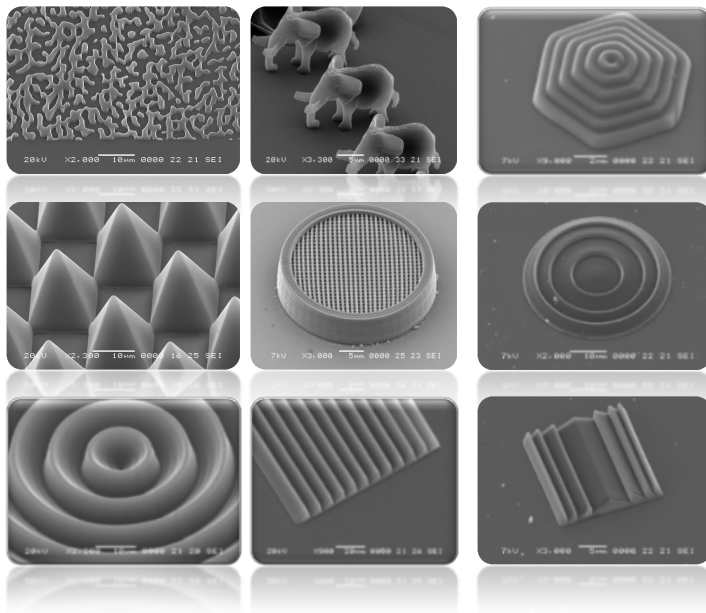


Laser material processing for a wide range of applications



Paul Hartmann

Wien, 29.10.2018

Outline

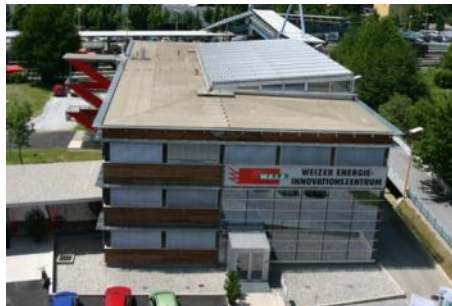
1. Intro: Institute MATERIALS
 2. Laser Production Technologies with multi-kW IR continuous wave-Lasers:
 - Laser Welding
 - Laser Alloying
 - Laser Cladding
 - Additive manufacturing
 - Laser Cladding / LMD
 - 3D Metal Printing / SLM
 3. Laser Production Technologies with UV and short-pulsed Lasers
 - Direct Laser Ablation
 - Maskless Laser Lithography
 - 2-Photon-Absorption Lithography
-

1. Introduction: MATERIALS

Institute for Surface Technologies and Photonics

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- Director:
 - Paul Hartmann
- 5 Research Groups
~ 85 Employees
- 3 Locations in Austria
 - Weiz
 - Niklasdorf
 - Pinkafeld



**Hybrid Electronics
and Patterning**
Barbara Stadlober

**Light and Optical
Technologies**
Christian Sommer

Smart Connected Lighting
Franz-Peter Wenzl

**Laser and Plasma
Processing**
Wolfgang Waldhauser

**Sensors and
Functional Printing**
Jan Hesse

Outline

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Laser Welding: a widely established process in industry

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Basics:

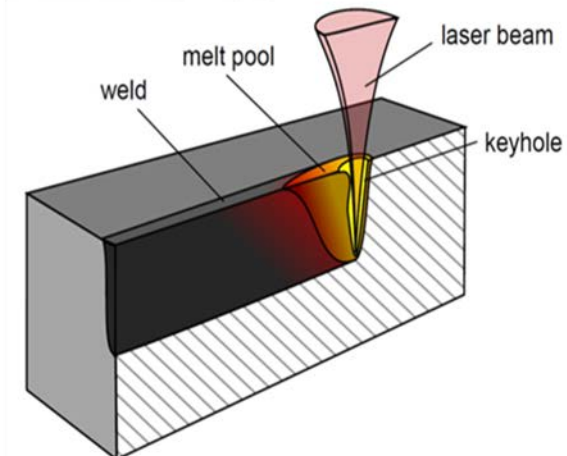
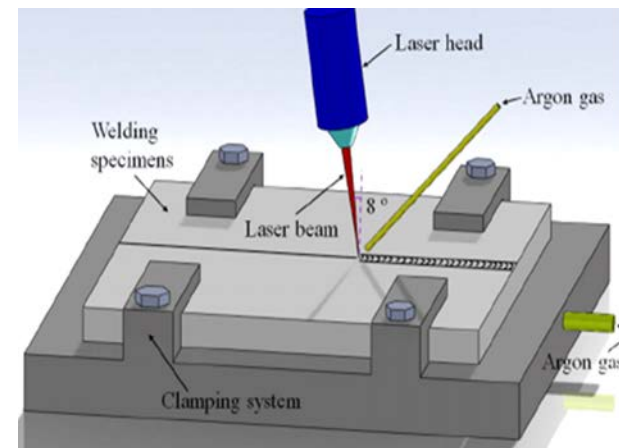
- Laser Welding is a non-contact process that requires access to the weld zone from one side of the parts being welded
- The weld is formed as the intense laser light rapidly heats the material (typically calculated in ms)

Lasers

- CO₂ -, and Nd:YAG Lasers (cw, multi-kW)
- Robot-assisted

Application areas

- Automotive industry (car body production, gear welding etc.)
- Mechanical engineering industry

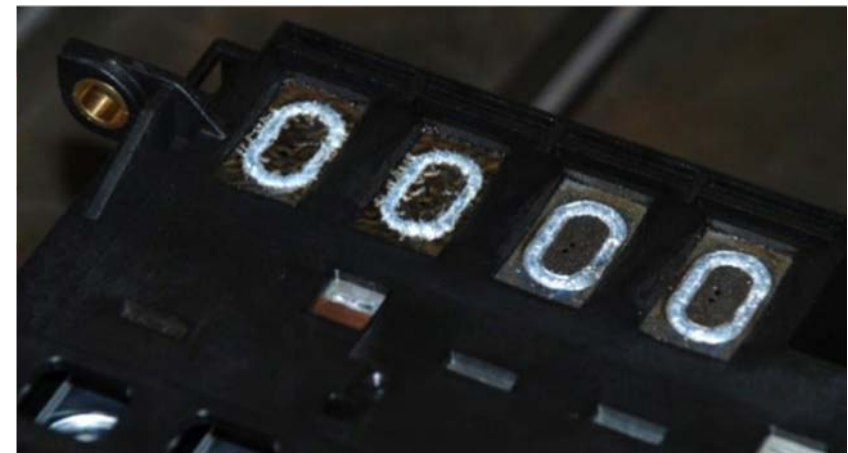


Novel application of laser welding ...battery packs for e-mobility

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Benefits/Motivation

- difficult material combinations (Cu/Al)
- thin sheets ($< 0,3$ mm)
- exactly defined welding depth
- minimum thermal load ($< 80^{\circ}\text{C}$ at welding root)



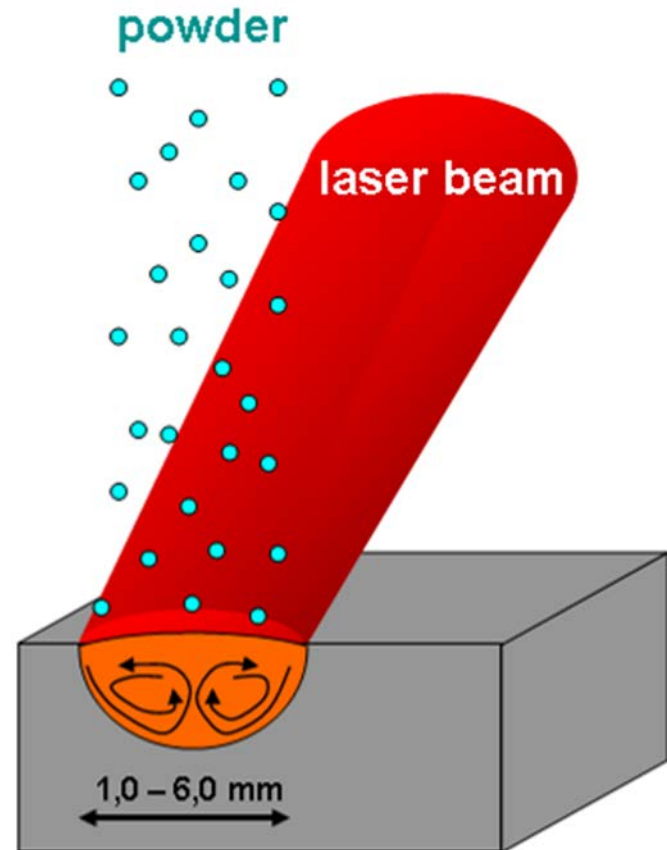
Laser Alloying: a niche technology for hardening of metals and ceramics

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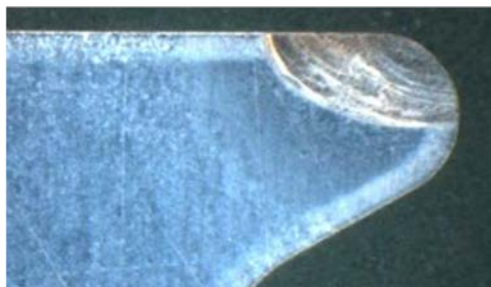
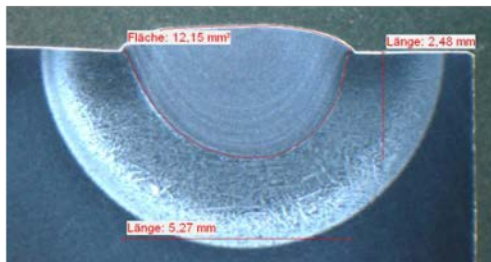
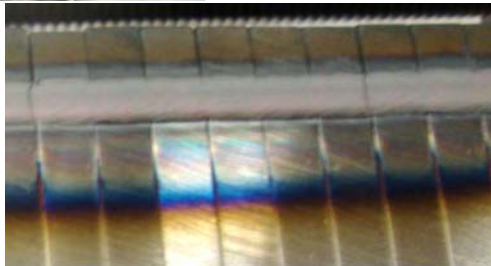
2 major phases of laser alloying

- Carrying alloying element onto the substrates surface (e.g., Vanadium Carbide in Steel)
- Melting alloying element together with the substrate → intermixing of substrate and alloying material

Only metal alloys and metal ceramic composites can be applied as the substrates for laser alloying

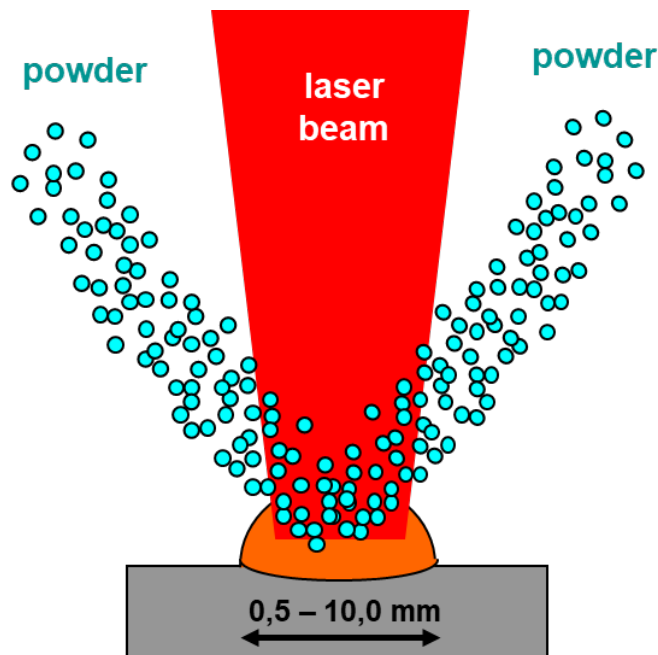


Laser Alloying ...of bending tools



Laser additive manufacturing

1) Laser cladding / Laser metal deposition (LMD)



New trends in laser production technologies



Applications of Laser cladding

- protection layers
- reshaping/repairing
- additive manufacturing (LMD)



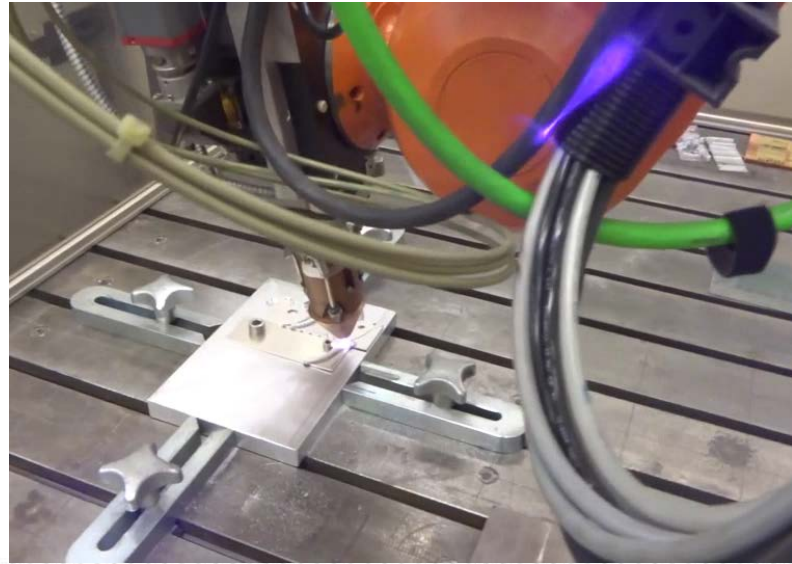
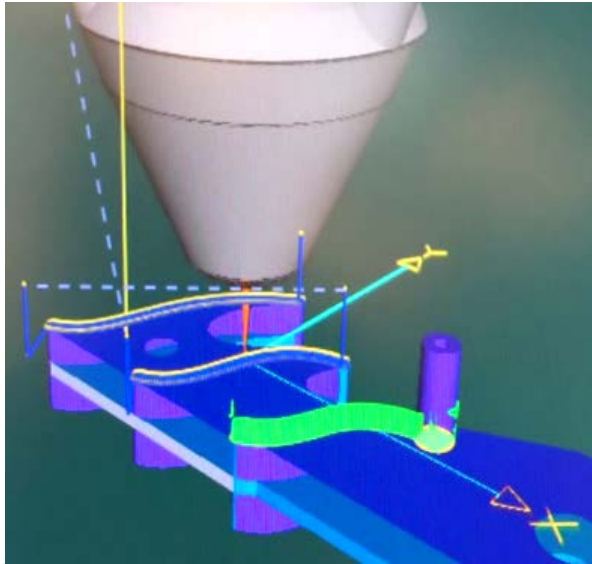
Application of Laser Cladding

5-axis laser based additive manufacturing via LMD (aviation component)

CAD model and motion path simulation with TopLas3D



Process in reality and finished shape after subsequent milling



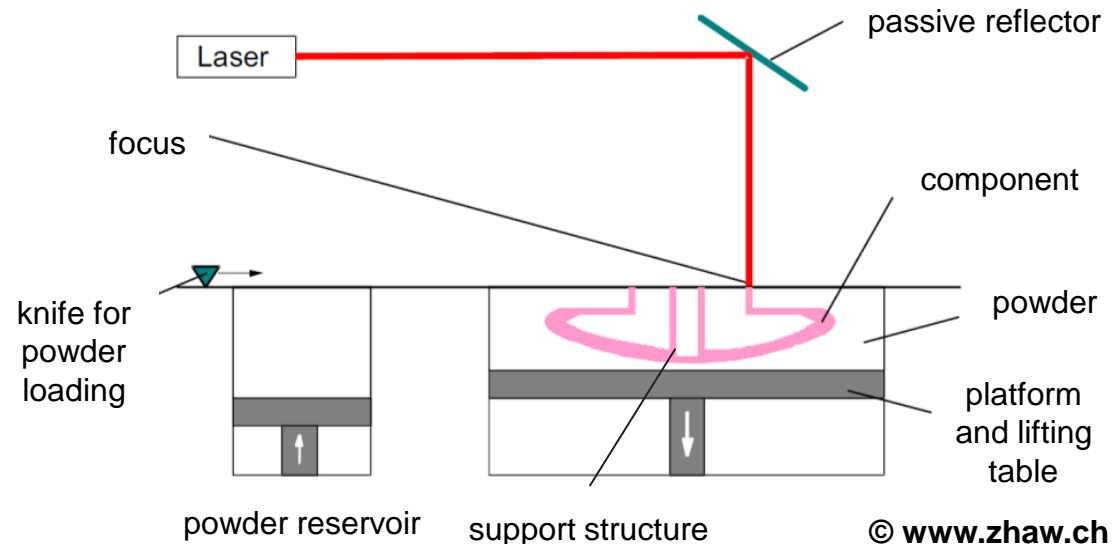
Laser Additive Manufacturing

2.) Selective Laser Melting (SLM)

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Process principle

- Layered structure »from bottom to top« (additive)
- Apply a layer of metal powder
- Local solidification of the material, fusion of the powder particles by laser beam
- Lowering the component platform and apply the next material layer



© www.zhaw.ch

Metal Powder

- tool and thermally treated steels
- Ti, Al, Ni, Co base alloys

Characteristics

- High volume fraction (> 99%)



Additive Manufacturing via SLM

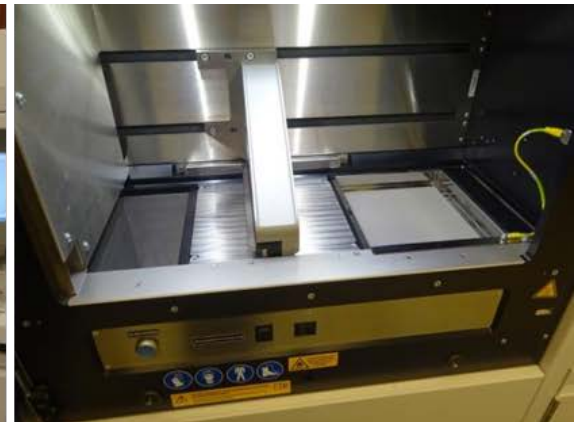
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SLM @ MATERIALS

EOS M280

- 400 W
- 100 μm
- 7 m/s
- 250 x 250 x 325 mm

Plus: Farsoon-SLM device

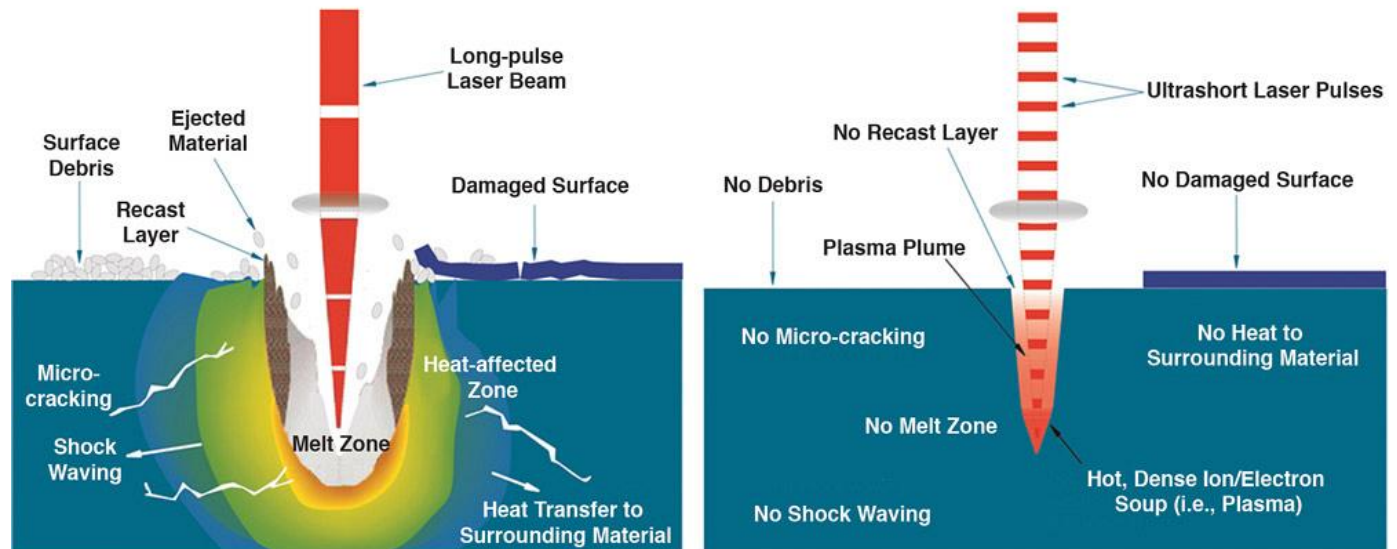


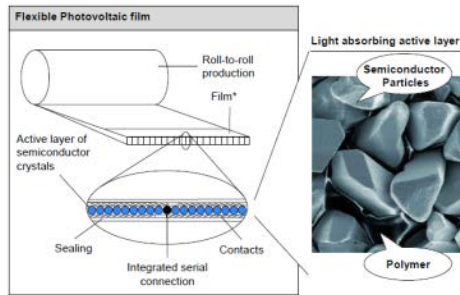
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Micro- and Nanoprocessing Micromachining

- Micromachining with picosecond IR lasers
 - ablation of various materials (e.g. composites, metals)
 - cutting of polymer materials
 - cutting of ceramics
 - cutting/drilling of metal

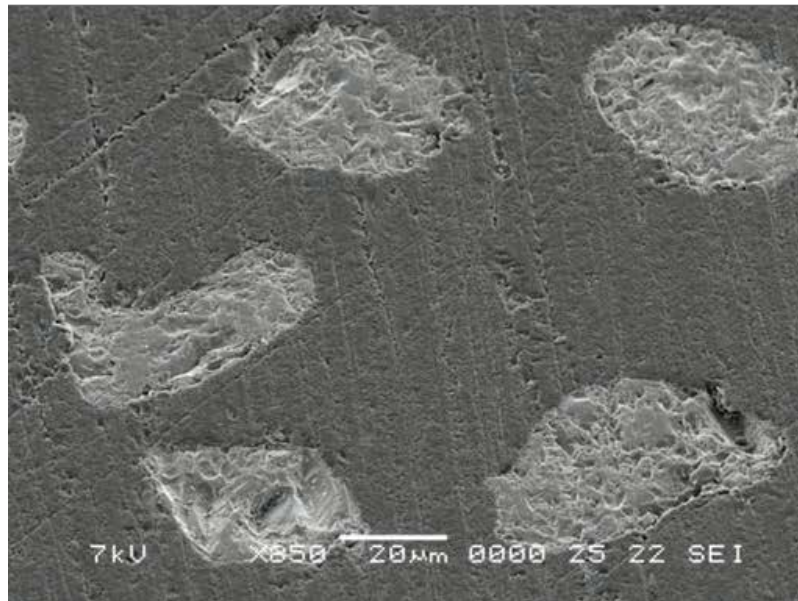




Micromachining ...ablation of composite materials

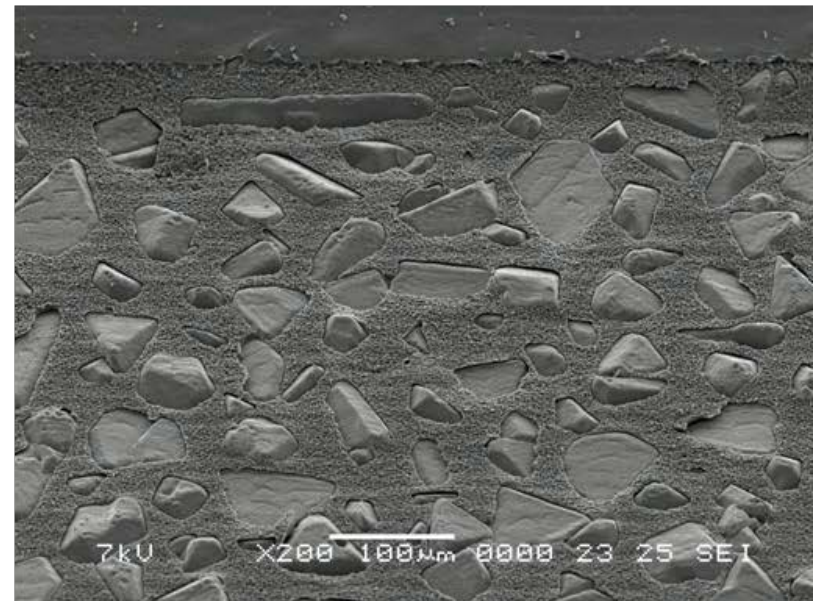
■ Rear side ablation of flexible photovoltaic CZTS film (crystalsol solar module)

Mechanical abrasion



Traditional mechanical abrasion limited in terms of process control, reproducibility

Laser ablation

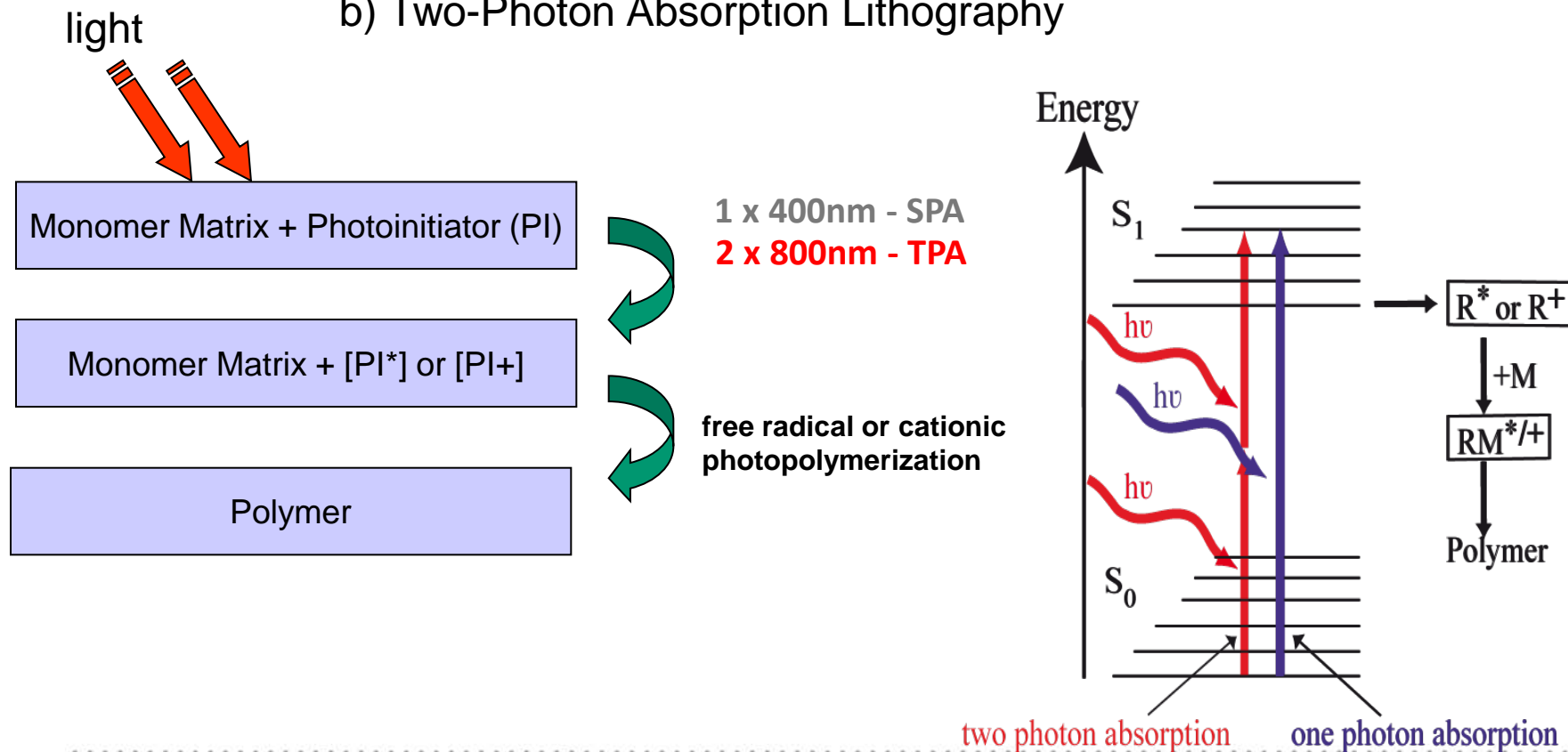


Newly developed laser ablation process offers excellent control of ablation depth by adjusting incident laser power → precise and homogeneous CZTS rear-side ablation

Laser-based Lithography

a) Single Photon Absorption Photolithography

b) Two-Photon Absorption Lithography



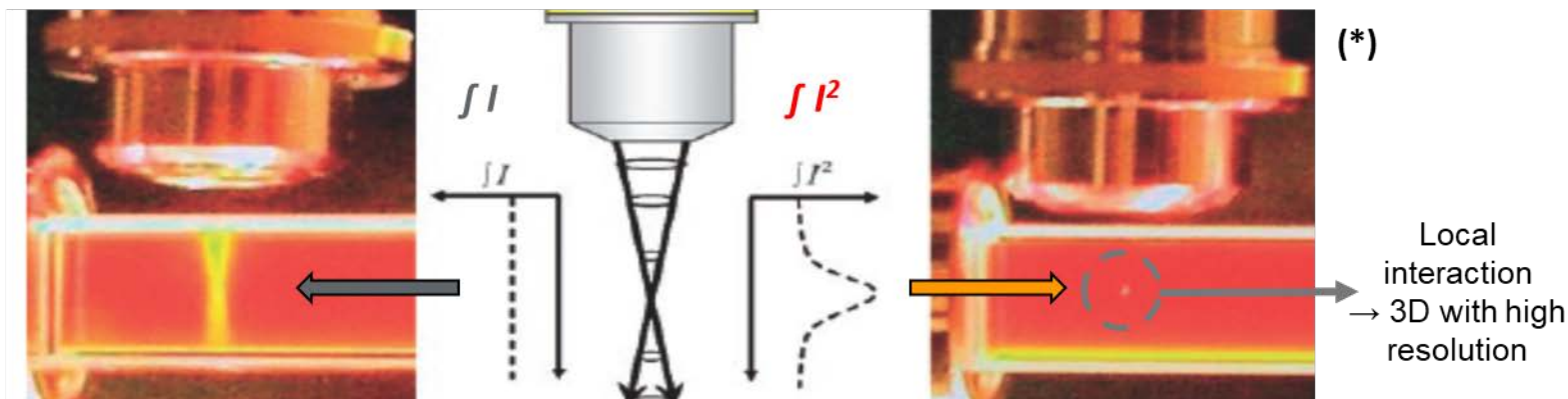
1 vs. 2 Photon Processes for Photopolymerization

1-Photon-Process

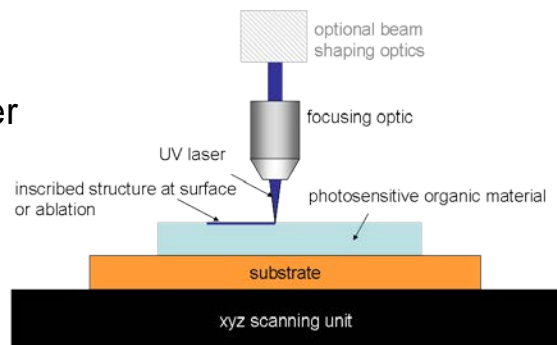
- layer by layer process
- Resolution: ~ 400nm

2-Photon-Process

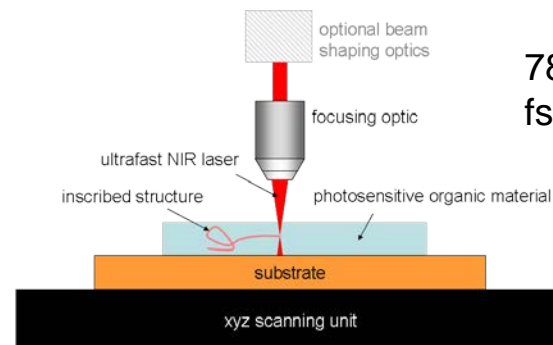
- „real“ 3D process
- Resolution: ~ 100 nm



375nm
cw-Laser



780nm
fs-Laser

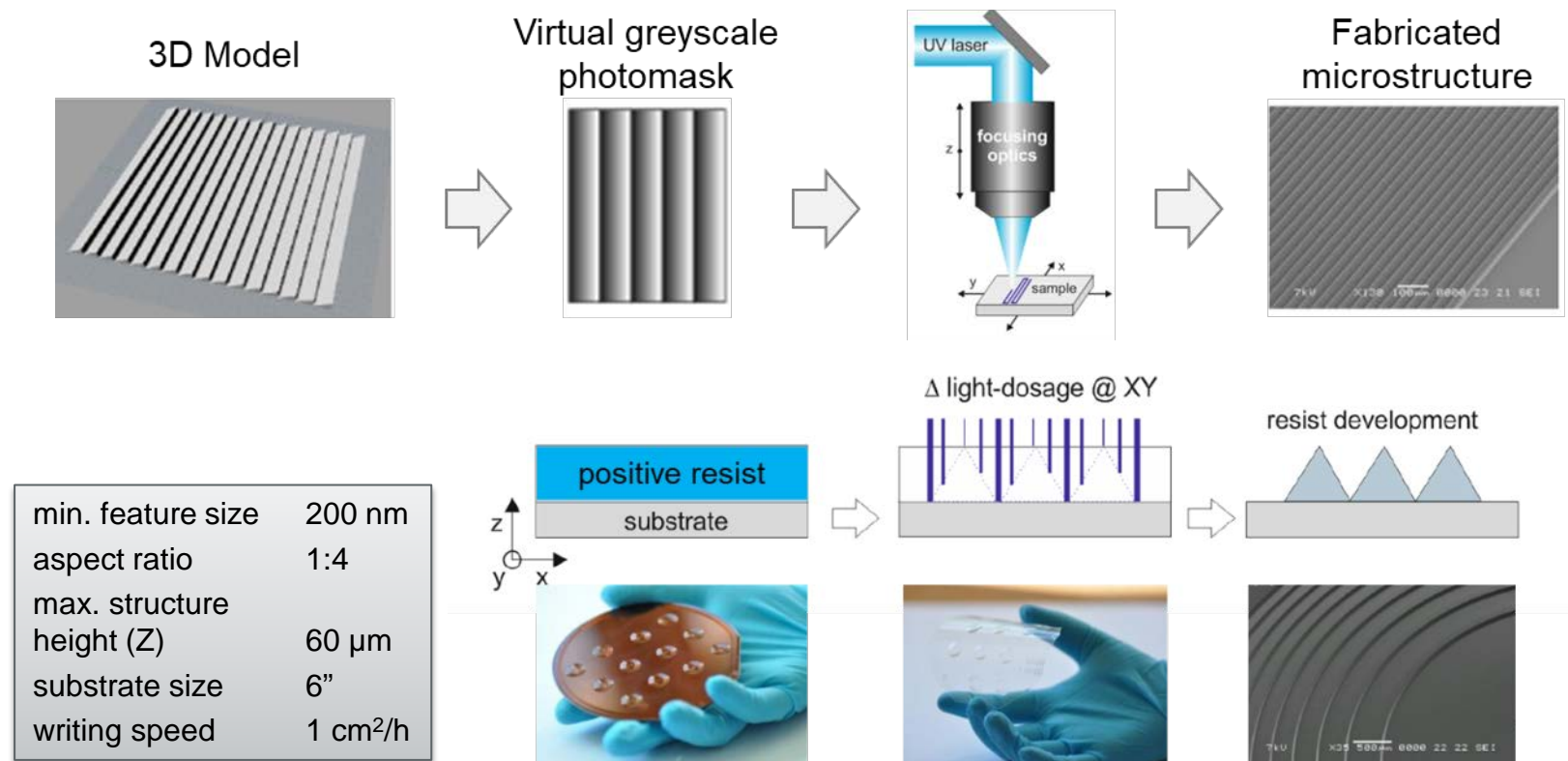


Maskless Laser Lithography

CAD Model is directly used for Mastering

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Single Photon Process



L. Kuna e al., J. Appl. Phys. 104, 074507 (2008); L. Kuna et al., Prog. Photovolt: Res. Appl. 23, 1120 (2015)

Maskless Laser Lithography

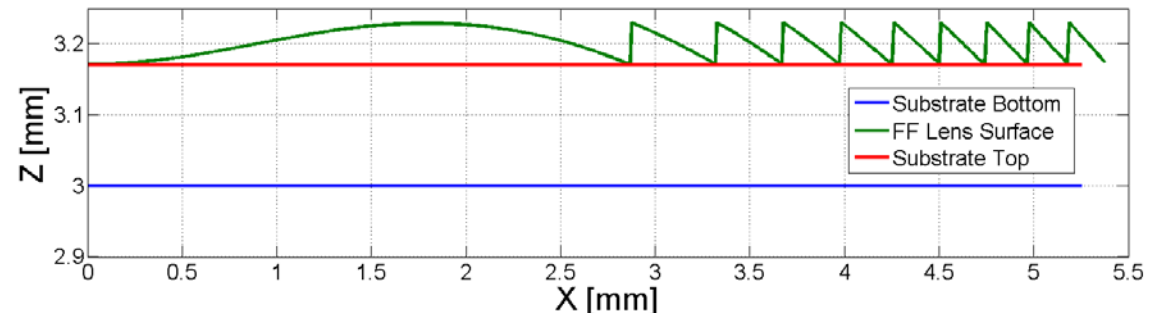
Application: Freeform μ -Optics



Fresnel-type structures to limit the height of the element

3D model of the FF micro-optical element.

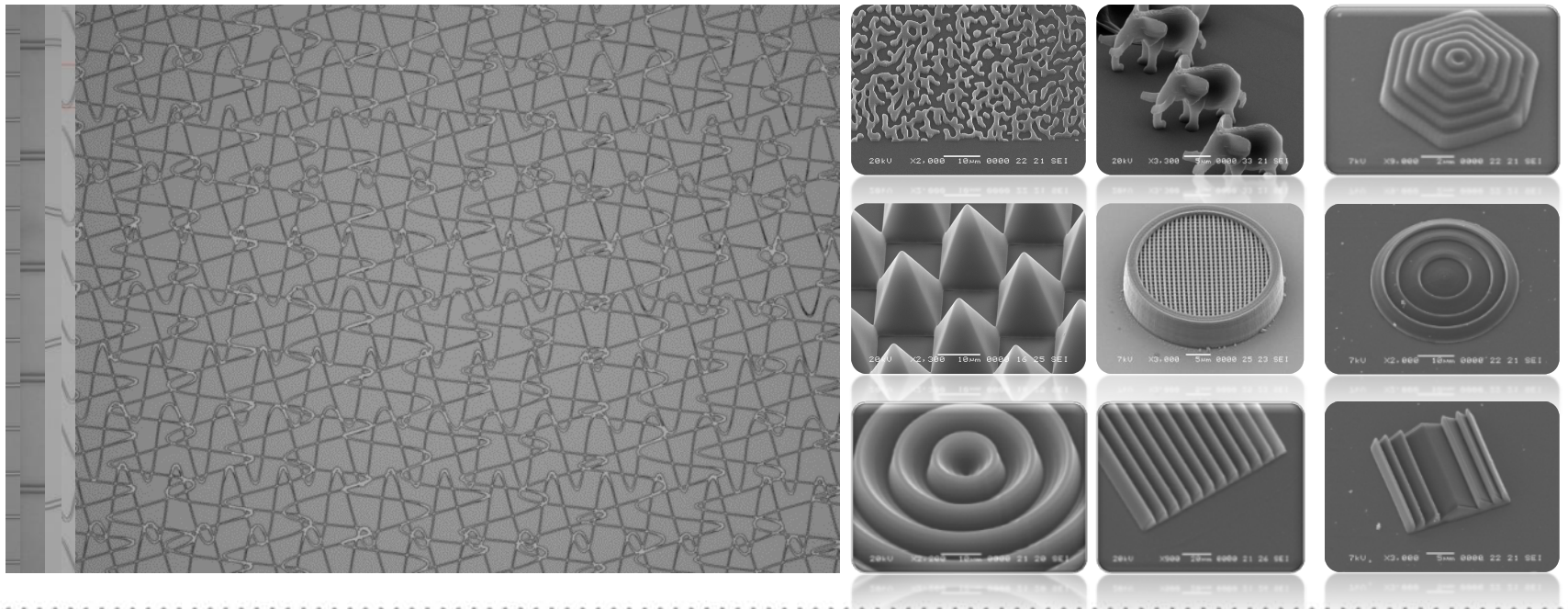
cross-section along one half of the FF micro-optical element



2-Photon Laser Absorption Lithography

Exposure of photosensitive materials

Two photon polymerisation for fabrication of micro-optics, holograms, etc. with a resolution down to the 100 nm-range



Introduction of European projects that can be used for your feasibility studies

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■ ACTPHAST 4.0

ACTPHAST4.0 is the next-generation “one-stop-shop” incubator for European companies, especially SMEs, to innovate with photonics faster, at lower cost and with greater impact.

Projects up to 100k€ can be supported



■ KET 4 clean production



Projects up to 50k€ can be supported

Contact JOANNEUM RESEARCH for further details

Thank you for your attention!



Thanks to

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- Michael Görtler
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- Valentin Satzinger
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JOANNEUM RESEARCH
Forschungsgesellschaft mbH

MATERIALS – Institute for
Surface Technologies and Photonics

Franz-Pichler-Straße 30
A-8160 Weiz

Phone: +43 316 876-3000

Fax: +43 316 8769-3000

materials@joanneum.at