

Photonic 4 intelligent processing

Smart solutions for Laser processing – beam delivery and sensor

Dr. Markus Kogel-Hollacher, R&D Projects

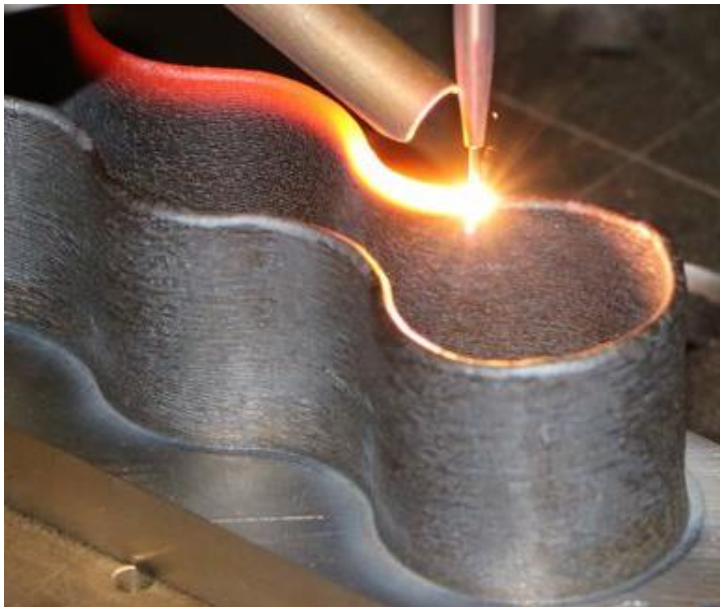
June 19th 2019



SALON INTERNATIONAL
LEADER DE LA HAUTE PRECISION
HORLOGERIE · JOAILLERIE · MICROTECHNOLOGIES · MEDTECH

THE ESSENCE OF LASER MATERIALS PROCESSING

- A laser is an energy source based on excited photons
- In order to gain the desired result a specific energy distribution of the photons has to be achieved
- Cutting, welding, surface treatment require dedicated power distribution
- Sensors are the eyes and ears in the production – at best guiding the process

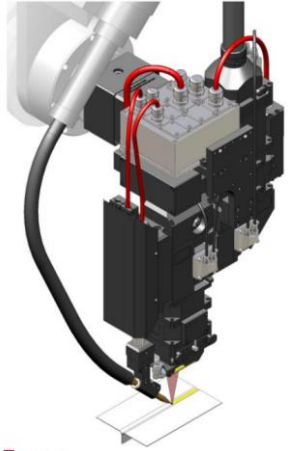


THE ESSENCE OF LASER MATERIALS PROCESSING

- On their way to the workpiece the photons can be guided by mirrors or optical fibers and be deflected by optical elements
- When the photons exit the laser source the right path is crucial
- Component manufacturers provide the “roads”, research institutes mainly have “programmed” the software for the GPS system
- The quality of the “roads” is the duty of the suppliers
- The “road alignment” is result to the expertise and creativity of researchers



CONVENTIONAL “PHOTON GUIDING” – PROCESSING HEADS



ALO3
scansonic



IVI HIGHYAG



LASERMECH
FiberWELD



PRECITEC



TRUMPF



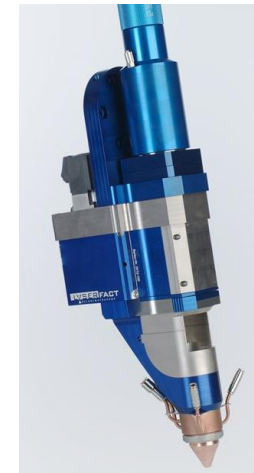
HAAS
Laser Technologies Inc.
Your Single Source Solution for Laser Beam Delivery Systems



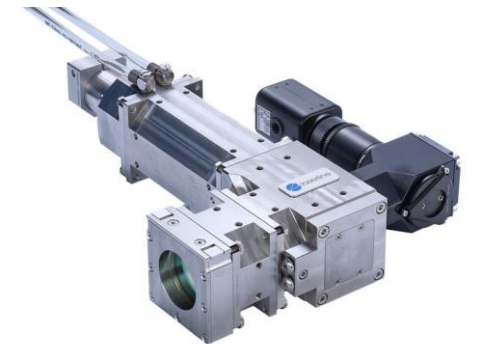
IPG
PHOTONICS



REIS
REIS LASERTEC



LASERFACT
Strahlwerkzeuge



laserline

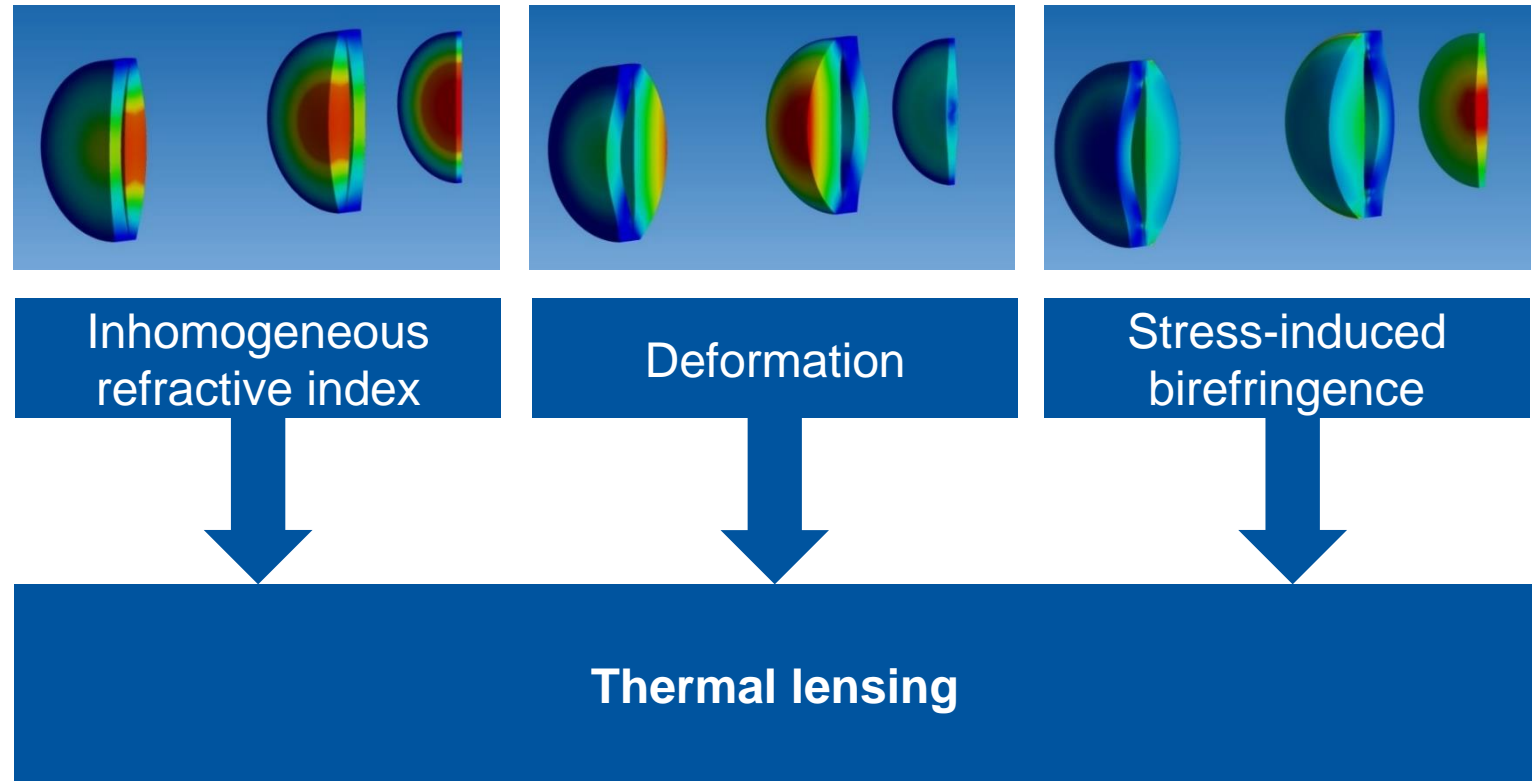
PRECITEC

THE QUALITY OF THE “ROADS” FOR PHOTONS

ISSUES THAT CAN INFLUENCE THE POWER DISTRIBUTION – THERMAL EFFECTS

- Absorption coefficient of glass and coating
- Laser power
- Intensity
- Angle of incidence of laser beam

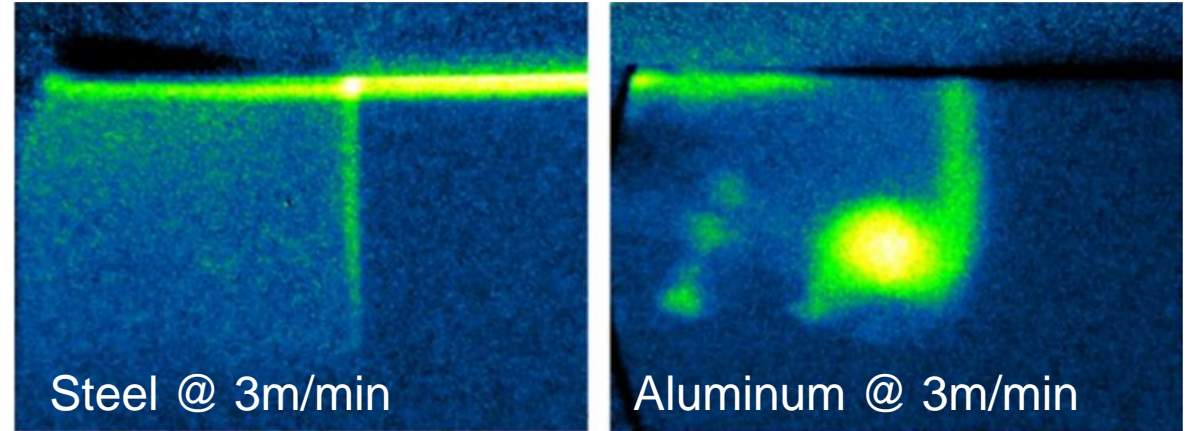
Recent developments in bulk material and quality of coating dramatically reduce thermal influence on the power distribution!



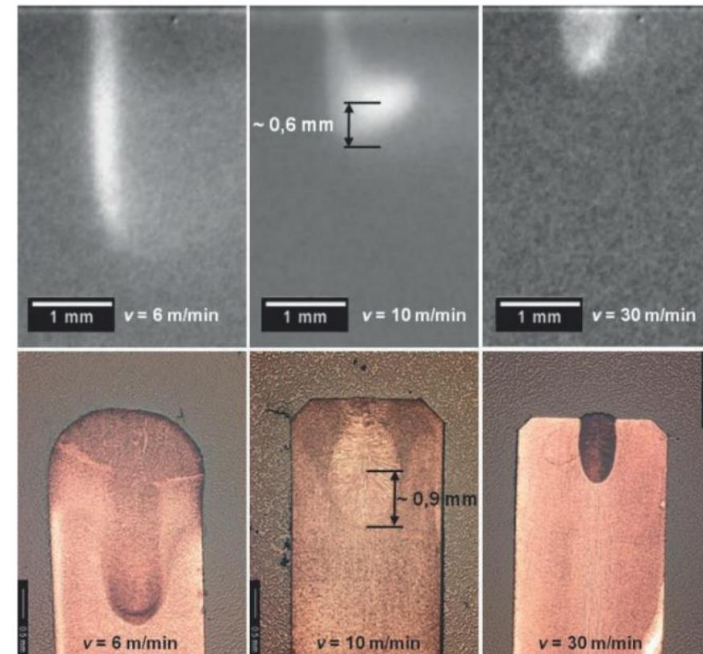
PROGRAMMING THE GPS SOFTWARE – IN-SITU DIAGNOSTICS

IFSW STUTT GART – X-RAY DIAGNOSTICS

- IFSW using a micro-focus X-ray source and an image converter which allow high speed recording with high spatial resolution
- The geometry of the capillary (keyhole) can be observed and measured during welding



Bronze @
6m/min
10m/min
30m/min

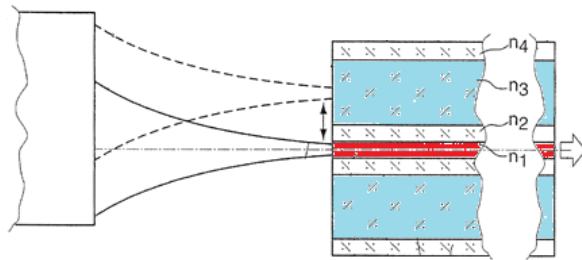


VARIABLE MODIFICATION OF THE BEAM CAUSTIC

SOLUTIONS ON THE MARKET – FIBER COUPLING POSITION



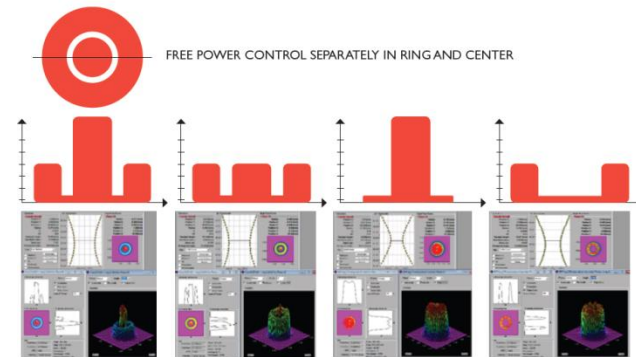
- Displaceable coupling by wedge element



- 2 fiber lasers, each one spliced to core and ring

ARM™ TECHNOLOGY

ARM™ is a patented technology that creates dynamic ringmode which can be adjusted on-the-fly as the application requires.



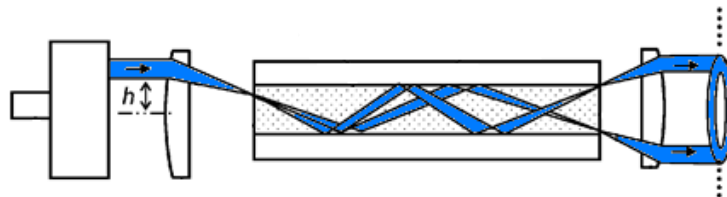
SPECIFICATIONS

POWER RATING

Power at the outer ring [kW]	Power at the inner spot [kW]		
	2	4	6
2	Standard	Standard	Standard
4	Standard	Contact Corelase	Contact Corelase
6	Standard	Contact Corelase	Contact Corelase
8	Contact Corelase	Contact Corelase	Contact Corelase



- Stepless displaceable coupling

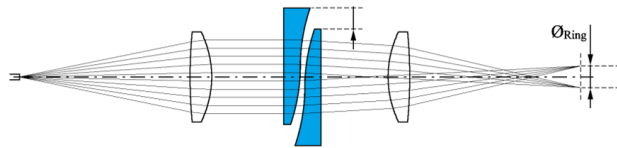


VARIABLE MODIFICATION OF THE BEAM CAUSTIC

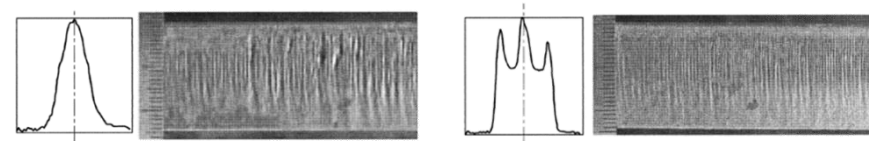
POTENTIALLY UPCOMING SOLUTIONS – PROCESSING OPTICS



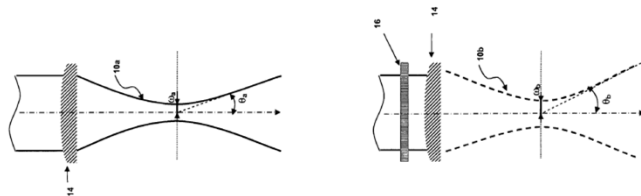
- Two movable free-form optics form a variable-angle axicon



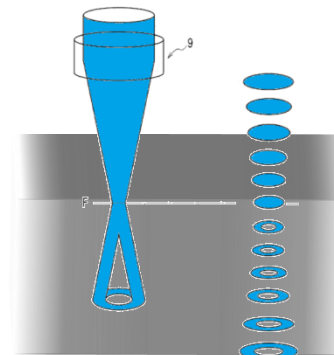
- Ring formation by spherical aberration



- Diffractive optics enlarge BPP



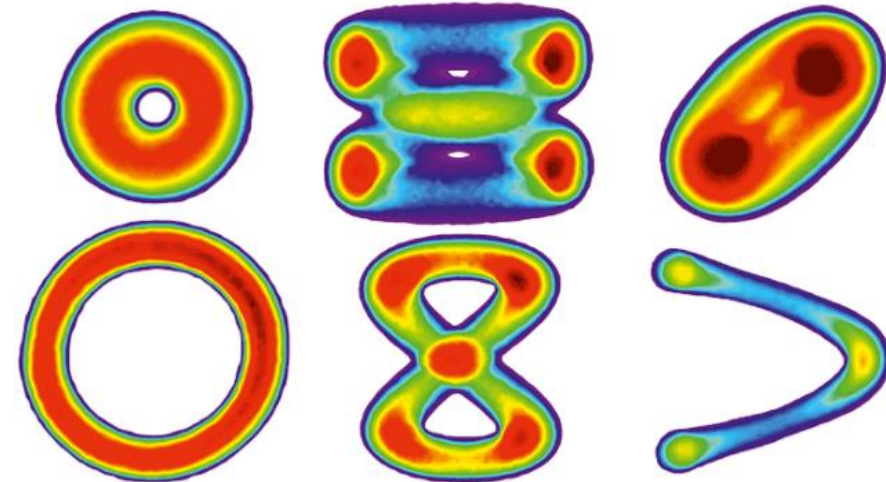
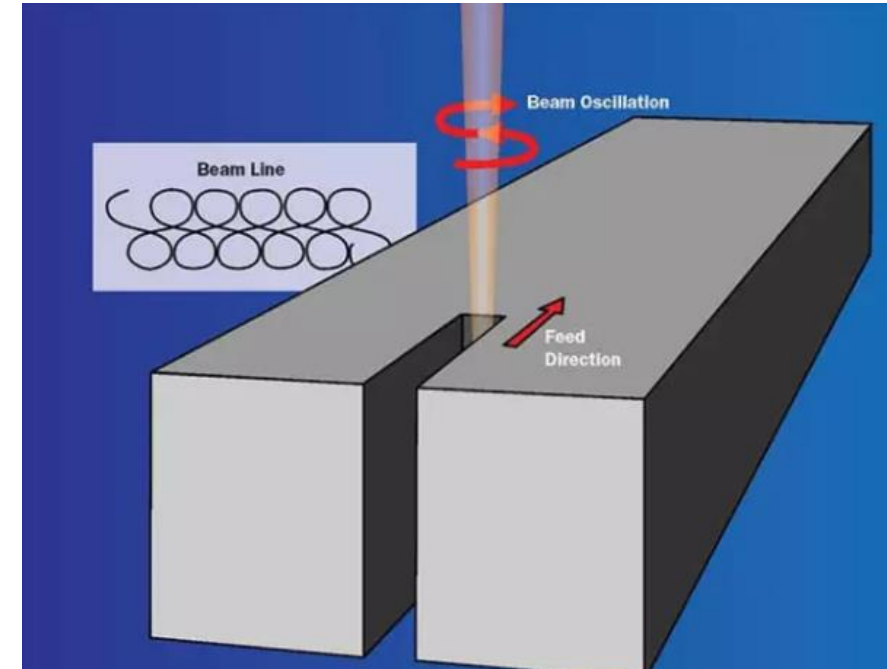
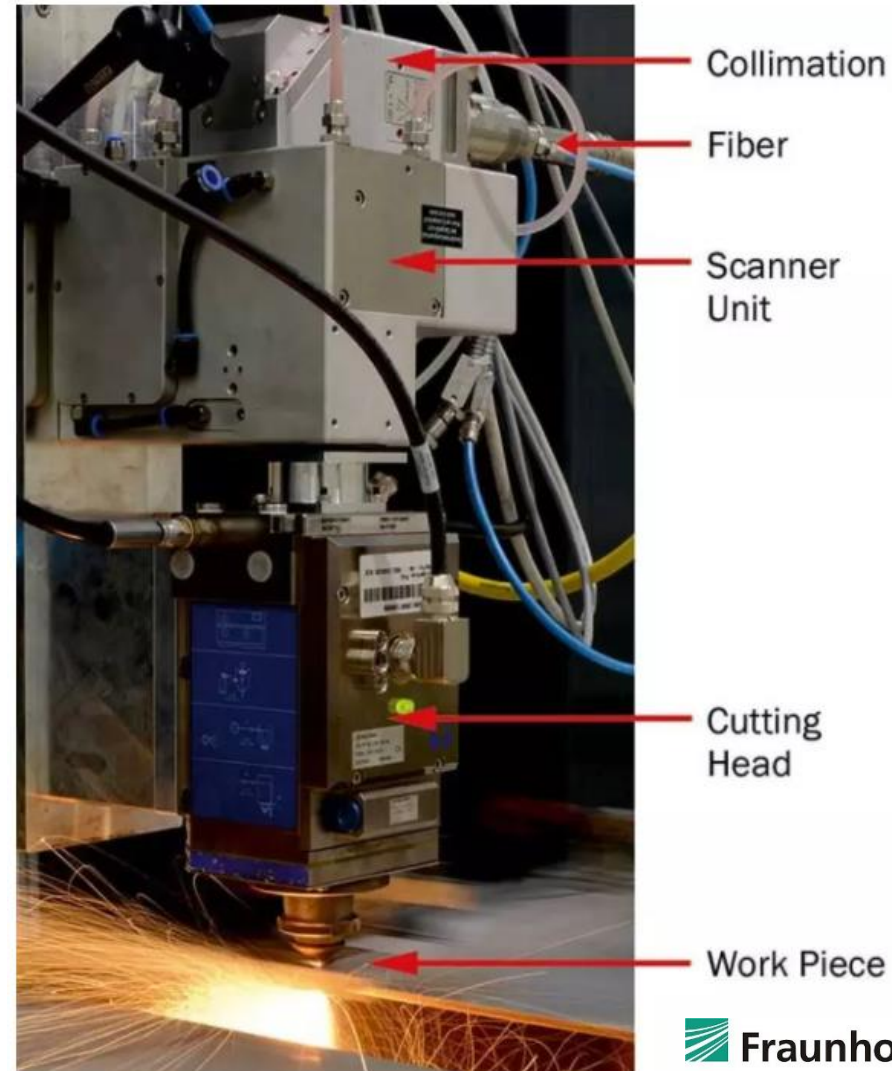
- Axicon creates ring behind the focus



PROGRAMMING THE GPS SOFTWARE – POWER MODULATION

FRAUNHOFER IWS WITH DYNAMIC BEAM SHAPING (DBS)

- two superimposed movements of the laser beam
- Scanlab 1kHz Scanner with 4kW single mode laser and a commercial cutting head
- oscillation speeds of the laser beam in the cut kerf can go as high as 500 m/min



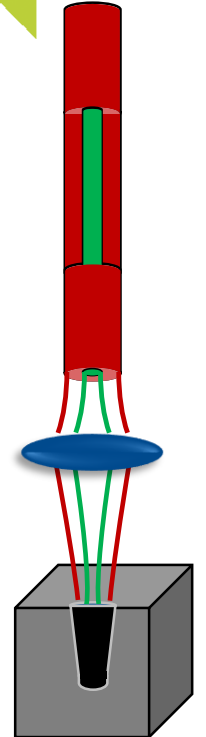
MODIFICATION OF THE BEAM – INTENSITY DISTRIBUTION

.NEW

BRIGHTLINE WELD – LOW-SPATTER LASER WELDING

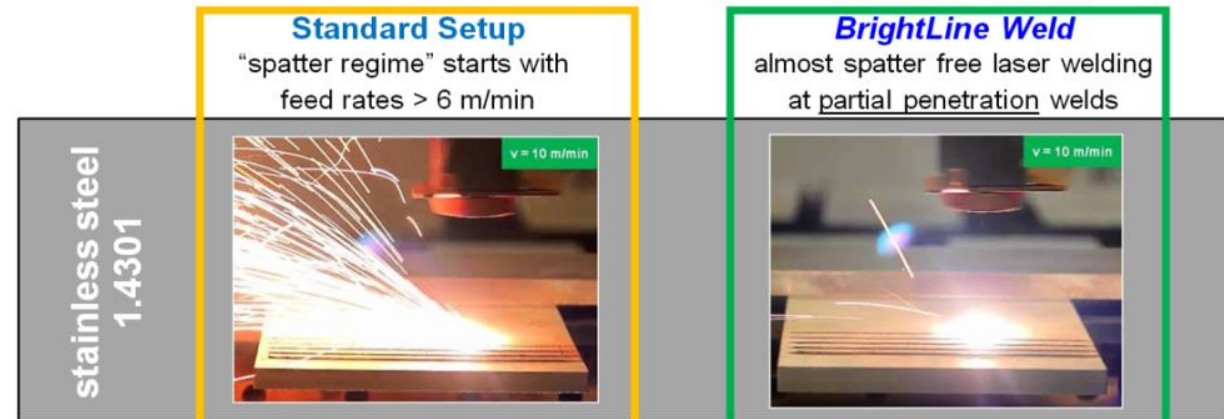
■ Setup:

- TruDisk disk laser
- Patented laser light cable layout from TRUMPF: 2in1 fiber
- Flexible distribution of laser power on inner or outer fiber core
- Adaptation to application-specific optimum



■ Advantages:

- Highest weld quality
- Significantly higher welding speeds
- Minimal spattering



MODIFICATION OF THE BEAM – INTENSITY DISTRIBUTION

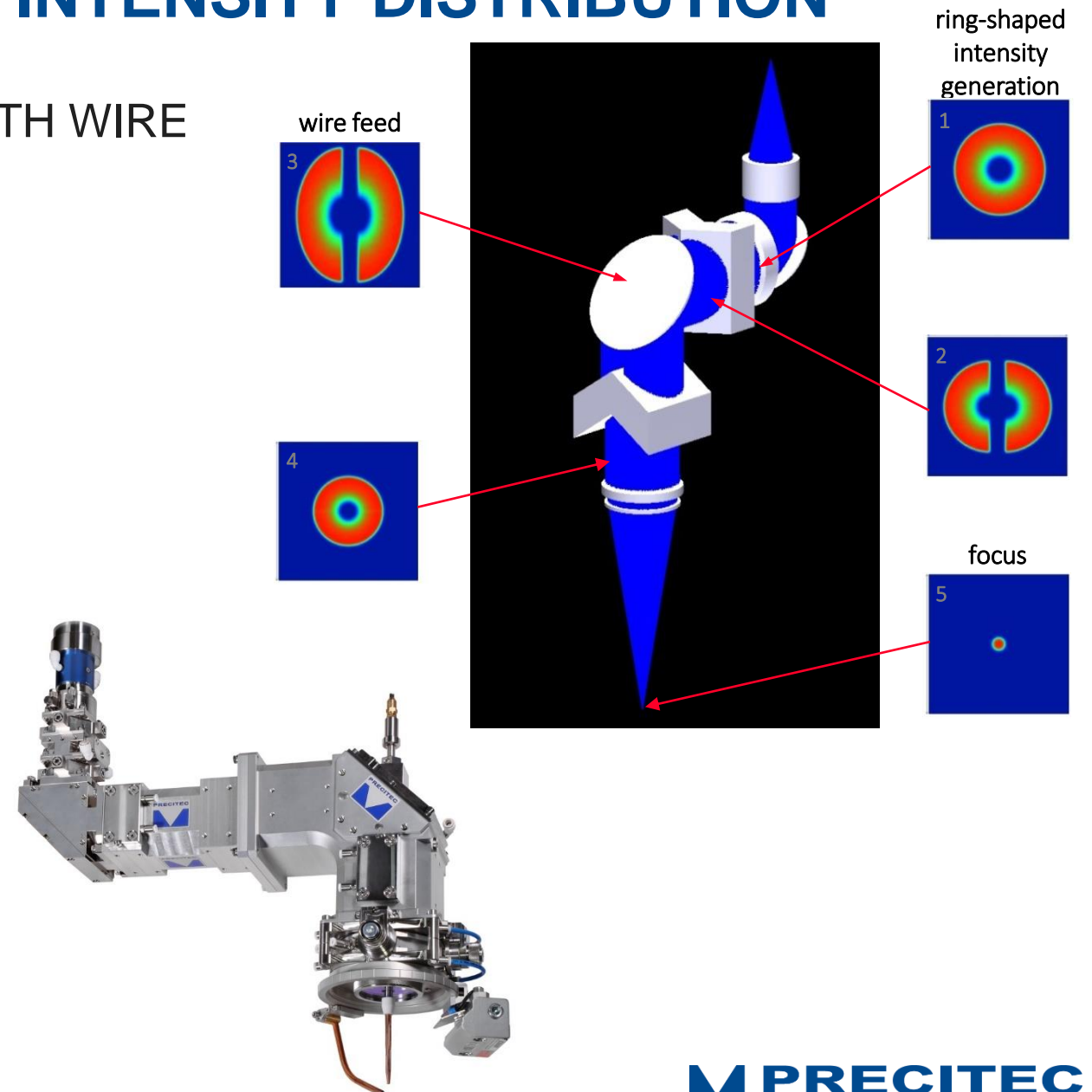
DIRECTION INDEPENDENT PROCESSING WITH WIRE

■ Setup:

- Obscuration-free wire feed
- beam shaping suitable for fiber-based laser systems

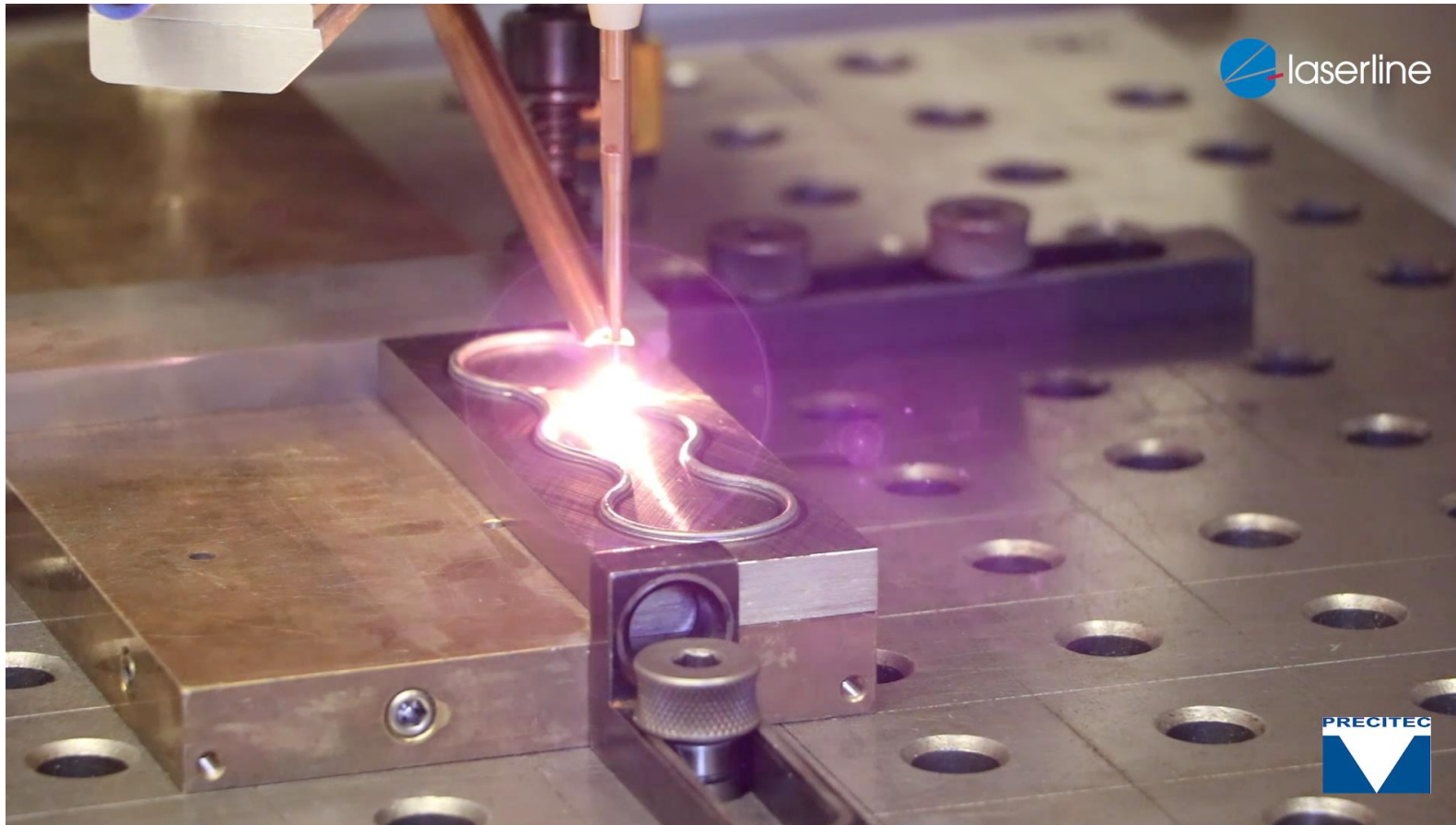
■ Advantages:

- Omni-directional processing
- Up to 100% energy absorption by the wire
- 100% material use
- For cladding, brazing, welding



MODIFICATION OF THE BEAM – INTENSITY DISTRIBUTION

LASER CLADDING WITH PRECITEC COAXPRINTER AND LASERLINE DIODE LASER



SENSORS – ON THE WAY TO INTELLIGENT PROCESSING

CAN OCT START ONE'S TRIUMPH IN LASER MATERIALS PROCESSING?

PRESS RELEASE

Optical Coherence Tomography Market 8.9% of CAGR with SD-OCT, Swept-Source OCT, Industry Highlight by Top Vendors Heidelberg Engineering GmbH, Optovue, Michelson Diagnostics, Thorlabs Inc. and Agfa He

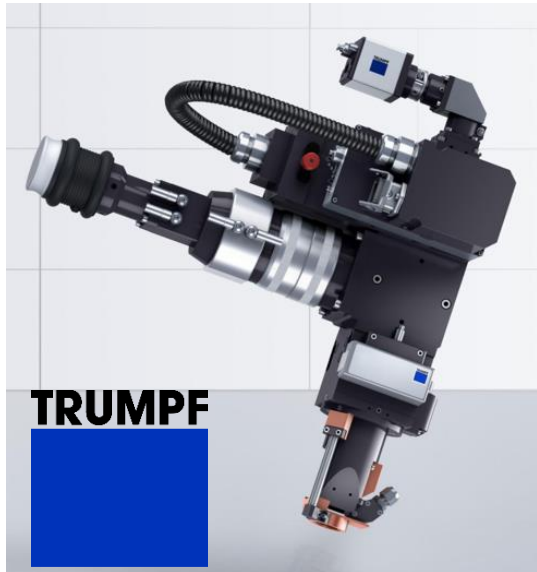
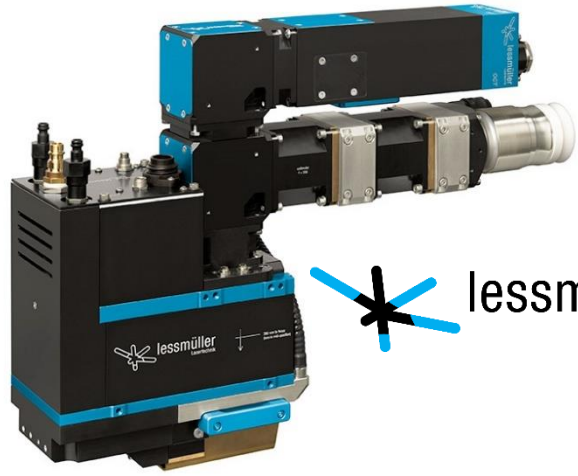
"Optical Coherence Tomography Market" The Global Optical Coherence Tomography Market is expected to grow at a CAGR of 8.9% during the forecast period 2017-2023. On the basis of the technology, Spectral-domain OCT...

Monday, May 14th 2018, 4:14 pm EDT

Global Optical Coherence Tomography Market – Overview:

The global optical coherence tomography market is growing with a moderate pace; mainly due to increase in genetic and diabetes patient population. Also major players involve in research and development to provide better treatment options. In this regards, on Jan. 4, 2018, Blackbird Robotersysteme GmbH and participating in a research project with the Technical University of Munich's Institute for Machine Tools and Industrial Management and multiple industrial partners to explore optical coherence tomography's potential for remote laser welding in auto manufacturing.

OCT – STATUS QUO



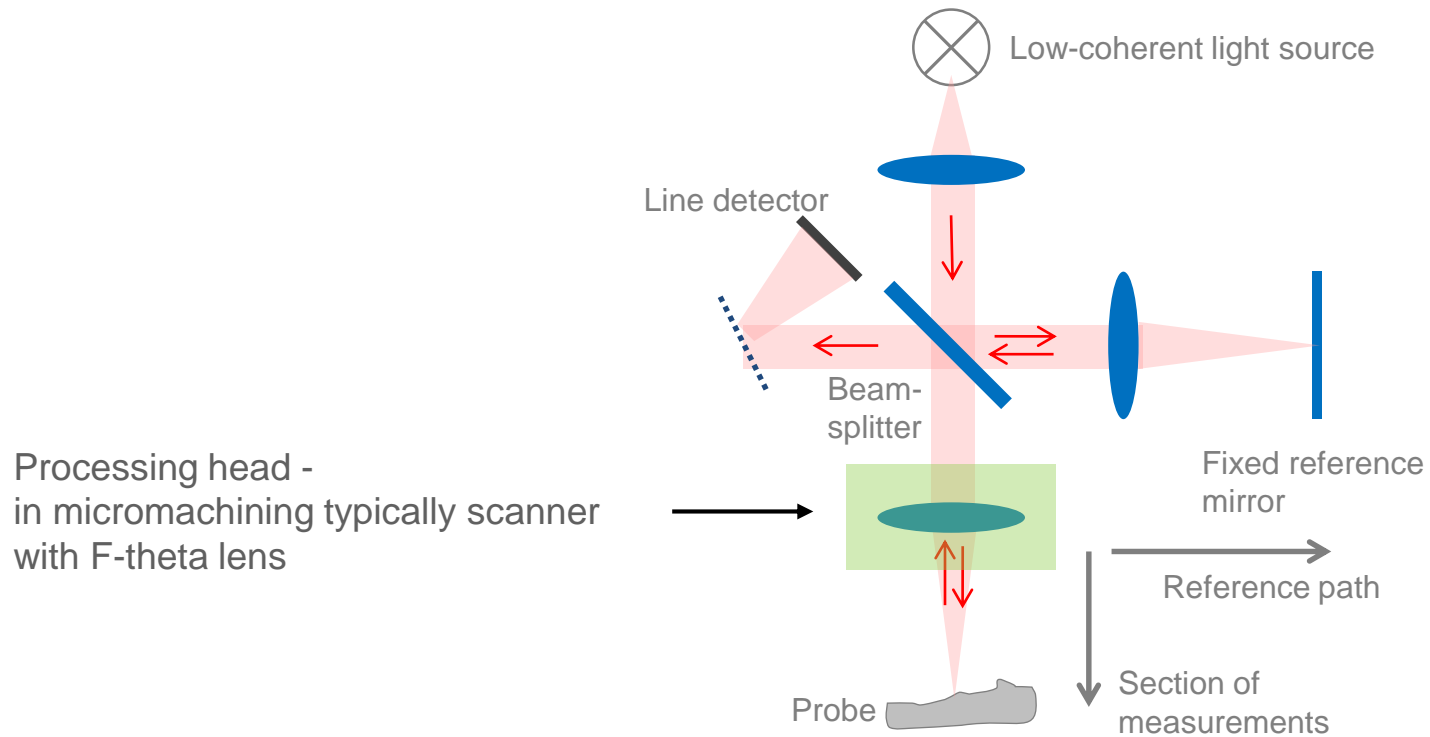
TRUMPF



OCT – STATUS QUO

PRINCIPLE OF LOW-COHERENCE INTERFEROMETRY

- Distance measurement by analysis of a signal modulation (interference of two partial waves)



OCT @ APPLICATIONS ON R&D LEVEL

APPROACH FOR LAYER THICKNESS CONTROL



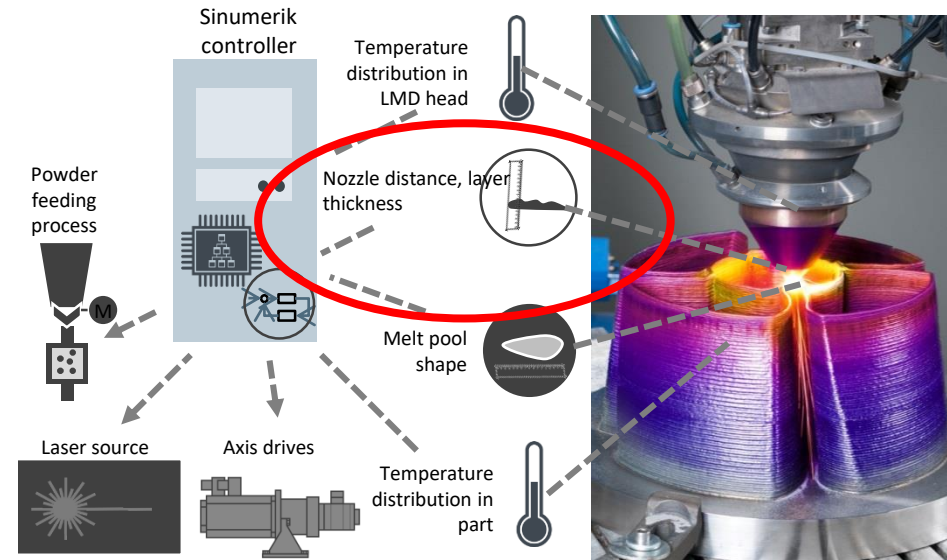
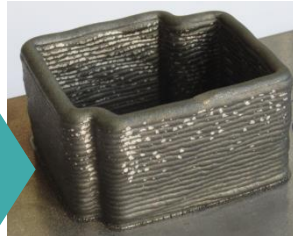
Challenge

Due to the lack of geometrical process data there can't be realized a constant layer thickness in the DED process. This leads to deviations from the required design and instable processes.



Requirements

Customers require an **automatically controlled** building process and a stable print quality: print first-time-right

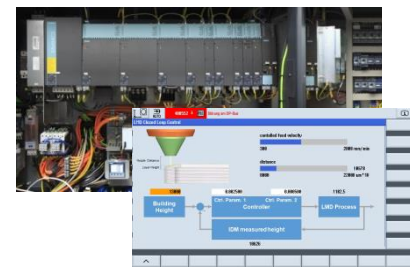


Solution

Layer Thickness – Feed Rate Control
Sensor offered by Precitec – working together with control cycles developed for SINUMERIK 840DsI

Common Technology Development

Siemens
Control Cycles for Sinumerik 840DsI



Precitec
Distance sensor for DED Heads



OCT @ APPLICATIONS ON R&D LEVEL

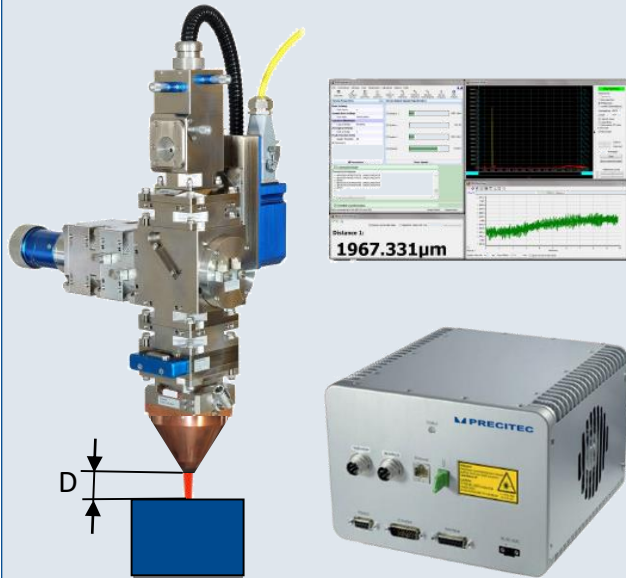
LAYER THICKNESS CONTROL - ARCHITECTURE



PRECITEC

IDM Sensor

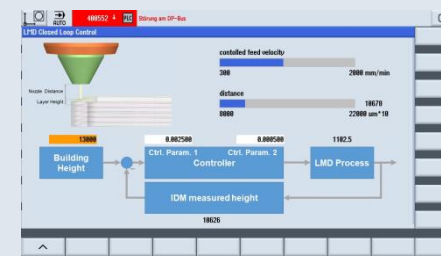
- In process measurement of nozzle distance
- Integrable in various LMD Heads



SIEMENS Machine Control

HMI-Module

Sinumerik
840D sl



Sensor Interface

ET 200 SP



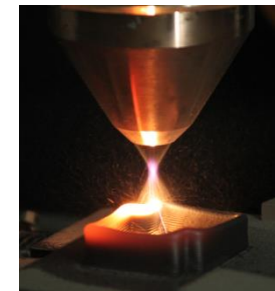
Building height:

$$h = \sqrt{\frac{4 \eta m_{out}}{\pi \rho c v}}$$

$$h = K_{LMD} \sqrt{\frac{\rho h}{\rho}}$$

$\rho = 7.5 \frac{kg}{m^3}$
 $\eta = 2.15$

Layer Thickness Control



Uncontrolled,
out of focus process

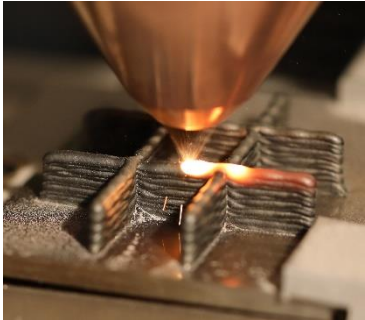


Controlled,
in focus process

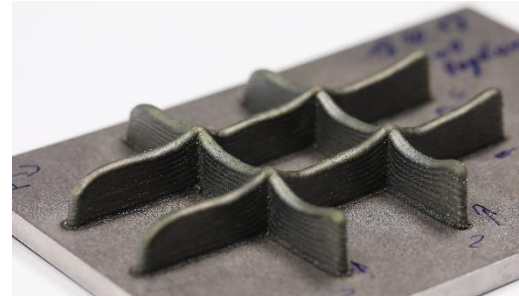
OCT @ APPLICATIONS ON R&D LEVEL

SAMPLE PARTS

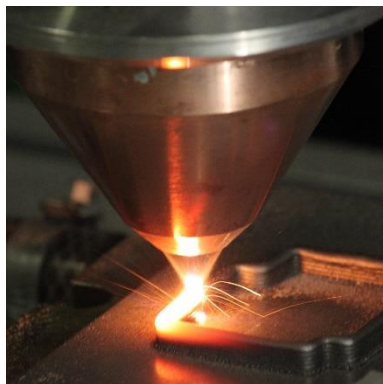
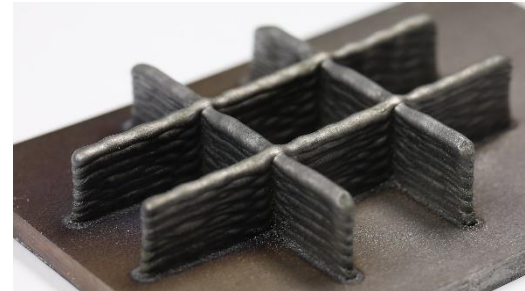
Standard DED process
with imperfections



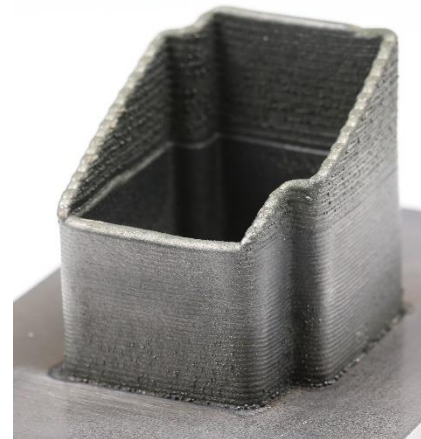
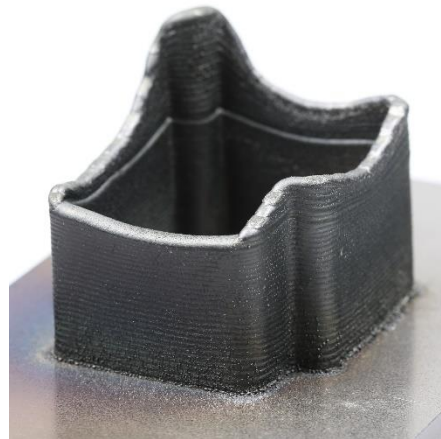
Hashtag: Crossing walls



Controlled DED process



Siemens Motor cover part



Results

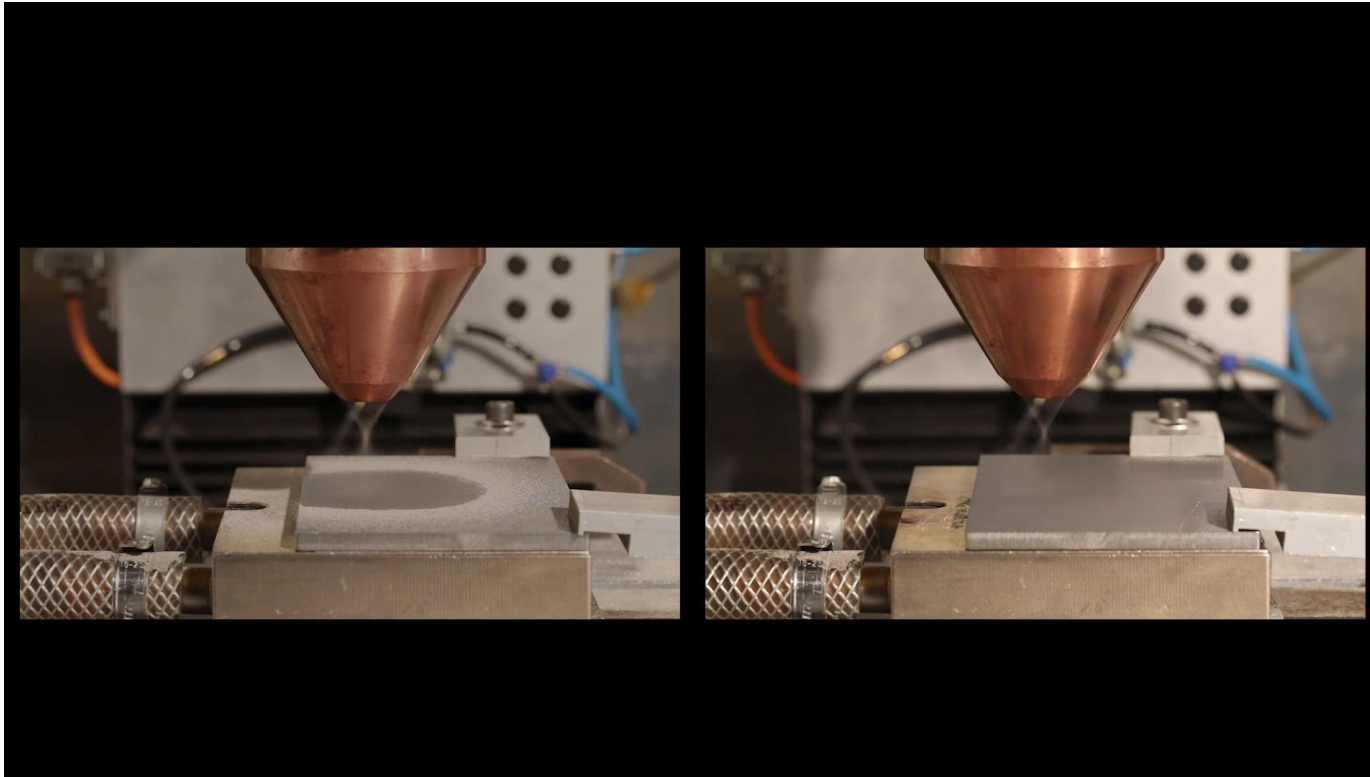
- IDM Sensor delivers reliable distance values during the DED Process
- Feed rate has the main impact on the layer thickness and is easy to control
- Control algorithms has to be adapted on various building strategy

Next steps

- Further development of control algorithms
- System implementation and testing in IBARMIA machine
- Close collaboration between Siemens, Precitec and RWTH Aachen to establish the closed loop motion control on the market

OCT @ APPLICATIONS ON R&D LEVEL

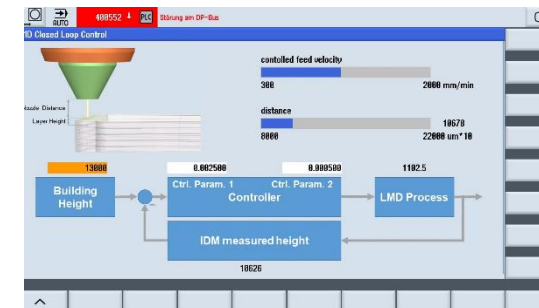
DED PROCESS WITH LAYER THICKNESS CONTROL



Movie DED Closed Loop Motion Control



3 axes test setup with Sinumerik 840D sl and Precitec Head and IDM System

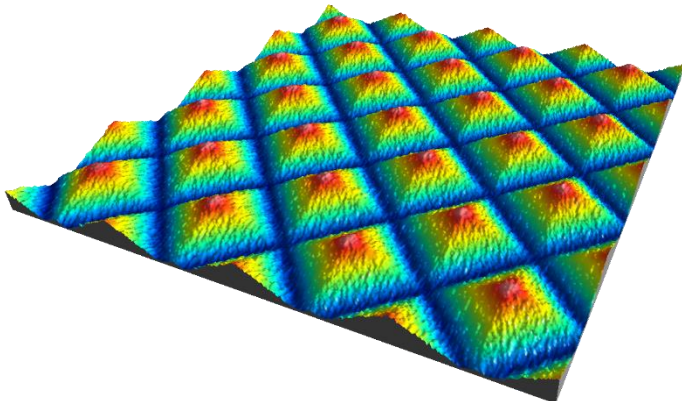
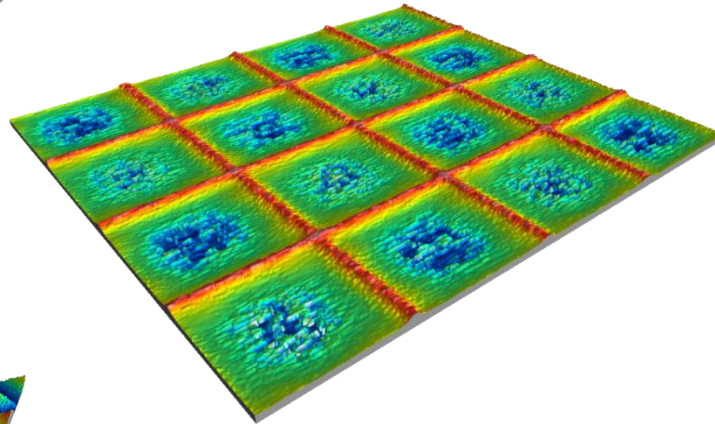
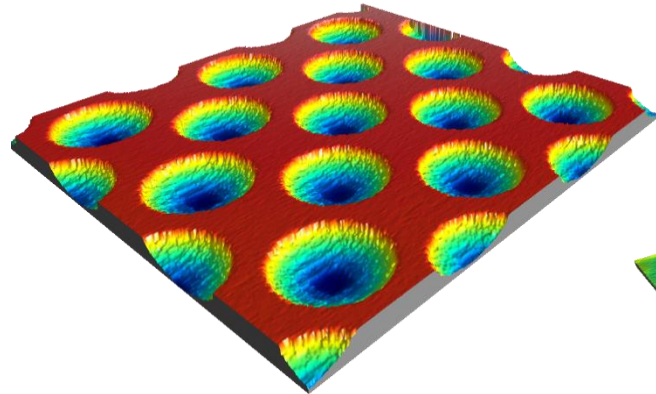


Customized Sinumerik Operate Display

OCT @ APPLICATIONS ON R&D LEVEL

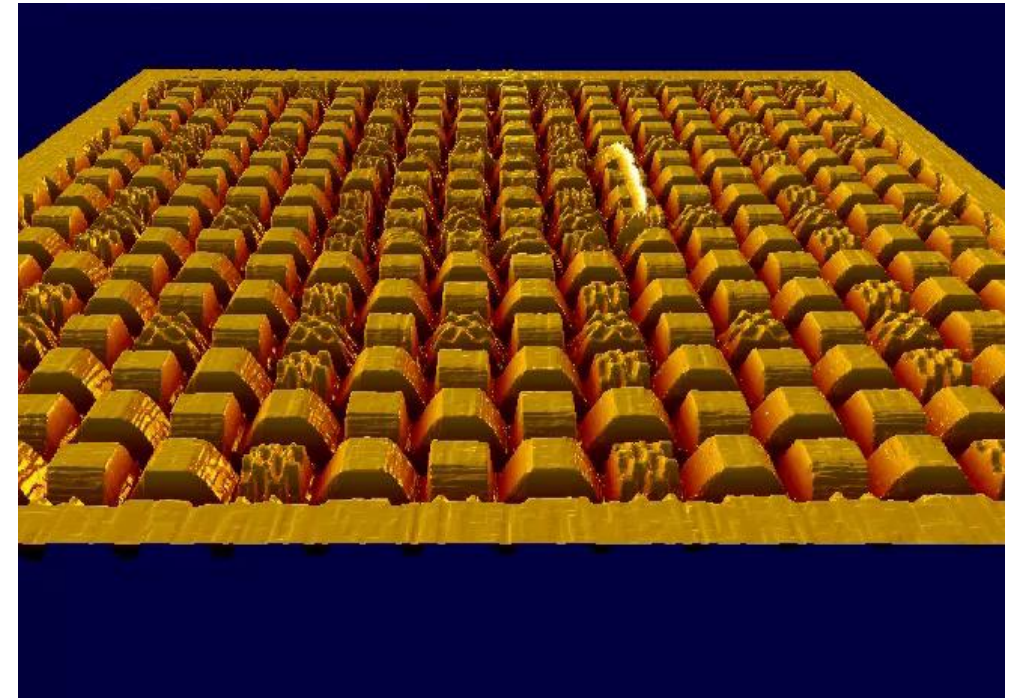
OCT ADAPTATION TO A LASER ABLATION PROCESS

- Utilization of the identical optical path as the structuring laser



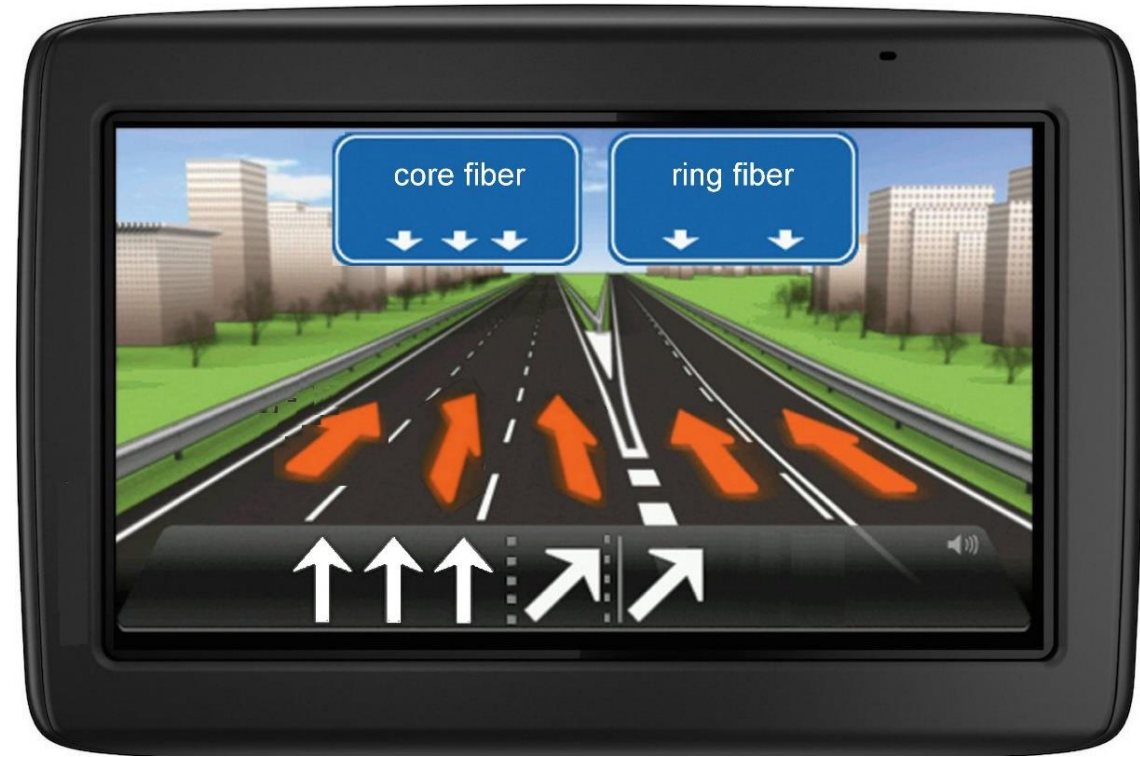
eVerest ReWork

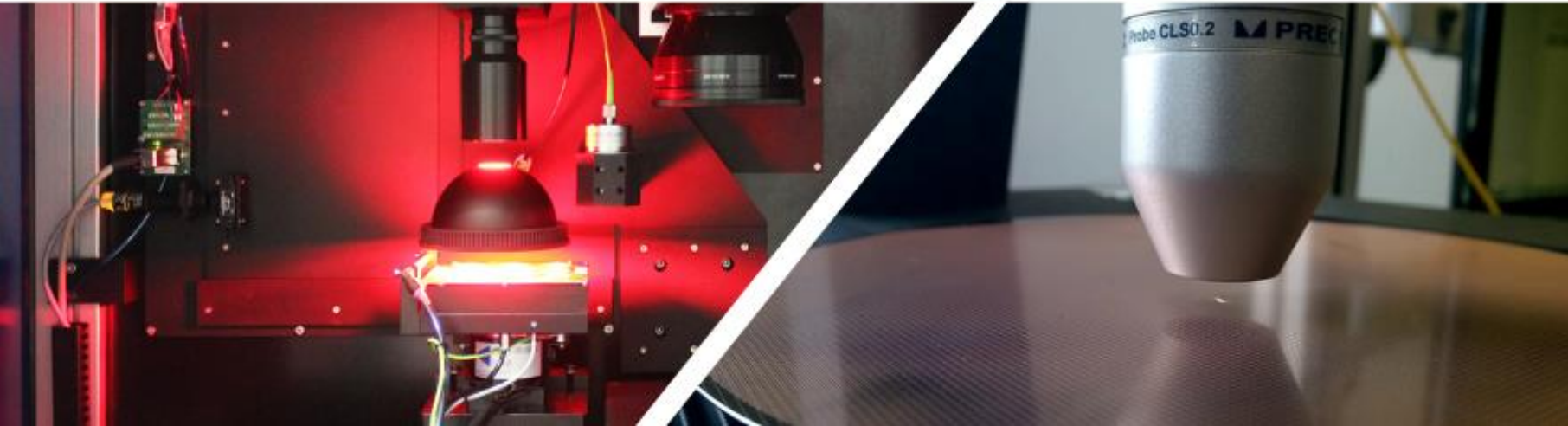
PRECISE »ToolRep«



TAKE AWAY MESSAGES

- ✓ For nearly every application there is an existing solution
- ✓ Don't hesitate to talk to the experts from industry and research
- ✓ The software for the “GPS system for photons” is on an extremely high level
- ✓ The work on the “quality of the roads” is ongoing
- ✓ Controlled processes based on innovative sensor technology is crucial to build machines 4 intelligent processing
- ✓ Without the support of Universities and Institutes, without dedicated funding we would not be able to bring innovation into new products





Thanks for your kind attention!

Dr. Markus Kogel-Hollacher
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