Ultrafast Laser Micro Processing in Practice

Swiss Laser Microprocessing Solutions

Swissphotonics Workshop ‖ EPHJ – EPMT – SMT 2013

SWISS MICRO LASER

LEADING IN MICRO PROCESSING

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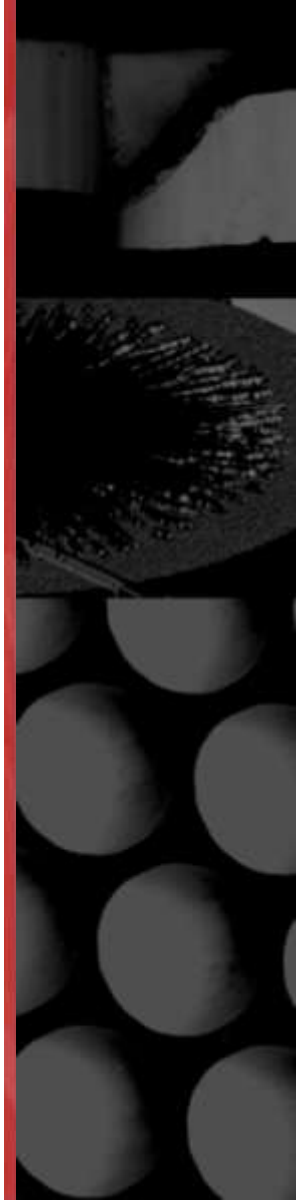

Outline

1. Introduction and Motivation
2. Swiss Micro Laser GmbH
3. Beam – Matter - Interaction
4. Prozess Efficiency und Scalability
5. Application Examples
6. Conclusion und Future Prospects

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Introduction and Motivation

STATE-OF-THE-ART
ULTRA FAST LASER BEAM SOURCES

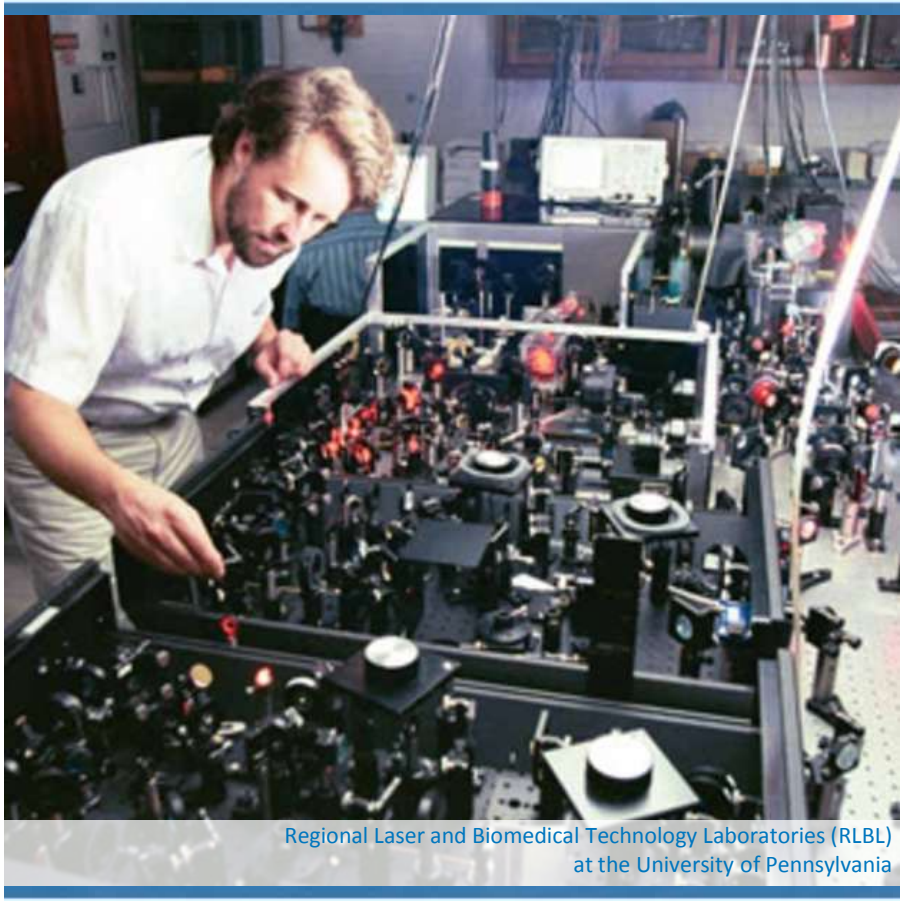
Advantages of Ultra Fast Laser Radiation

- Material Independent
- No Thermal Impact| »Cold Ablation«
- No Set-Up| Digital Manufacturing
- Highest Precision, lateral and vertical

Replacement of Existing Technologies

Development of New Techniques

- Functionalization of Surfaces



Regional Laser and Biomedical Technology Laboratories (RLBL) at the University of Pennsylvania

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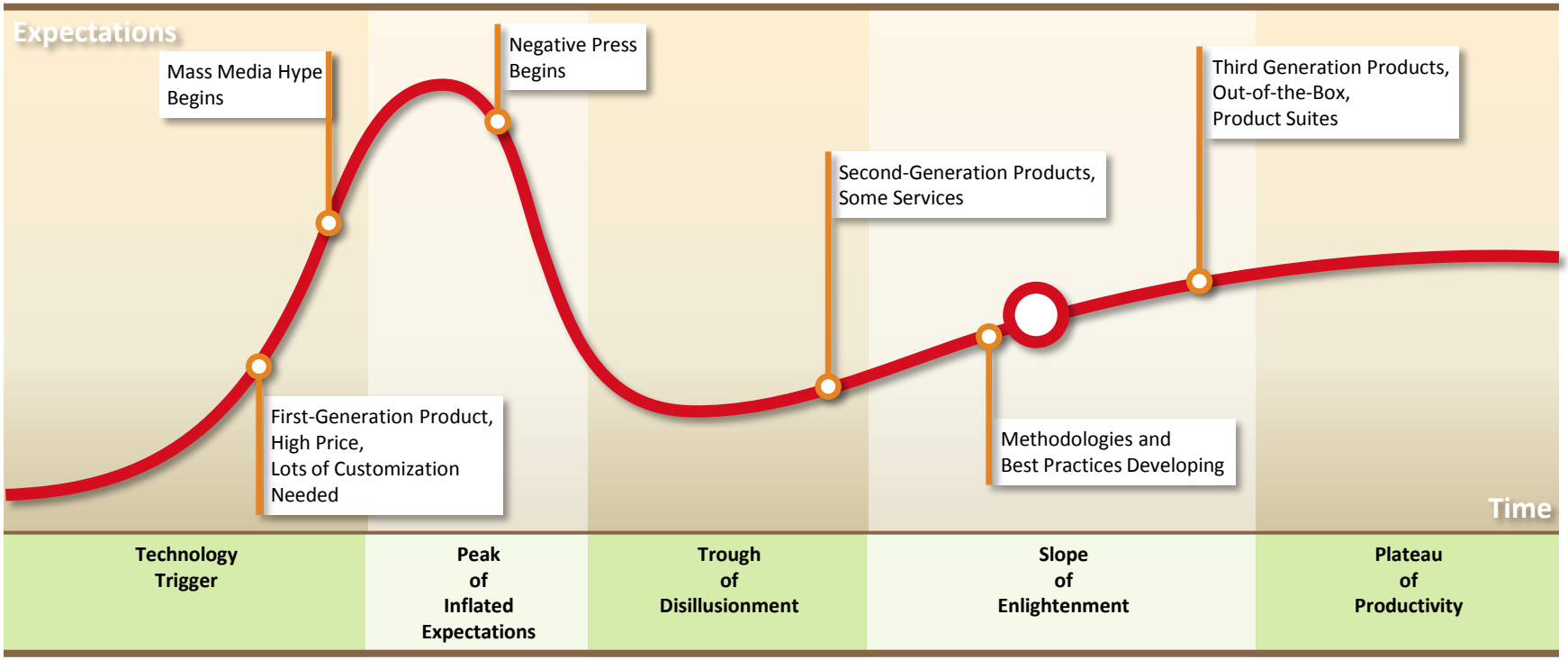
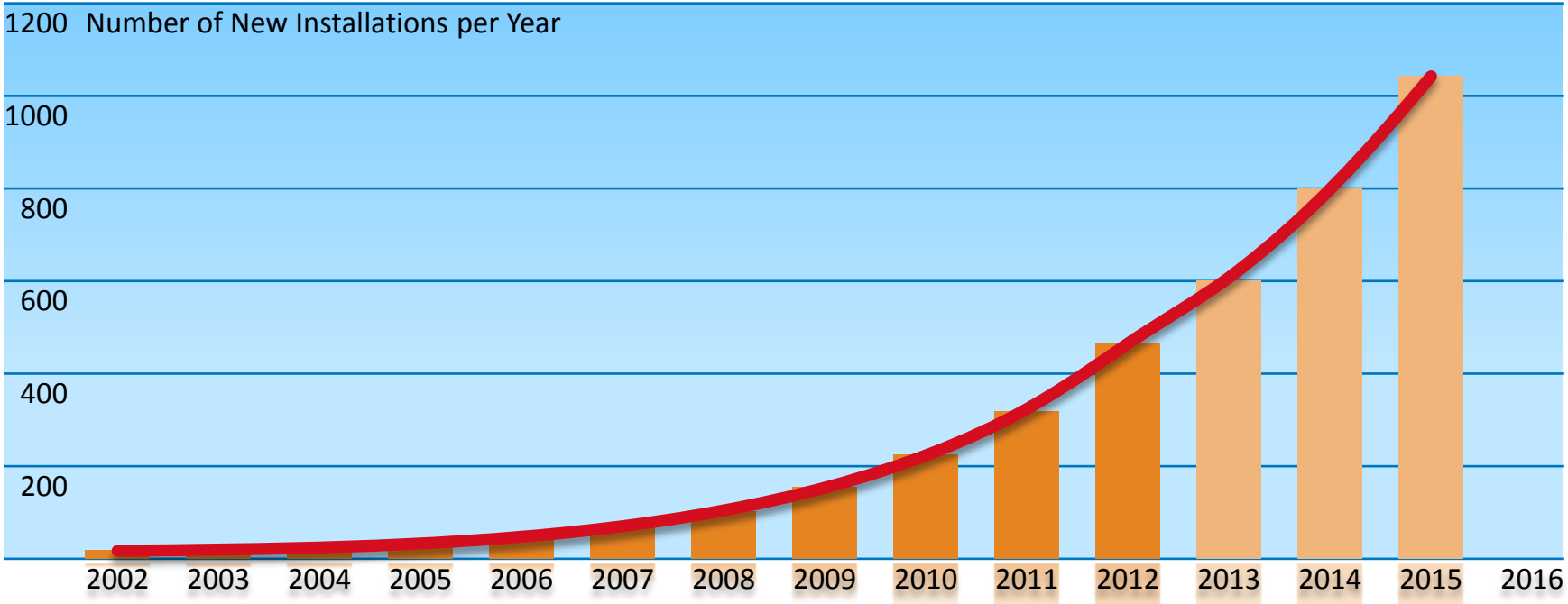
National Institute of Standards and Technology

Ultra Fast Laser Systems for Material Processing Hype-Cycle



Ultra Fast Laser Systems for Material Processing Forecast



Market Assessment by Fraunhofer ILT

Micro Material Processing as Contract Manufacturing

APPLICATION OF ULTRA FAST LASERS

- Only Pioneers and Risk-loving Companies
- Most Companies evaluate applications
- Challenges
  - Acquisition and Maintenance Costs
  - Level of Education of Employees
  - Development of Process and Machine
  - Additional Fundamental Development
    - Femtosecond Laser Beam Sources
    - All-In-Fiber Laser Beam Sources

OPPORTUNITY FOR CONTRACT MANUFACTURING

- Basic Research on Existing Products
- Feasibility Studies
- Prototypes
- Small and Special Series
- Professional Evaluation of Technical Challenges
- Reduction of Financial Risk

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Presentation of the Company

Swiss Micro Laser GmbH

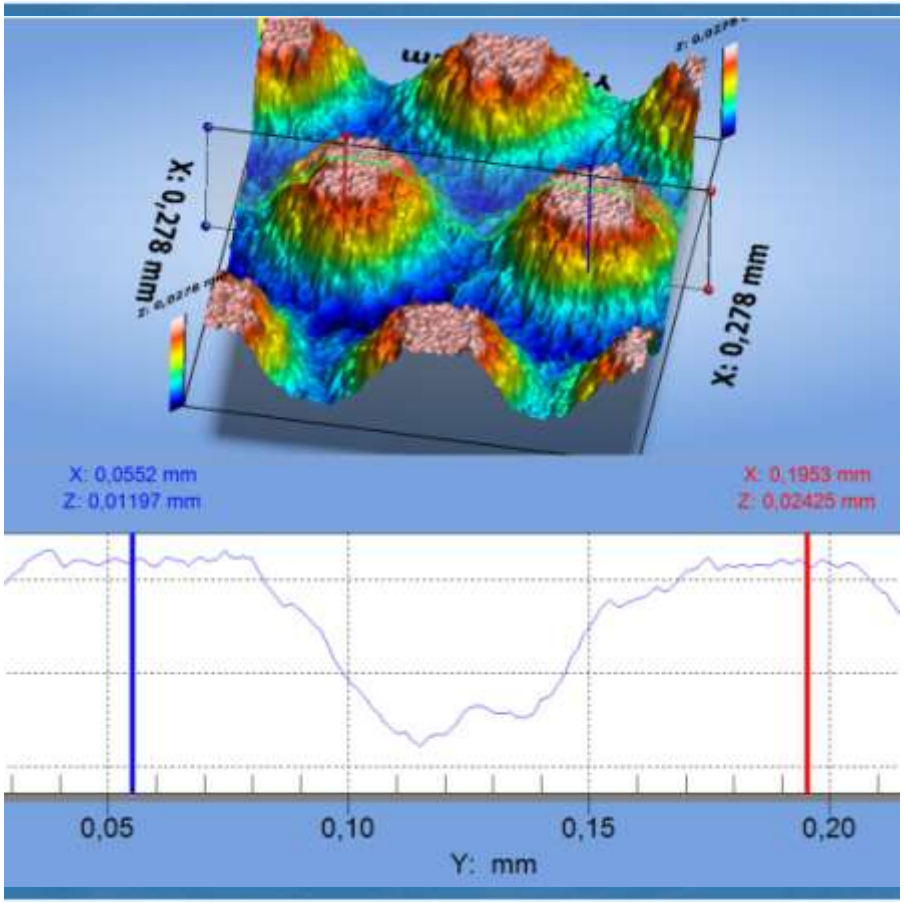
Luegisland 2-4
CH-8143 Stallikon
Schweiz

Swiss Micro Laser GmbH

Company Structure

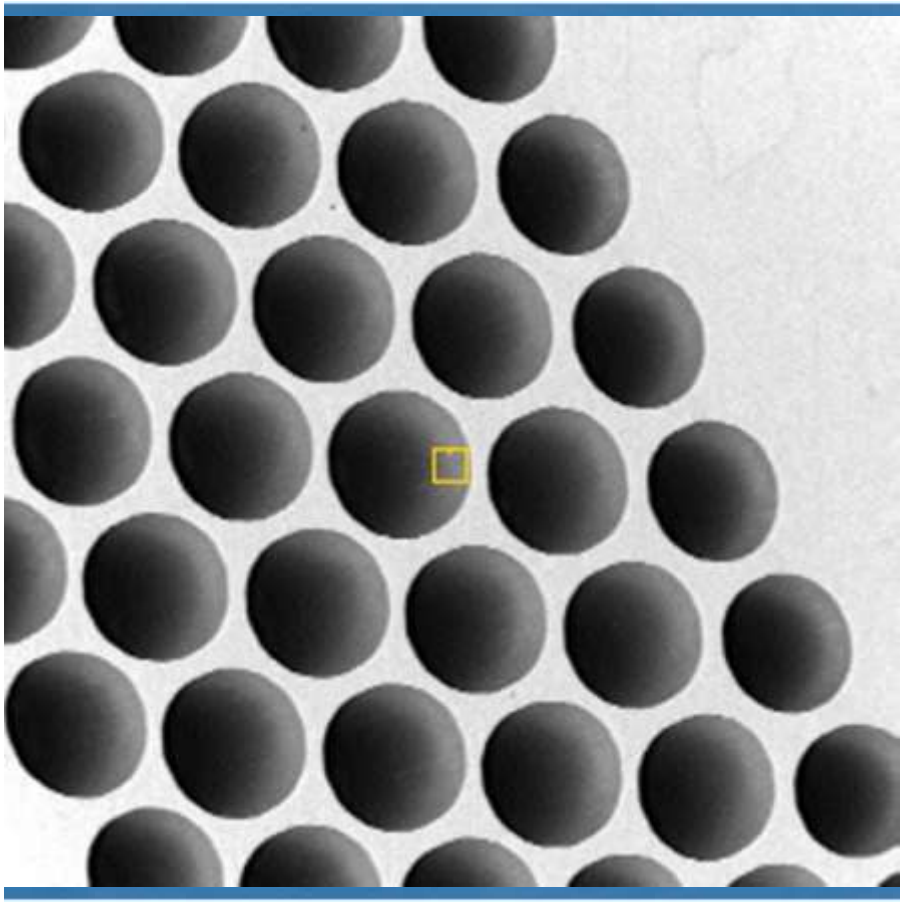
BACKGROUND

- 20 Years Track Record in Laser Technology
- More than 20 Employees
- Contract Manufacturing
- Research and Development
- High-Tech Company
- Subsidiaries in Europe and the US
- Close Collaborations / Strategic Partnerships with Laser Manufacturers and System Suppliers

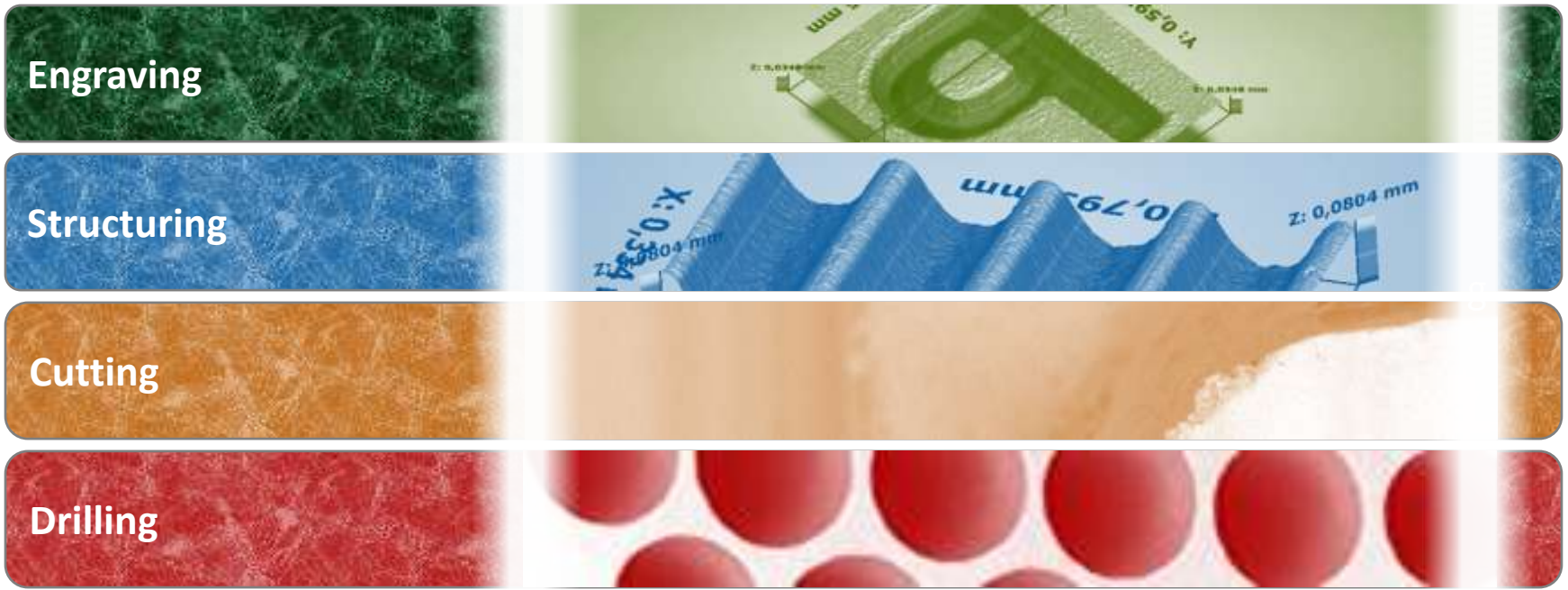


EQUIPMENT

- Clean Room
- Various Optical Measurement Equipment
- Scanning Electron Microscope SEM
- 7 Nanosecond Laser UV IR
- 11 Picosecond Laser UV IR
- 1 Femtosecond Laser IR



Technologies



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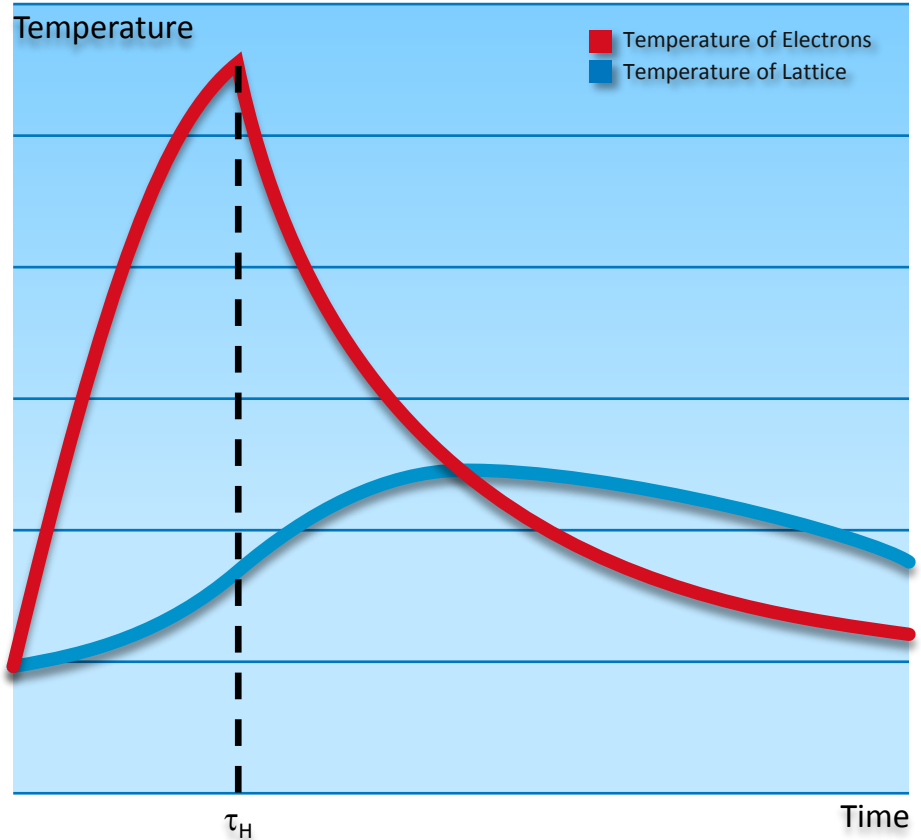
Fundamentals

Beam – Matter - Interaction

THEORY
TWO-TEMPERATURE-MODEL

- Independent Treatment of Temperatures of Electrons und Lattice
- Energy of Ultra Fast Laser Pulses is completely absorbed by the Electrons
- Accelerated Electrons Crack the Bonds and Material Vaporizes



M. N. Libenson: Ultrashort-Pulse Laser-Matter Interaction and Fast Instabilities
International Trends in Applied Optics, 2002

Reality

- » Cold Ablation« only Valid for Slow Processing or Single Laser Pulses
- For High Repetition Rates and Small Geometries Warming of Base Material Noticeable
- Consequence: Influence on Processing Result
  - Oxidation / Burning
  - Creation of Stresses
  - Creation of Melt

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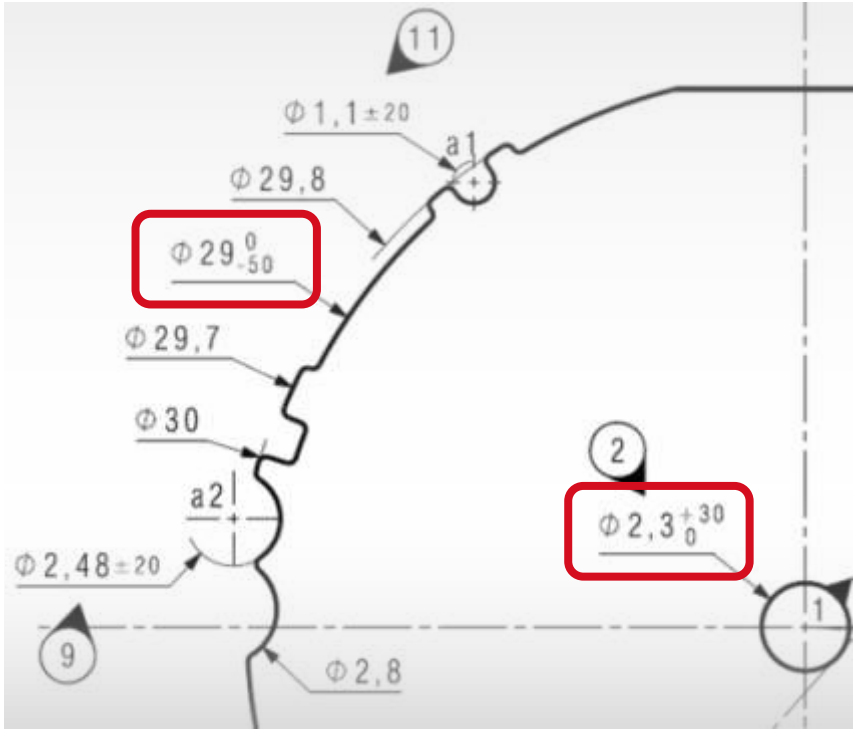
Laser Beam System and Machine Concept

Limiting Factors

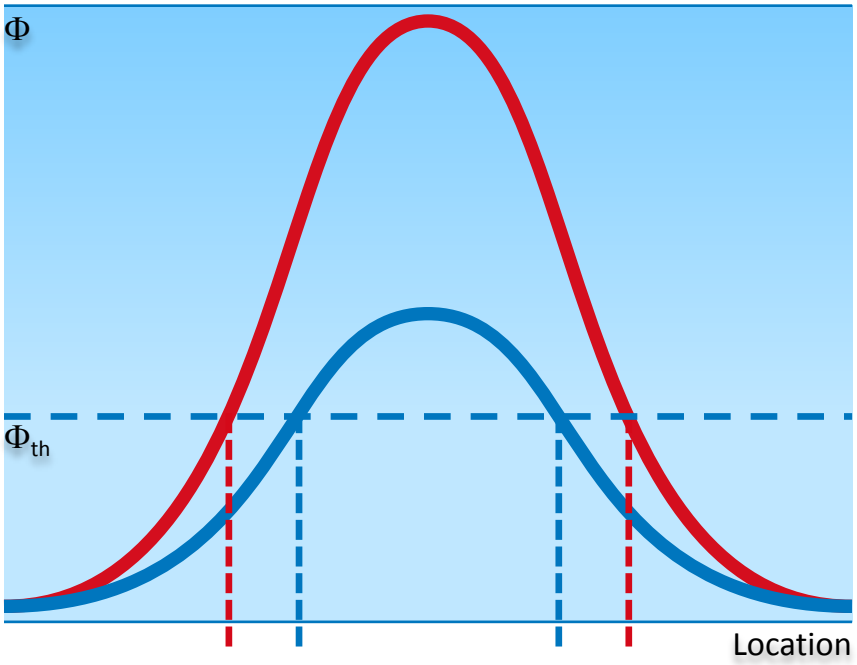
Process Efficiency und Scalability

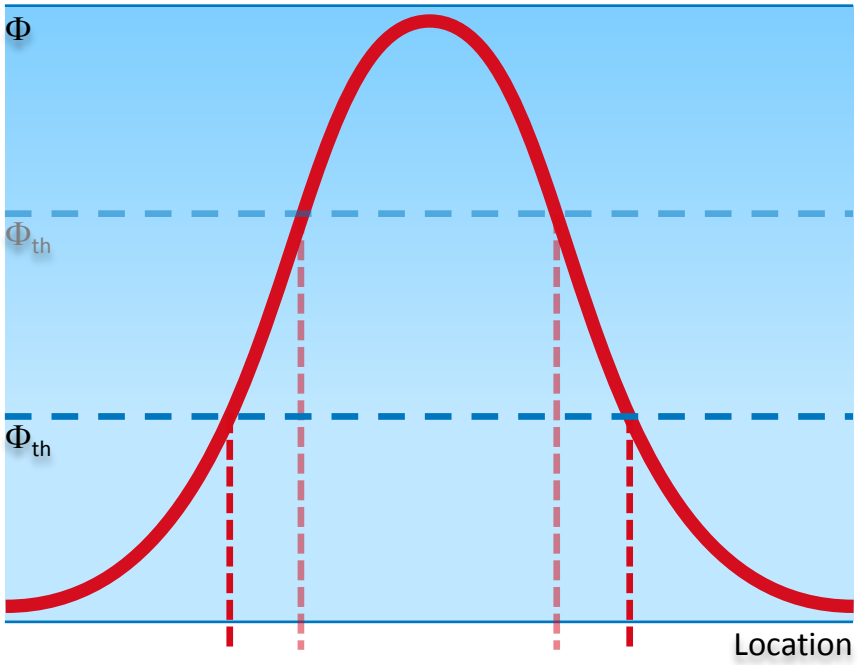
Preparations

- Files in dxf, stp,…
  - Polygon Lines not closed
  - Tolerances not symmetric
- Engraving | Structuring
  - 2D 2½D 3D
  - Processing Strategy
- Cutting
  - Cutting Width vs. Material Thickness
  - Correction of Radius



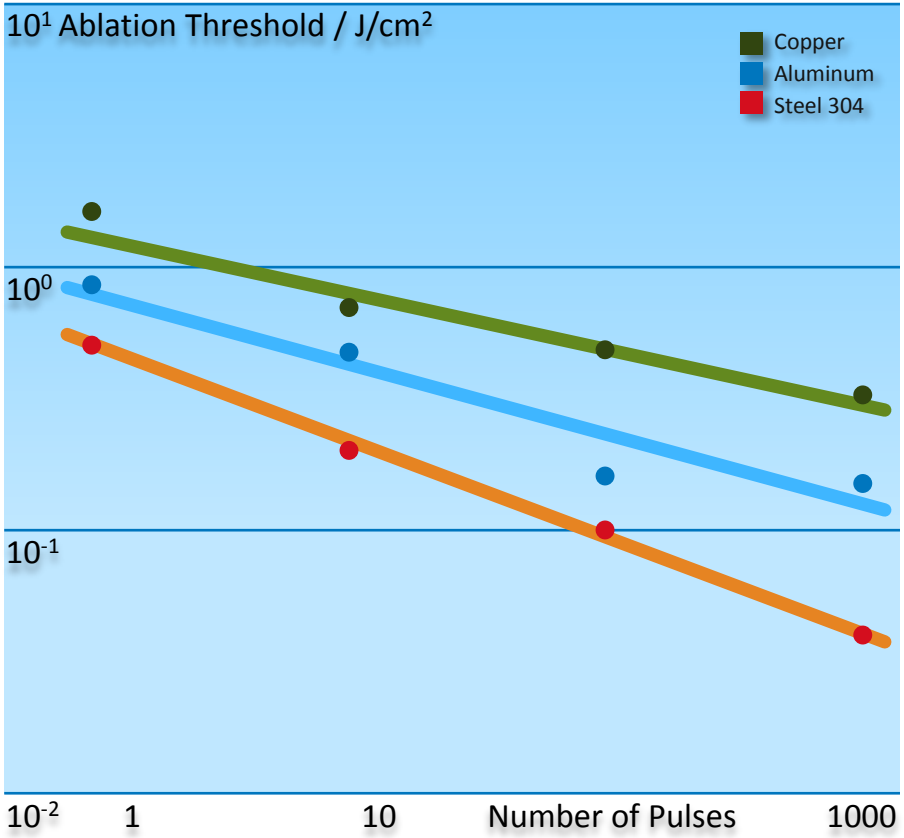
Effective Beam Radius





DEPENDENCE OF ABLATION THRESHOLD

- Ablation Threshold Drops with Number of Pulses
- Ablation Depth Depends on Processing Strategy
- Ablation Depth does not Scale Linearly
- Inhomogeneity or Impurity in Base Material may Lead to Generation of Cones



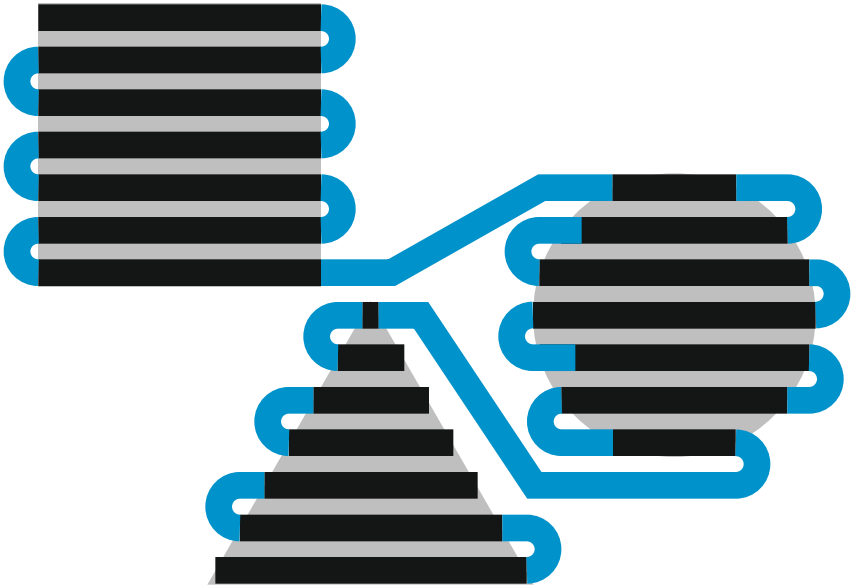
G. Raciukaitis: Use of High Repetition Rate and High Power Lasers
JLMN Journal of Laser Micro/Nanoengineering Vol. 4 (3), 2009

Prozess Efficiency und Scalability

Processing Strategies

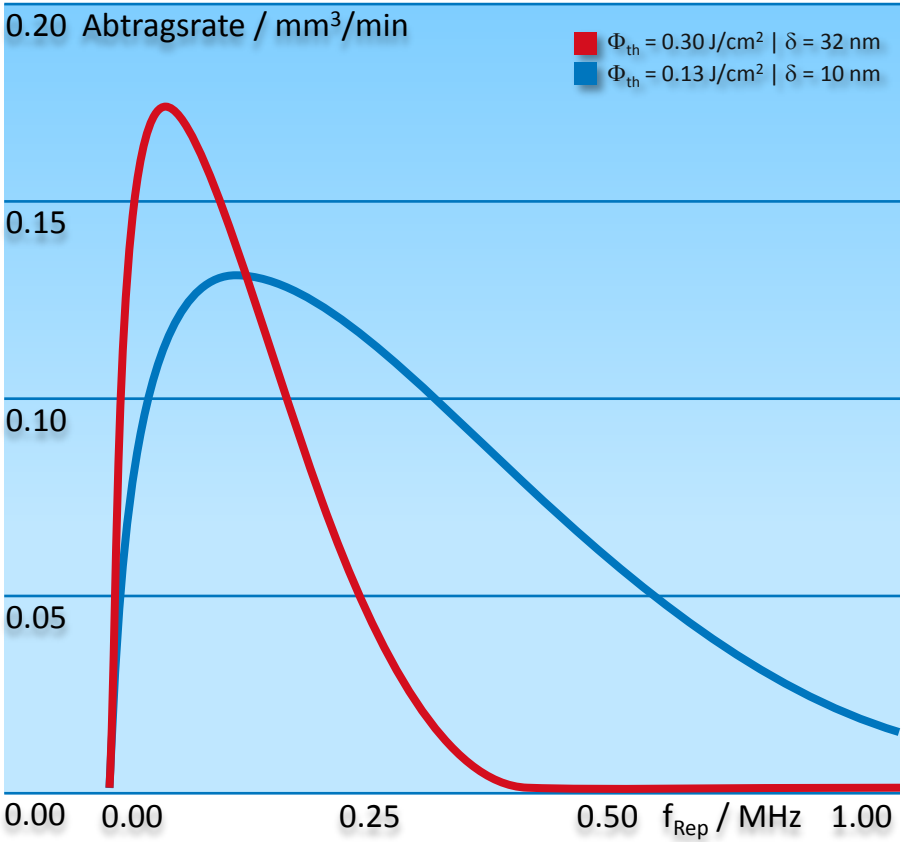
»OVERALL PICTURE «

»SINGLE SHAPE«



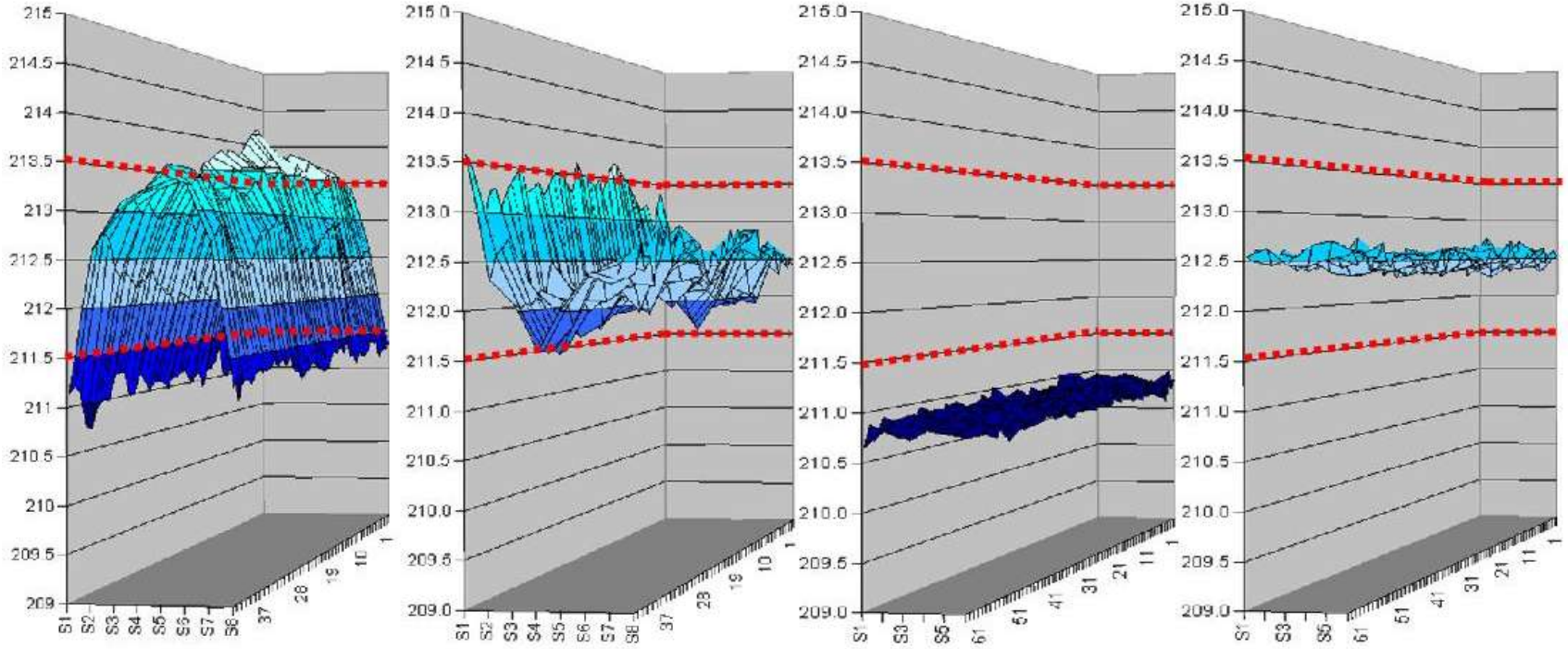
DEPENDENCE OF ABLATION RATE

- Ablation Rate Depending on Repetition Rate
- Maximum depending on
  - Ablation Threshold
  - Optical Penetration Depth
- Processing Speed Generally not in any Order Scalable



Neuenschwander, B.: From ps to fs: Dependence of the Material Removal Rate and the Surface Quality on the Pulse Duration for Metals, Semiconductors and Oxides, ICALEO 2012, Paper M1004 (2012)

Process Development and Optimization



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Drilling

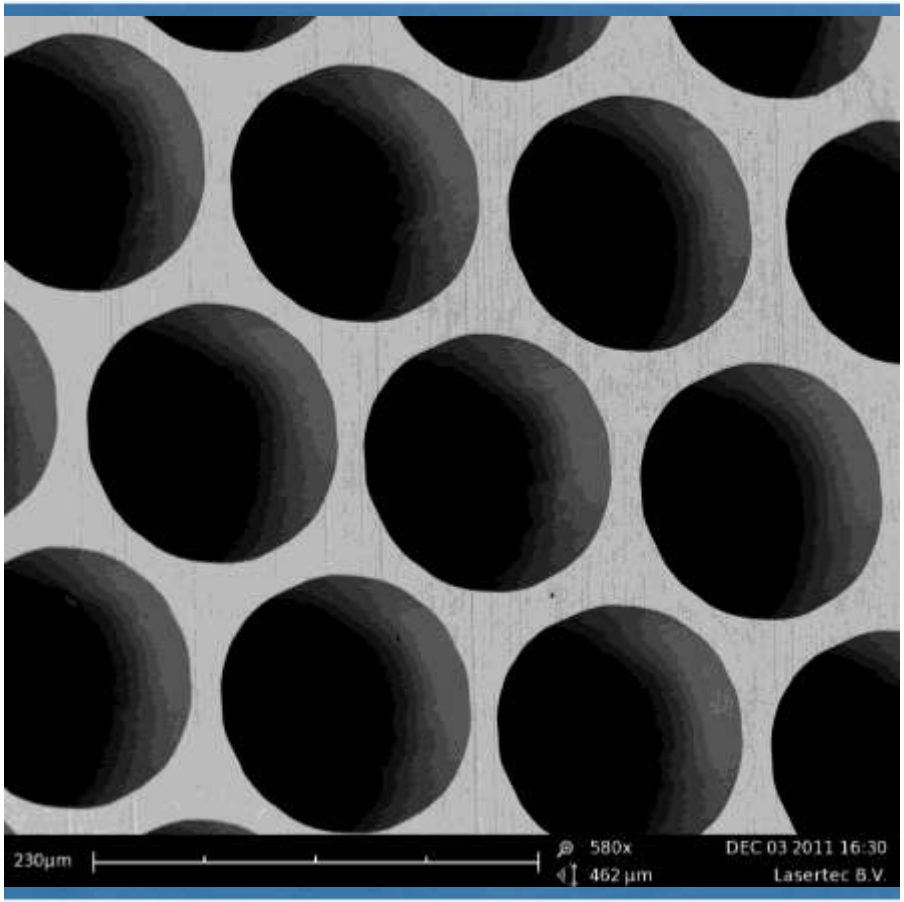
Cutting

Engraving

Application Examples

PRECISION DRILLING IN 300 µm COPPER FOIL

Hole Diameter	130 µm
Distance between two Holes	20 µm
Position Accuracy	1 µm



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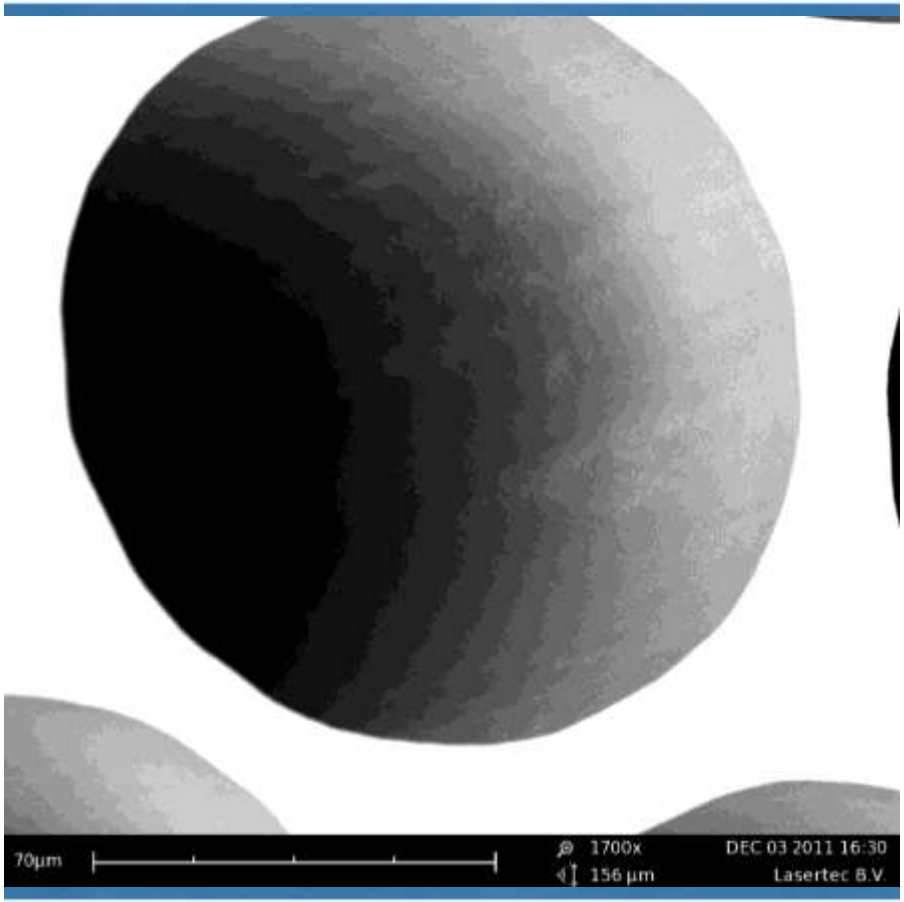
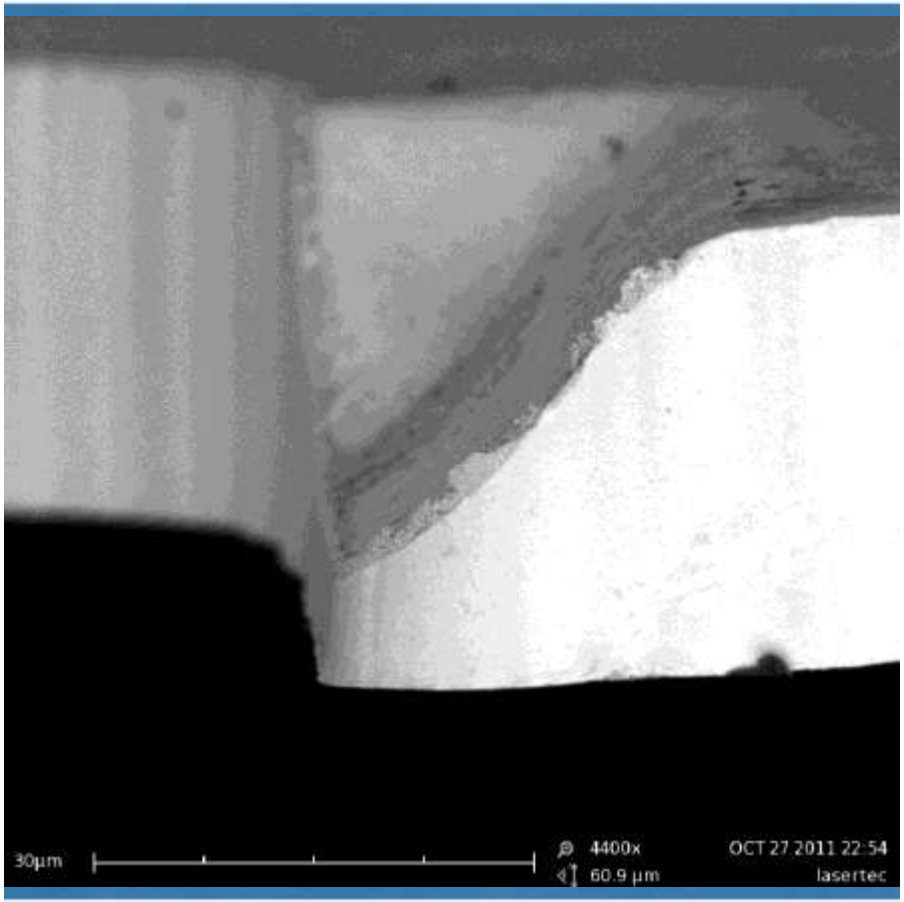


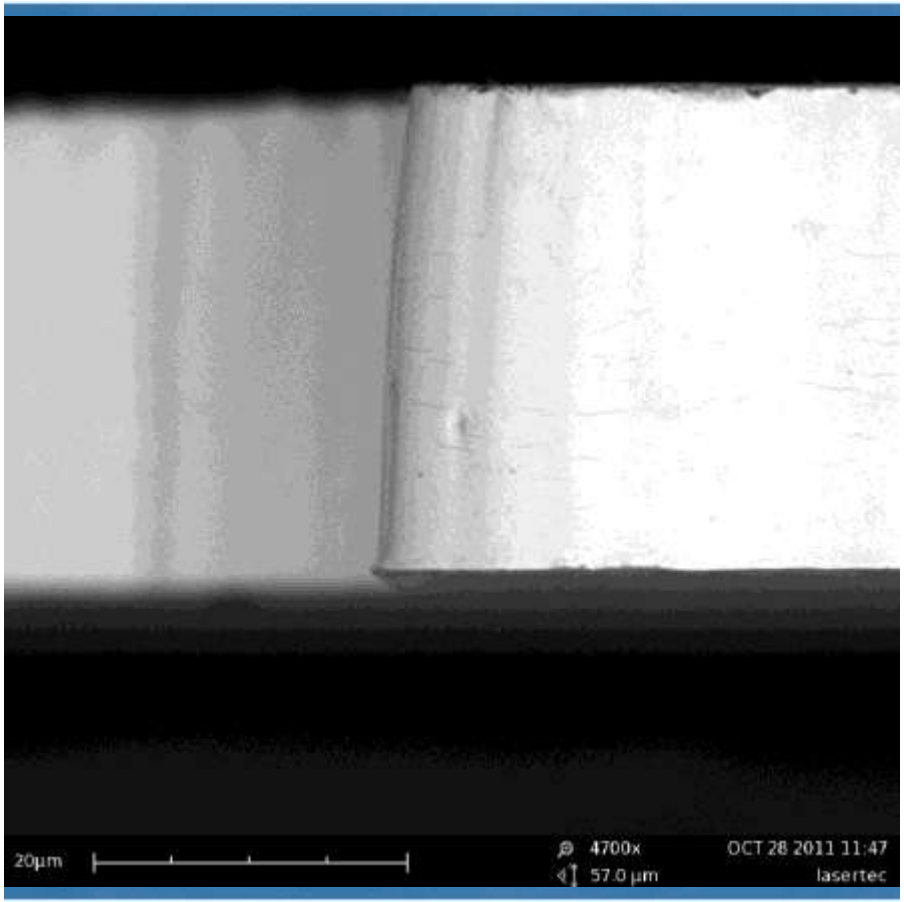
CUTTING OF 30 µm MOLYBDENUM FOIL

Freeform Surface at Cutting Edge



CUTTING OF 30 µm MOLYBDENUM FOIL

Taper

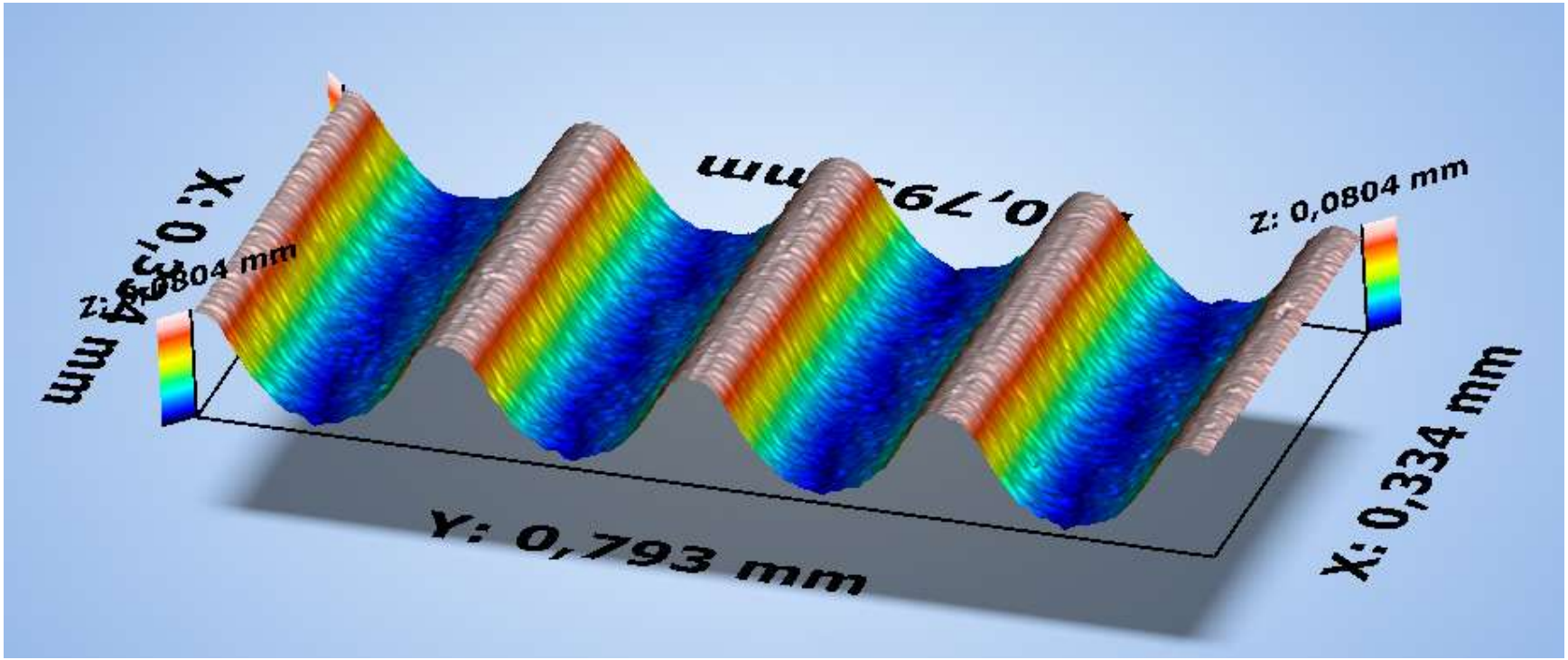


Application Examples

Commemorative Coin with Multiview

Application Examples

Multilenses



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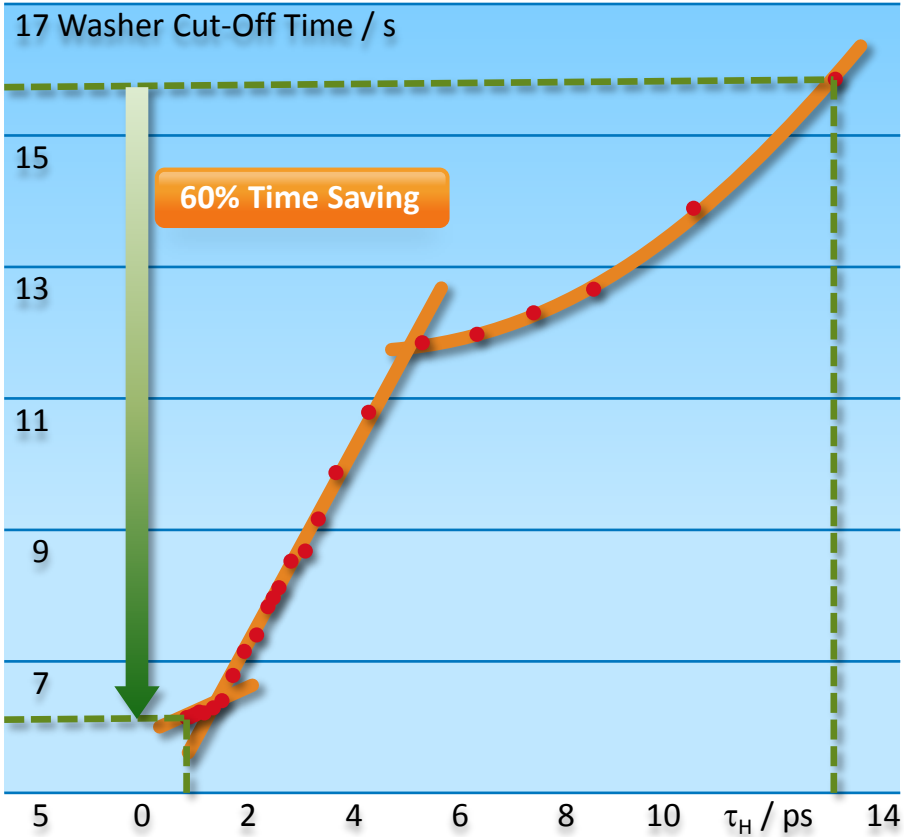
Laser Beam Systems

Beam Positioning

Conclusion und Future Prospects

LASER BEAM SYSTEMS FEMTOSECOND LASER

Application of Femtosecond Lasers promises more efficient Processing



M. Mielke: High Energy Ultra Fast Fiber Laser Systems at 1552nm for Industrial Applications
FISC Workshop, Dresden, September 2010

Micro Processing with Ultra Fast Laser Radiation in Contract Manufacturing

Factors for Success

- Apply State-of-the-Art Lasers and Machines
- Be Innovative
- Rely on Experience of your Employees and Promote Professional Training
- Listen Carefully to Your Customers

Current Technical Challenges

- Understanding of Interaction Mechanisms of Ultra Fast Laser Radiation with Matter as a Base for Process Optimization
- Provision of Beam Deflection Units with Feed Rates of > 100 m/s
- Feasibility of Synchronization of Beam Deflection Units with Ultra Fast Laser System
- Concepts of Processes Parallelization for Ultra Fast Laser Systems with High Average Power
- Reduction of Acquisition Cost for Ultra Fast Laser Systems with Low Average Power

STRAHLPOSITIONIERUNG POLYGONSCANNER

Max. Scan Speed	340	m/s
	12.000	rpm
Focal Distance	163	mm
Beam Diameter	25	µm
Size of Scan Field	100 x 100	mm^2
Additional Linear Motor		
Number of Mirrors	11	
Max. Output Frequency		
Modulated	20	MHz
Digital	40	MHz

Fraunhofer ILT

ACKNOWLEDGMENT

I Owe my Colleagues of

Lasertec B.V.

Marco Bak

Peter Vreeswijk

Walter Knulst

a Debt of Gratitude for Their Excellent Support!

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For additional information or in case of further questions

Meet us at booth C104

Thank You Very Much for Your Attention and Enjoy the EPMT 2013