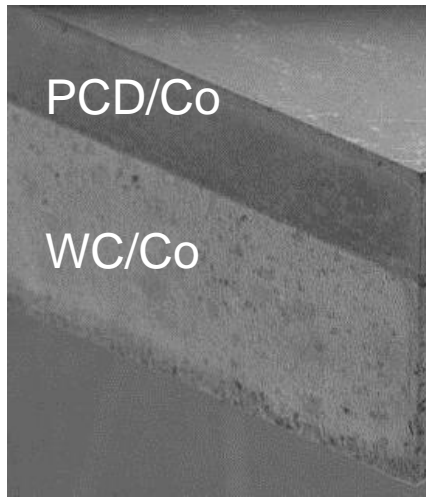
- Cutting tools
- PCD/Co
- MCD
- PcBN

- MEMS
- Watch
- Medical (NiTi)

- Turbine comp.
- CMC (SiC/SiC)
- Silicon 20 mm
- Thick metal alloys

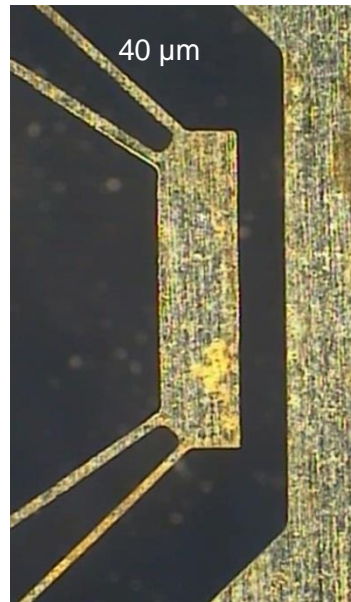
A. Fields of application

Hard materials



- Cutting tools
- PCD/Co
- MCD
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Micro-Machining



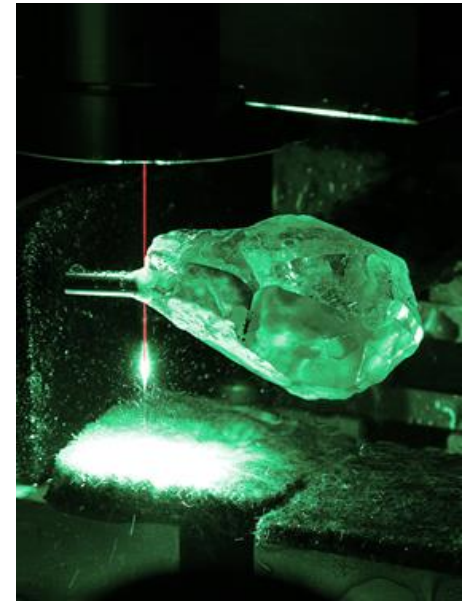
- MEMS
- Watch
- Medical (NiTi)

Industrial



- Turbine comp.
- CMC (SiC/SiC)
- Silicon 20 mm
- Thick metal alloys

Diamond



- Slicing
- Rough cutting
- Natural/Synthetic
- Low mass loss

Near net shape machining: the cutting approach



Towards near net shape machining

Laser MicroJet as a cutting tool
5 axis positioning and slicing



CVD – Diamond Coning

Towards near net shape machining

Laser MicroJet as a cutting tool
5 axis positioning and slicing



CVD – Diamond Coning



CVD – Diamond Facetting

- 8 Crown facets
- 8 Pavillion facets

Towards near net shape machining

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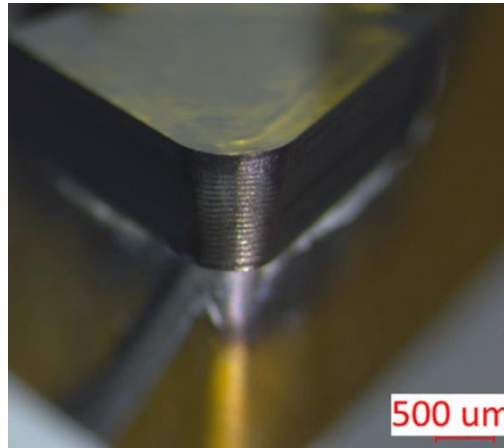
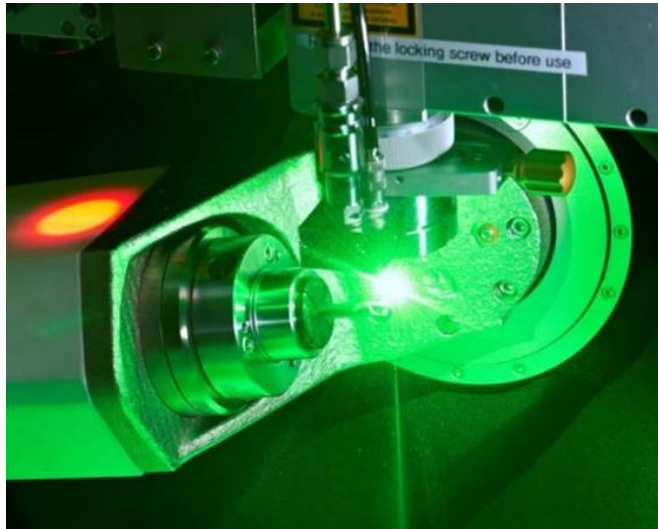
Natural Diamond Facetting

- 8 Crown facets
- 8 Pavillion facets

Towards near net shape machining

Laser MicroJet as a cutting tool

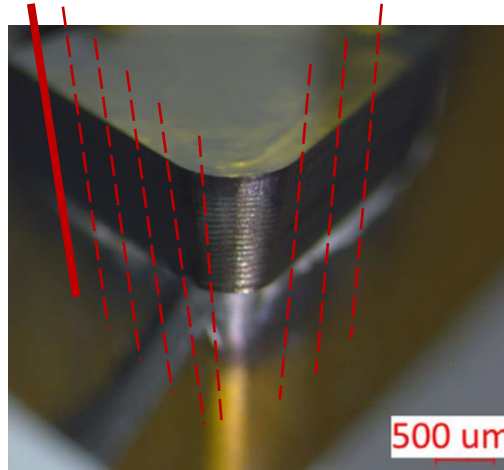
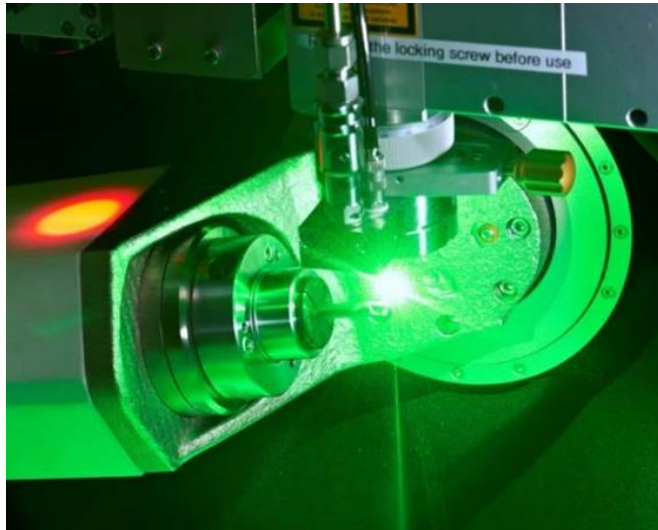
5 axis simultaneous trajectories



Towards near net shape machining

Laser MicroJet as a cutting tool

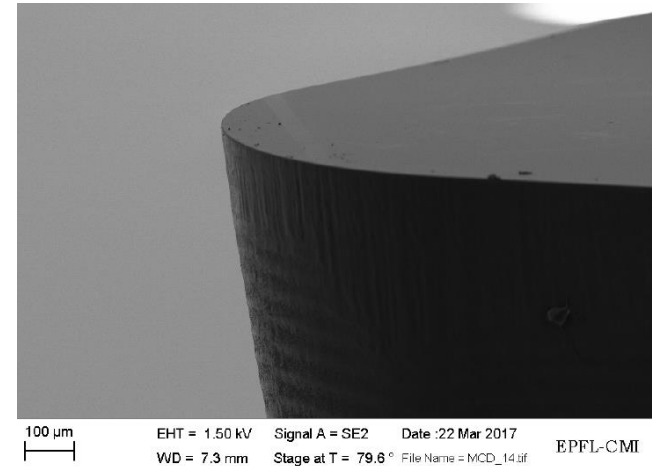
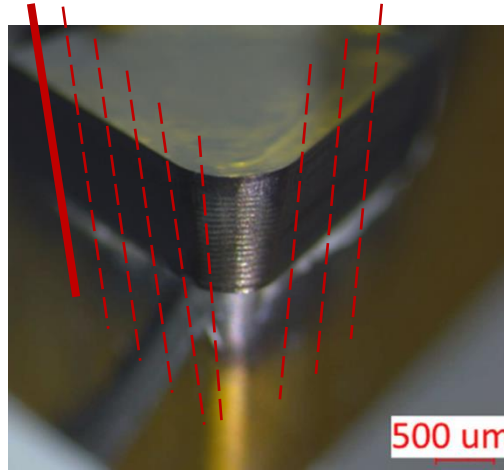
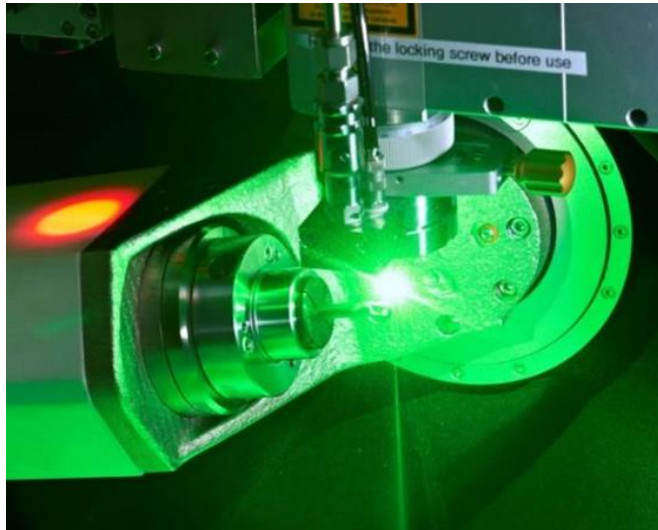
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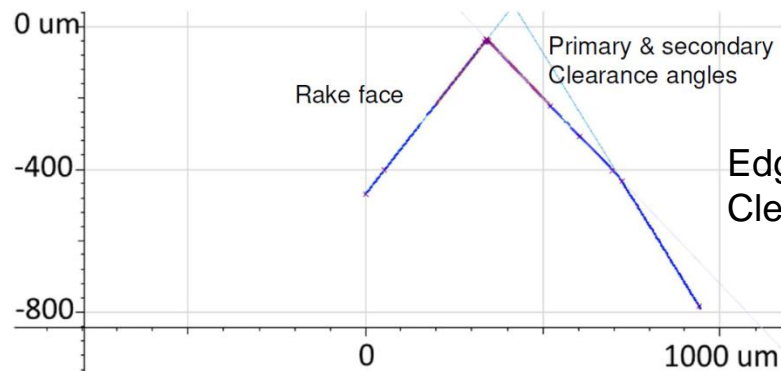
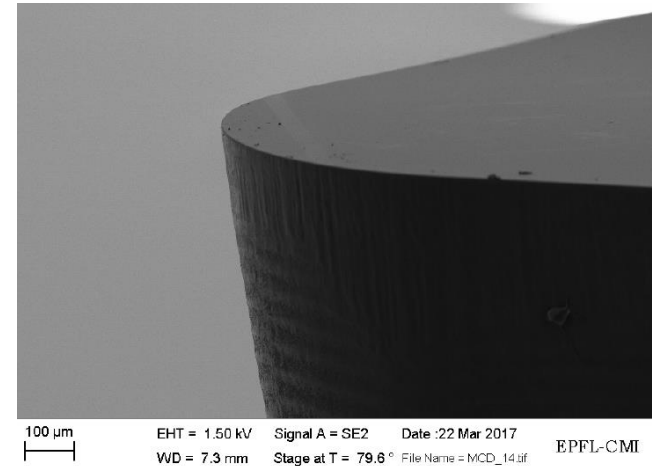
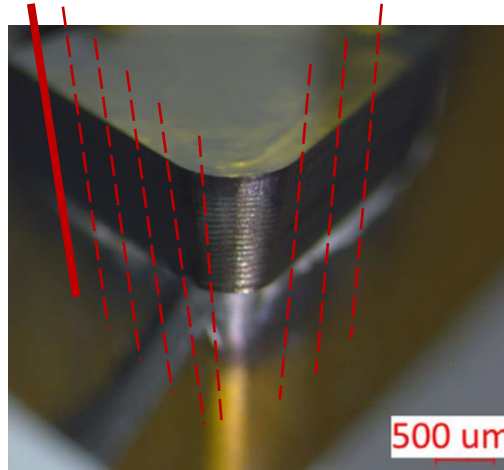
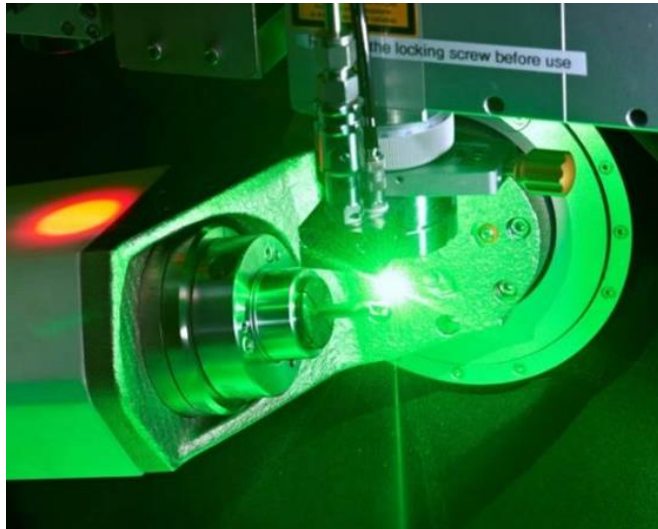
5 axis simultaneous trajectories



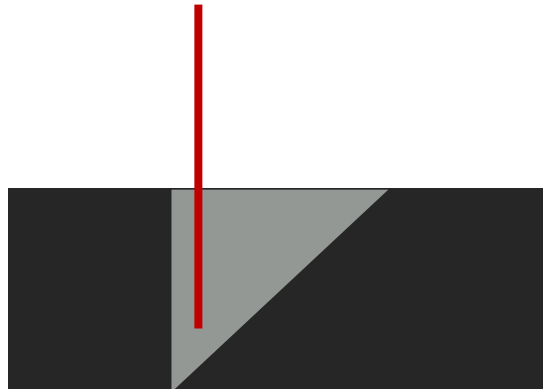
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Laser MicroJet as a cutting tool

5 axis simultaneous trajectories

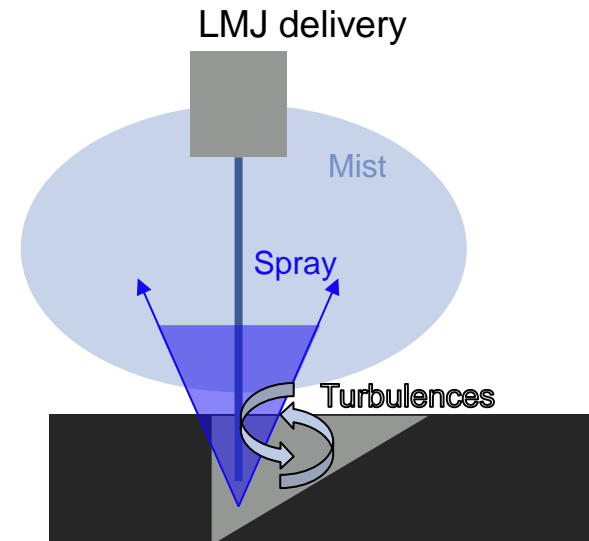
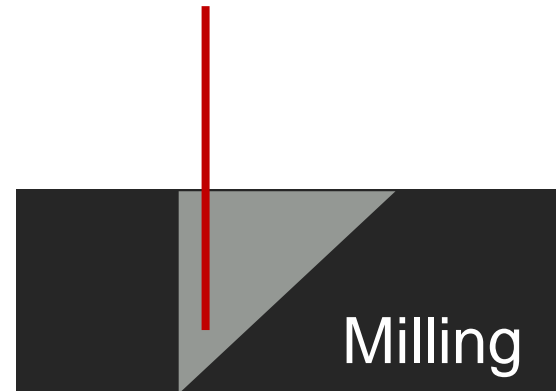
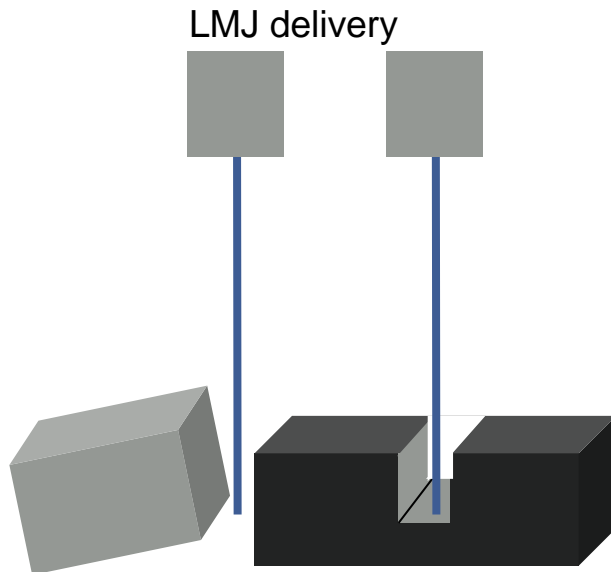


Near net shape machining: the milling approach



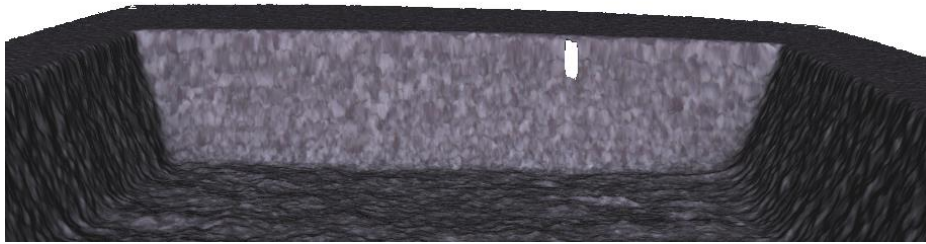
Towards near net shape machining

The change in paradigm:



Towards near net shape machining

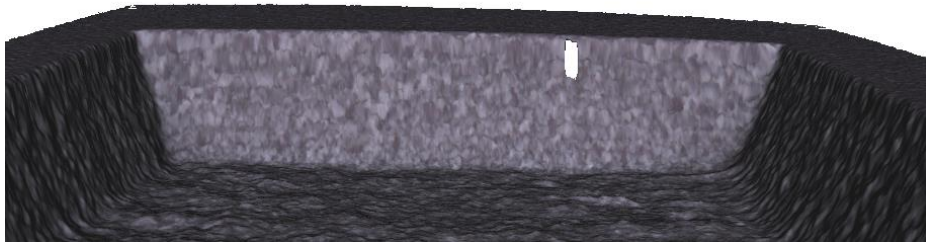
Laser MicroJet as milling tool: making the right tool for the job



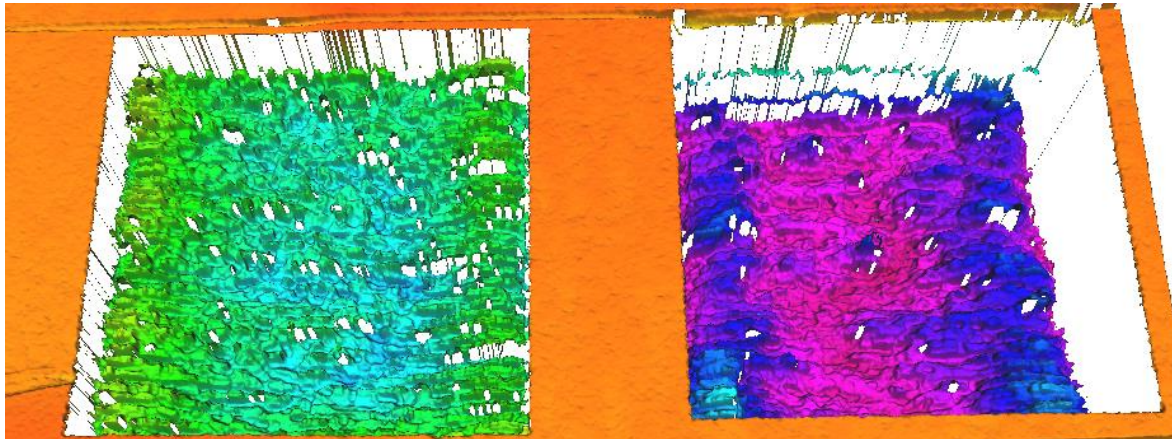
Ceramic pocketing: good result with parametric optimization

Towards near net shape machining

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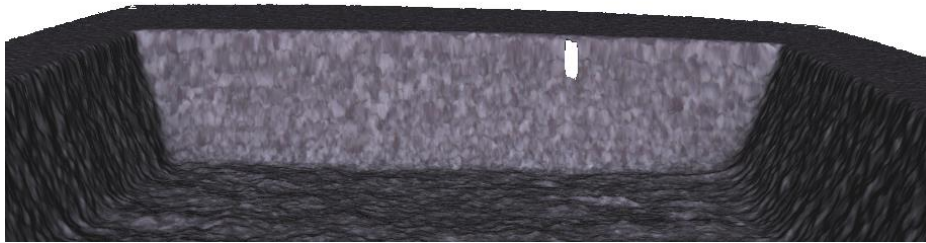
Ceramic pocketing: good result with parametric optimization



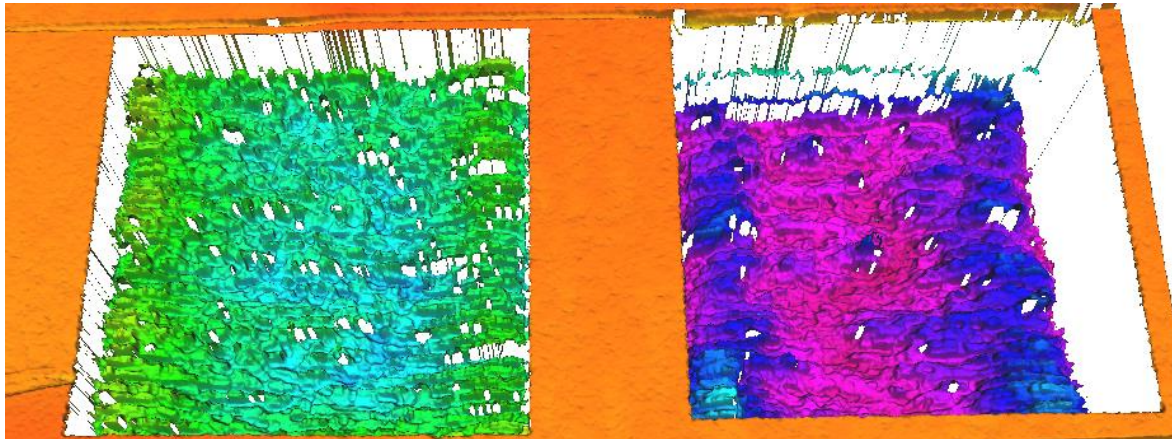
Metal alloy pocketing: results can be highly variable

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Ceramic pocketing: good result with parametric optimization



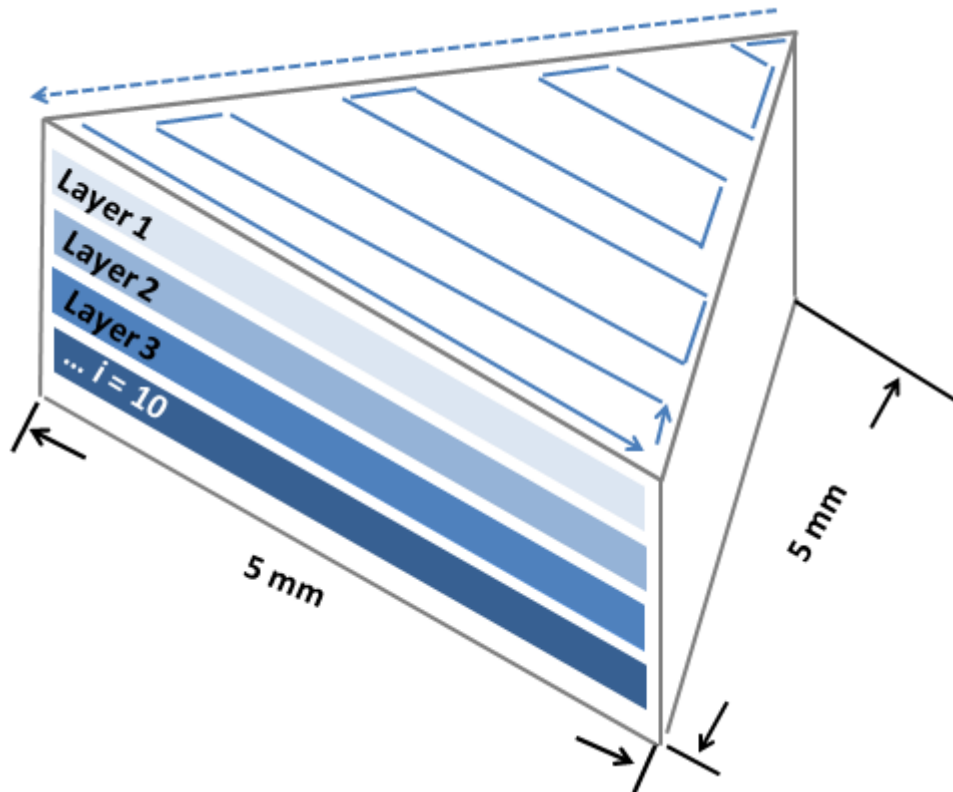
Metal alloy pocketing: results can be highly variable



Parametric optimization is fine, robustness is better! ➡ New generation of hardware

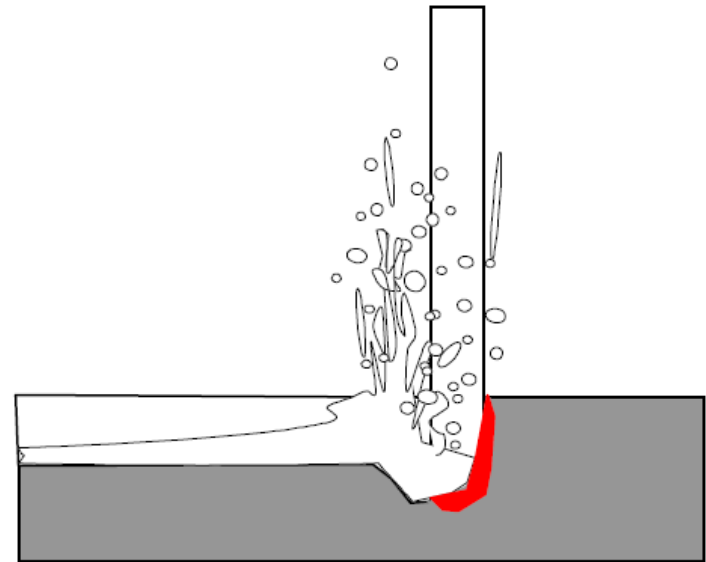
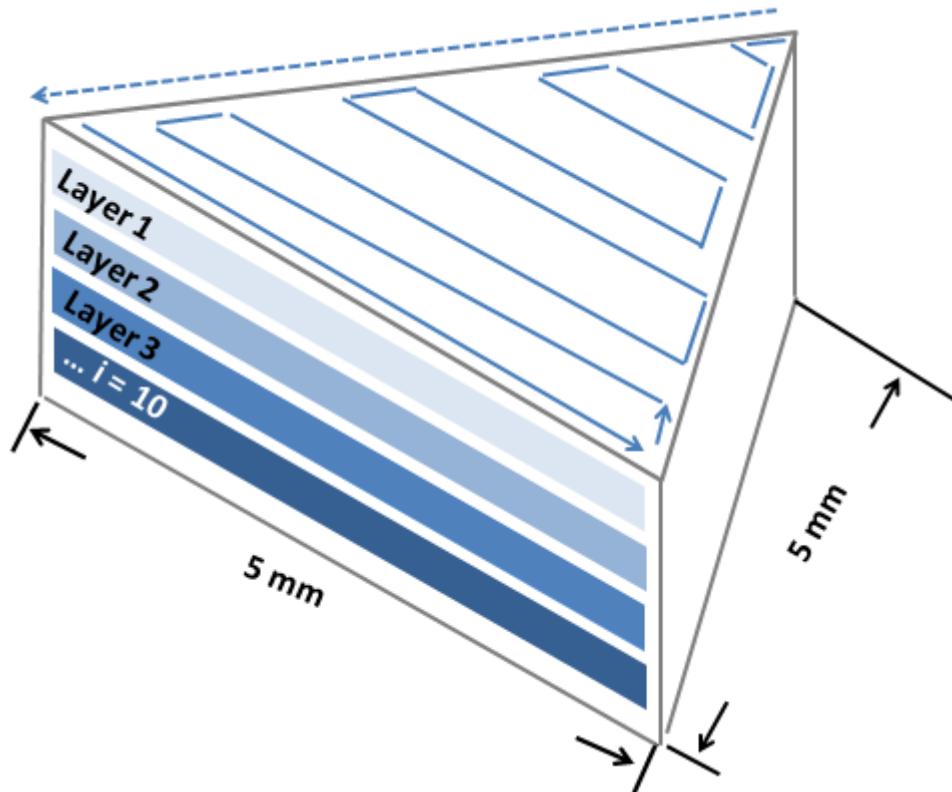
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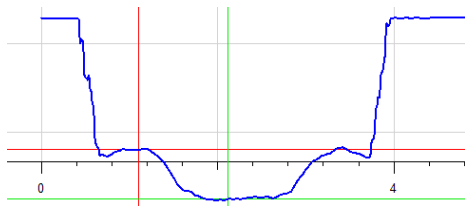
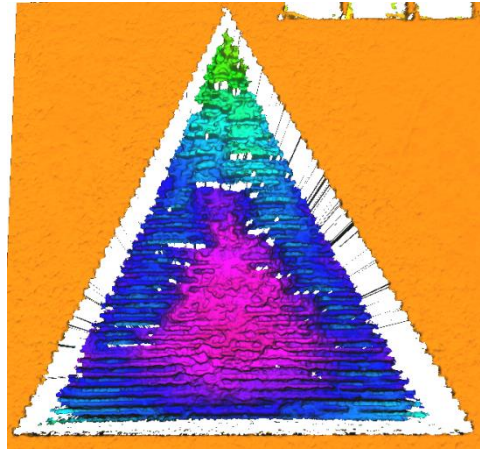


Shape selected for maximum instability

- Dwelling near walls
- Sharp corners

Towards near net shape machining

Laser MicroJet as milling tool: making the right tool for the job

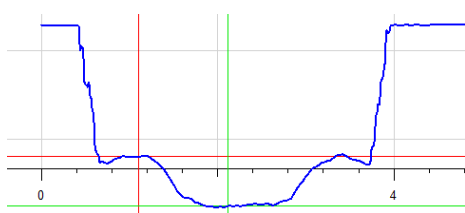
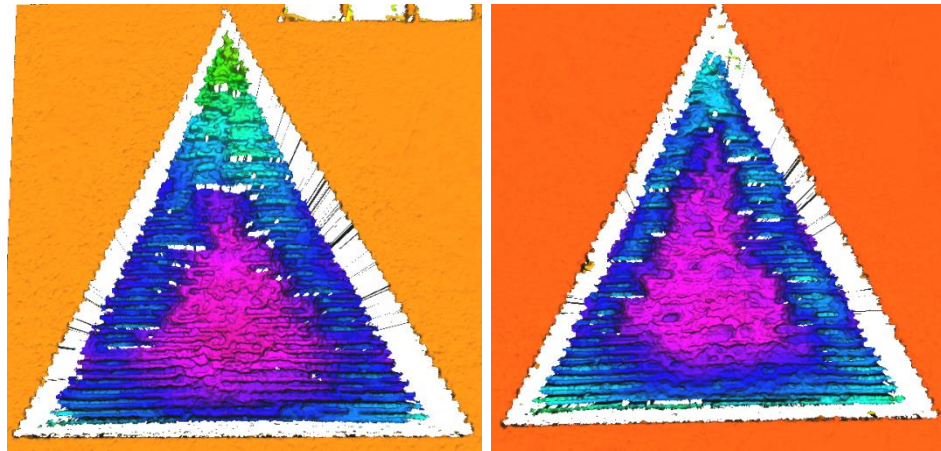


Hardware current

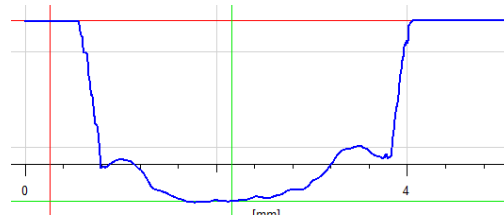


Towards near net shape machining

Laser MicroJet as milling tool: making the right tool for the job



Hardware current

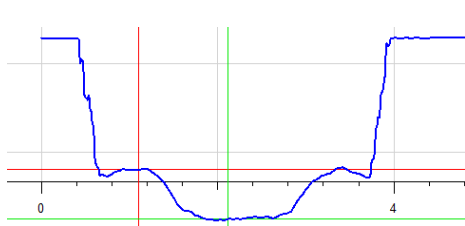
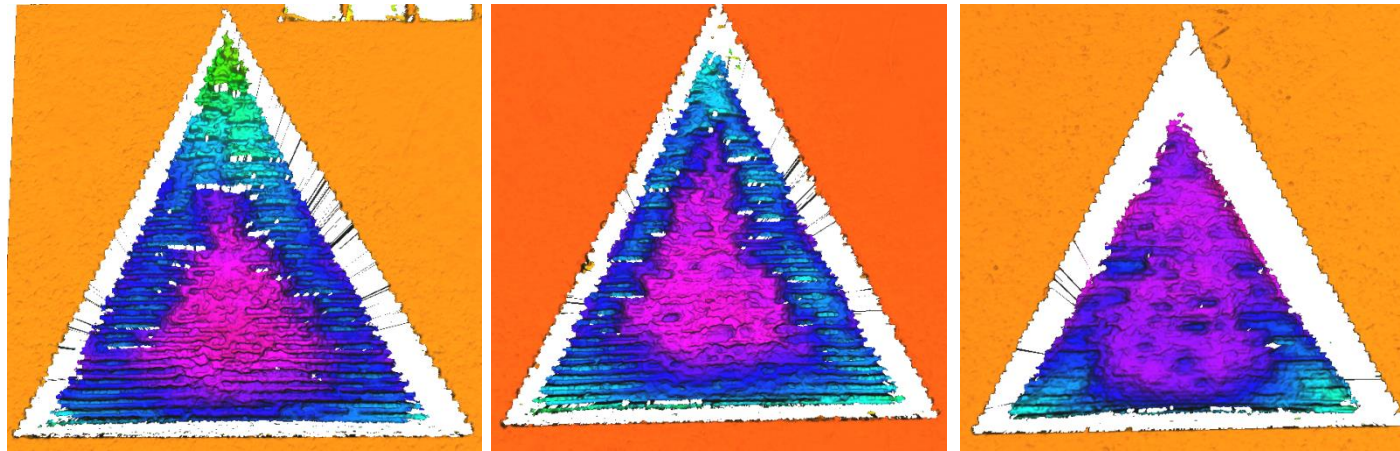


Mod.1

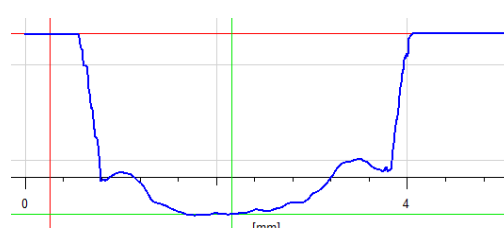


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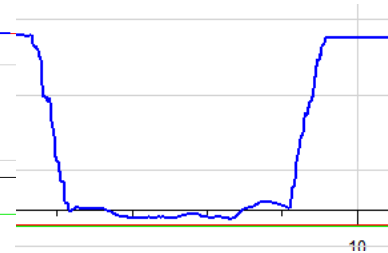
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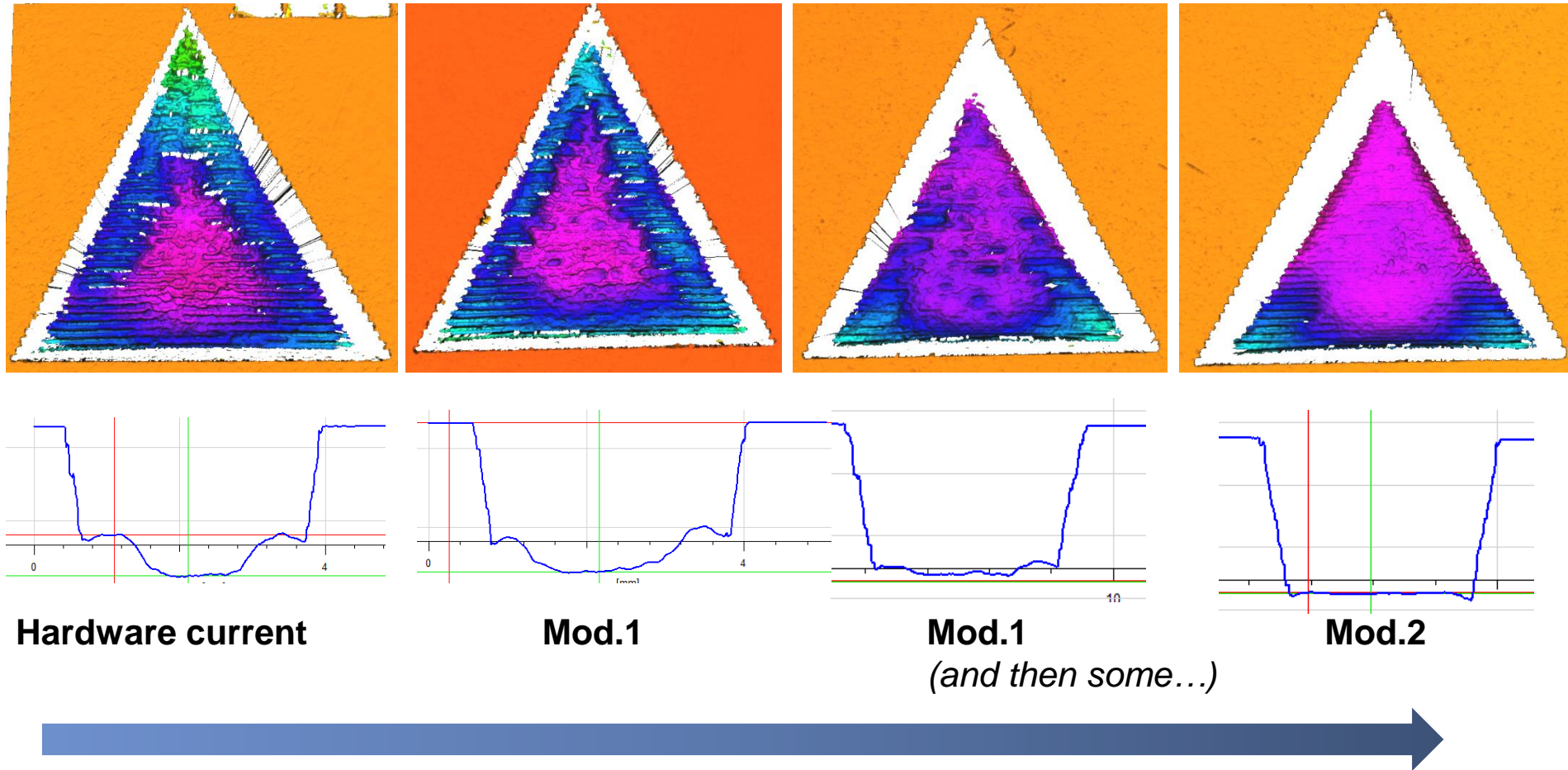


Mod.1
(and then some...)



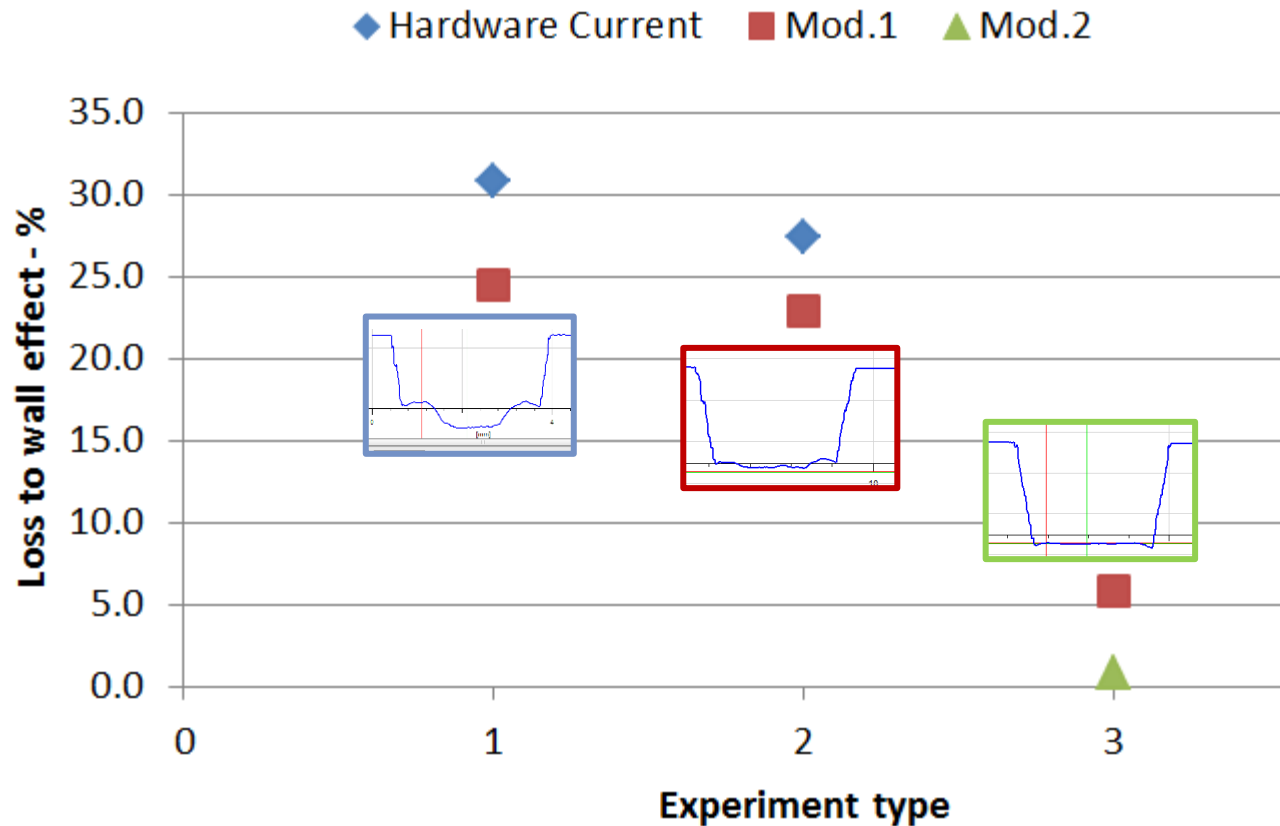
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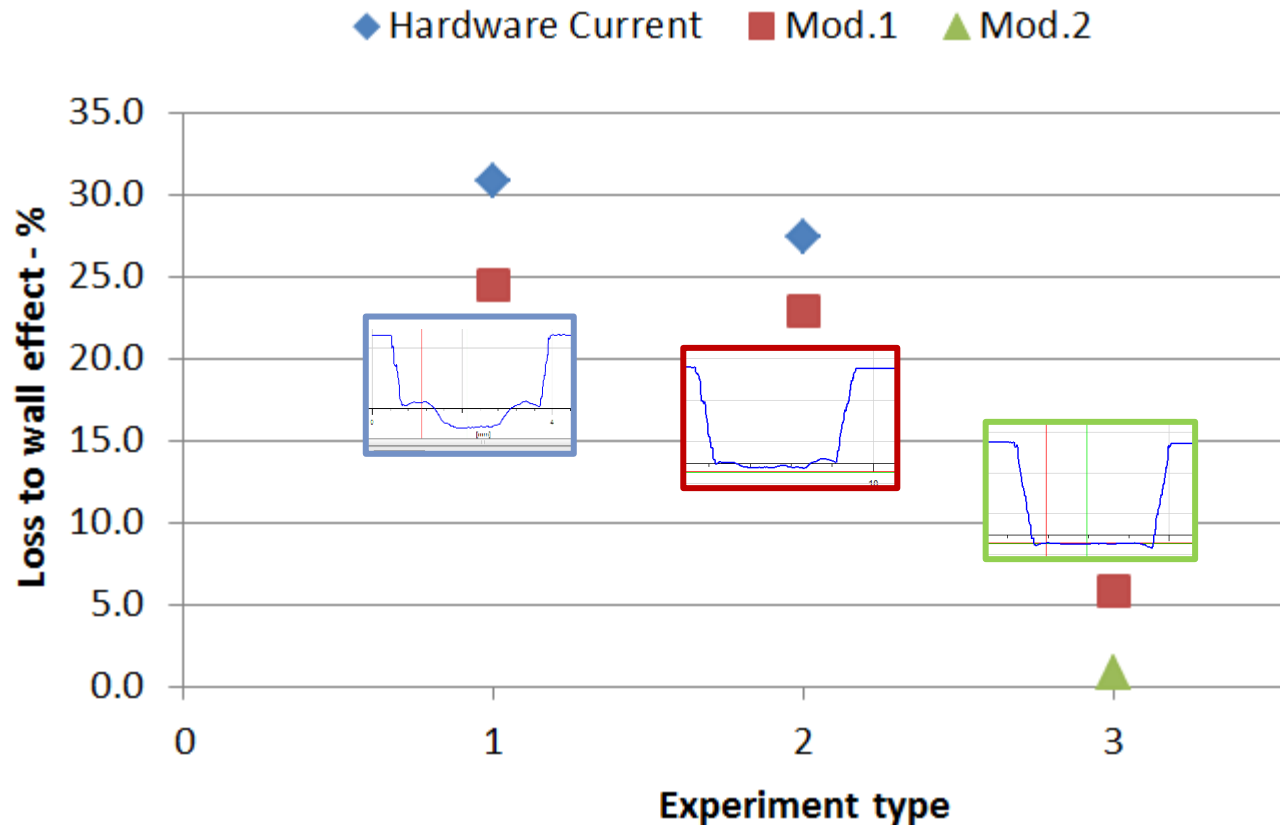
Towards near net shape machining

Laser MicroJet as milling tool: making the right tool for the job



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Wall effect is systematically reduced by 5%

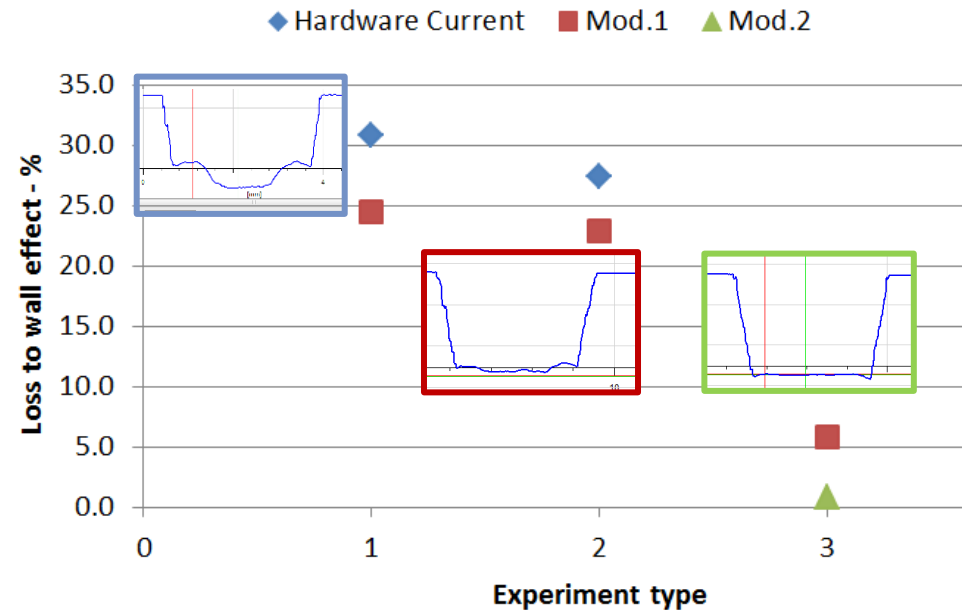
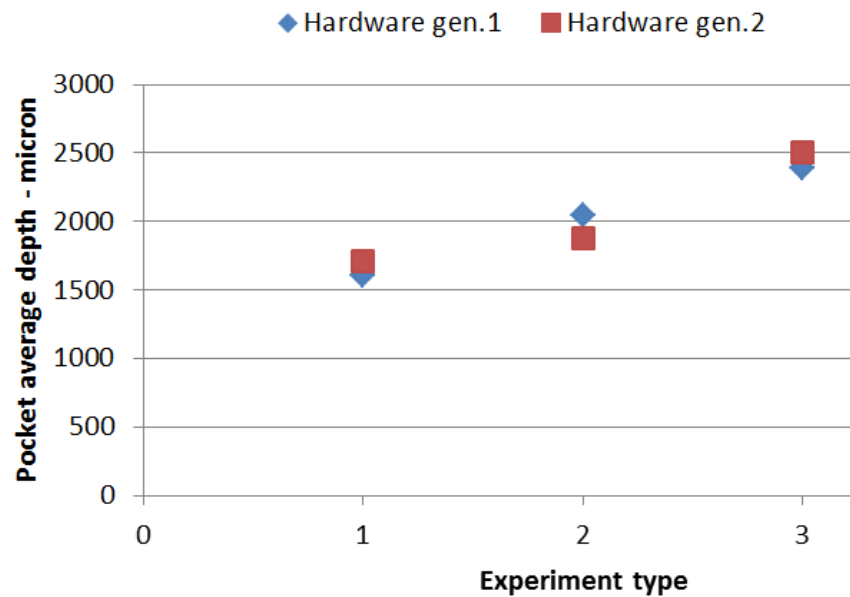
Mod.1 & Mod.2 have provided 25% improved feature definition



Towards near net shape machining

Laser MicroJet as milling tool: making the right tool for the job

Mod 2. average performance at least as good as peak current setup



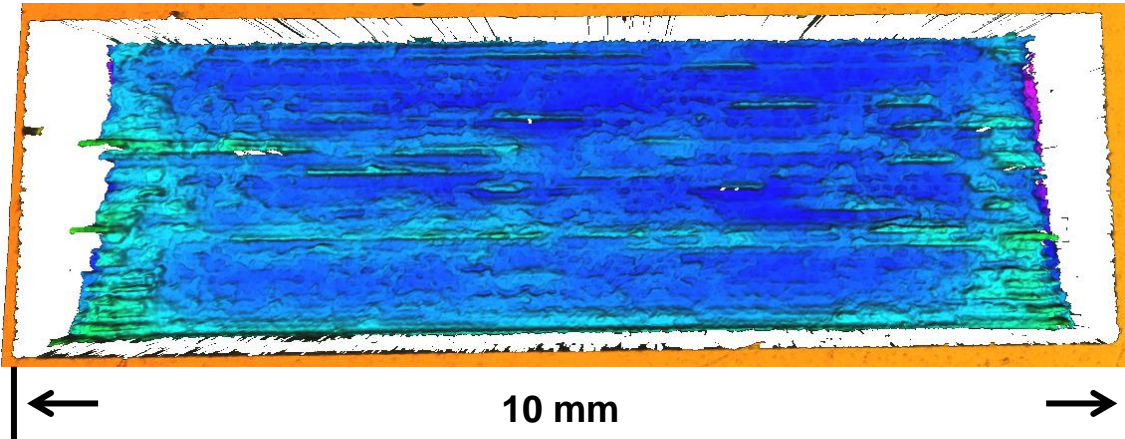
**Wall effect is systematically reduced by 5%
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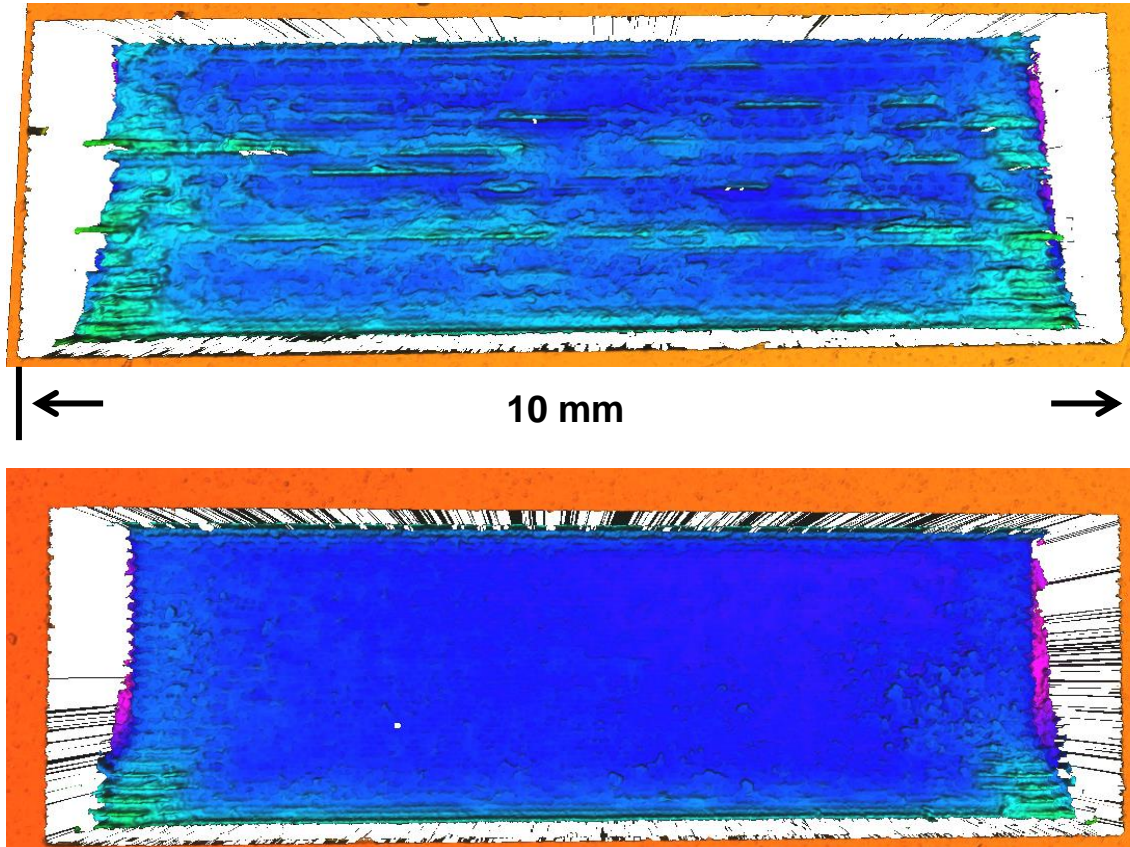
Long range variations can be controlled



Towards near net shape machining

Laser MicroJet as milling tool: making the right tool for the job

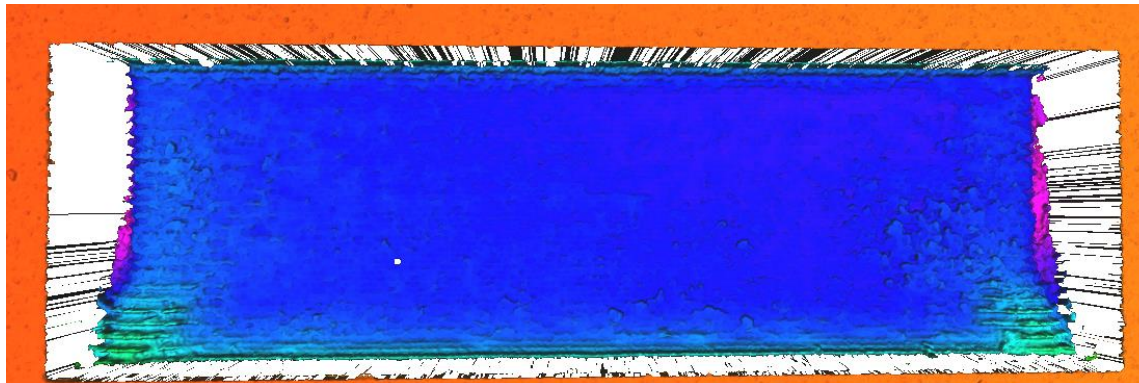
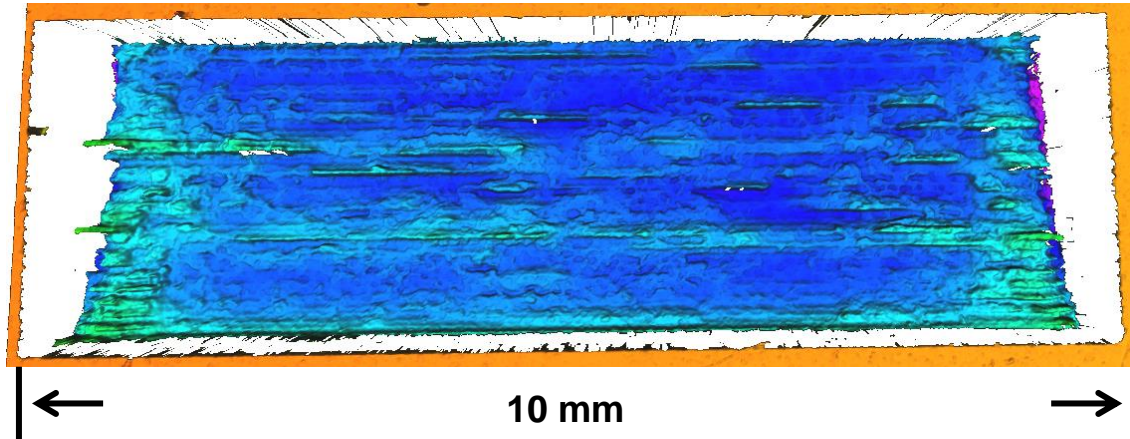
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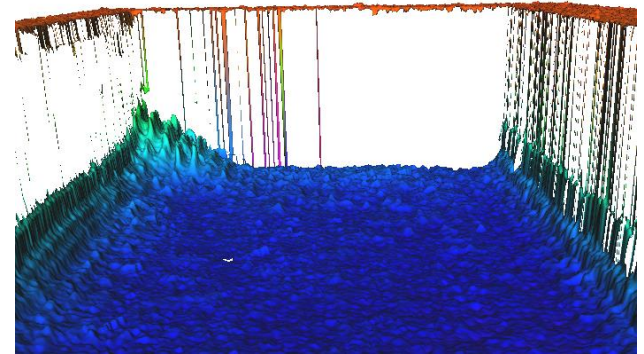
Towards near net shape machining

Laser MicroJet as milling tool: making the right tool for the job

Long range variations can be controlled



Gen 2. hardware seeks to stabilize the process regardless of scale or shape



Closing words

- Synova is constantly seeking new applications, gaining maturity at providing industrial, automatic, robust tools
- The LMJ has proven to be an effective **cutting tool** for industrial applications alongside other non-conventional techniques (EDM, Laser, AWJ...)
- The nature of the water jet light-guide is a strong drive for innovation, specifically to provide robust **milling** applications
- Continued R&D efforts focused on hardware development bring forth the promise of accurate 2.5D shaping.



Acknowledgements

Synova thanks the following partners for their support and creativity, from R&D to Industrialization:



DE BEERS



The University of
Nottingham

