

Production Processes for Micro System Manufacturing

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at MicroNanoTech

Content

- Introduction: IVAM Microtechnology Network
- Micro Structuring Processes
- Summary

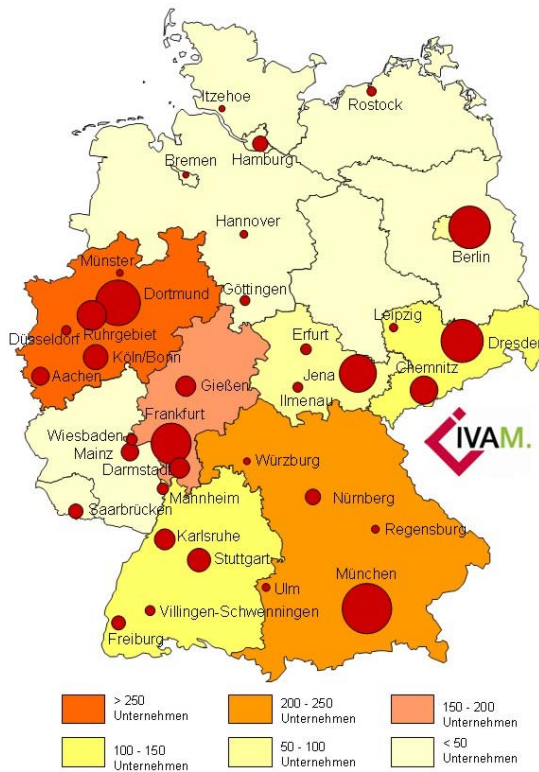
Content

- Introduction IVAM Microtechnology Network
- Micro Structuring Processes
- Summary

Who is IVAM?

IVAM is the largest German innovation network for micro- and nanotechnology

(s. www.kompetenznetze.de)



MST-Atlas Deutschland:
Cluster von Unternehmen der Mikro- und Nanotechnik und Neuen Materialien.
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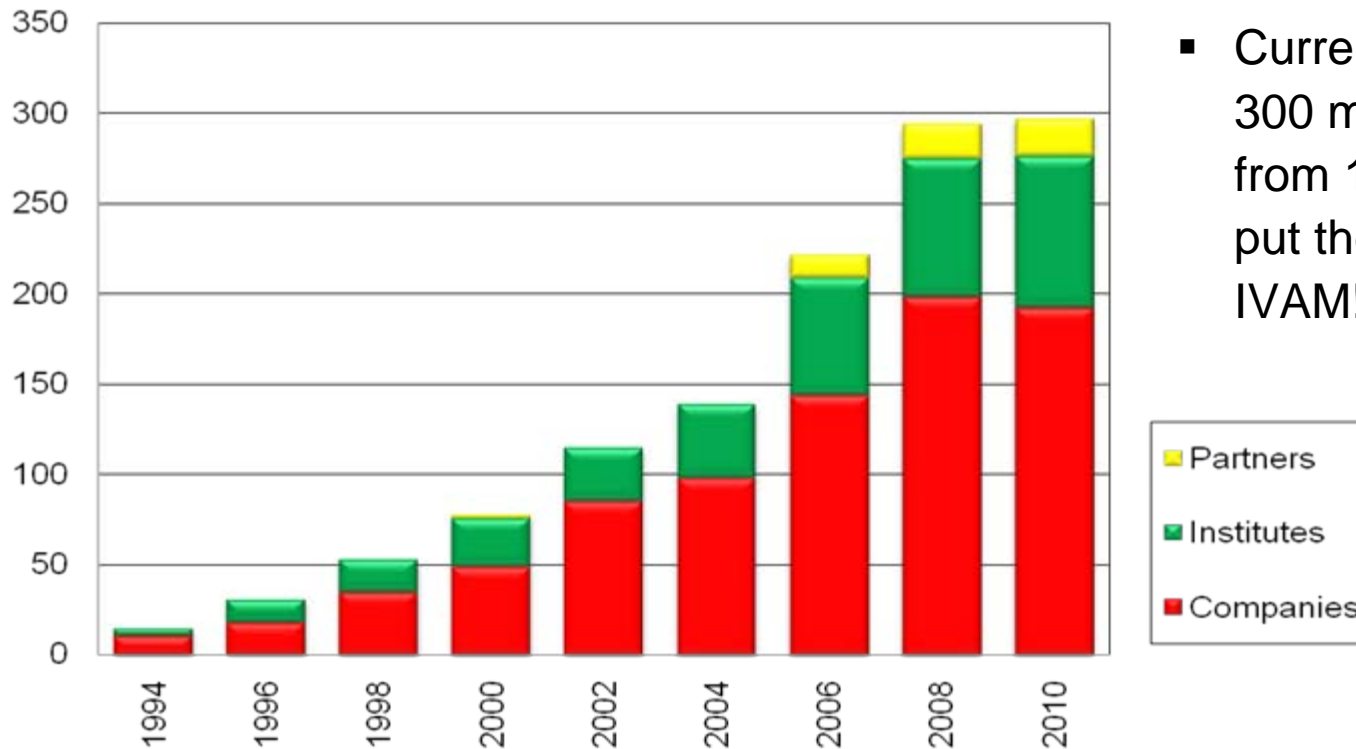


International IVAM Network



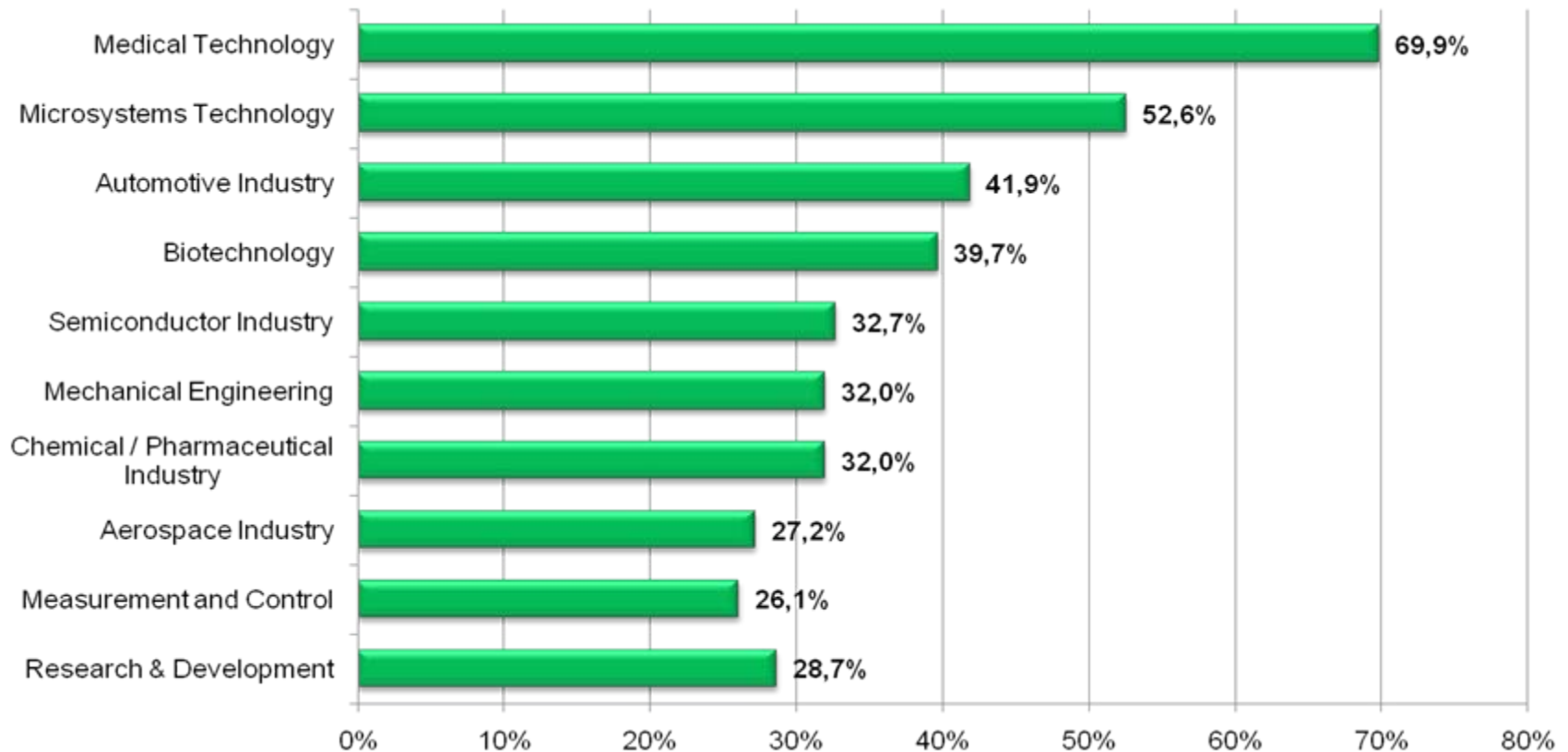
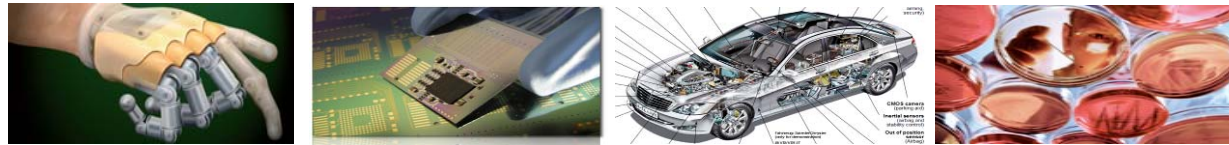
Membership Development

...representing nearly 34,000 employees

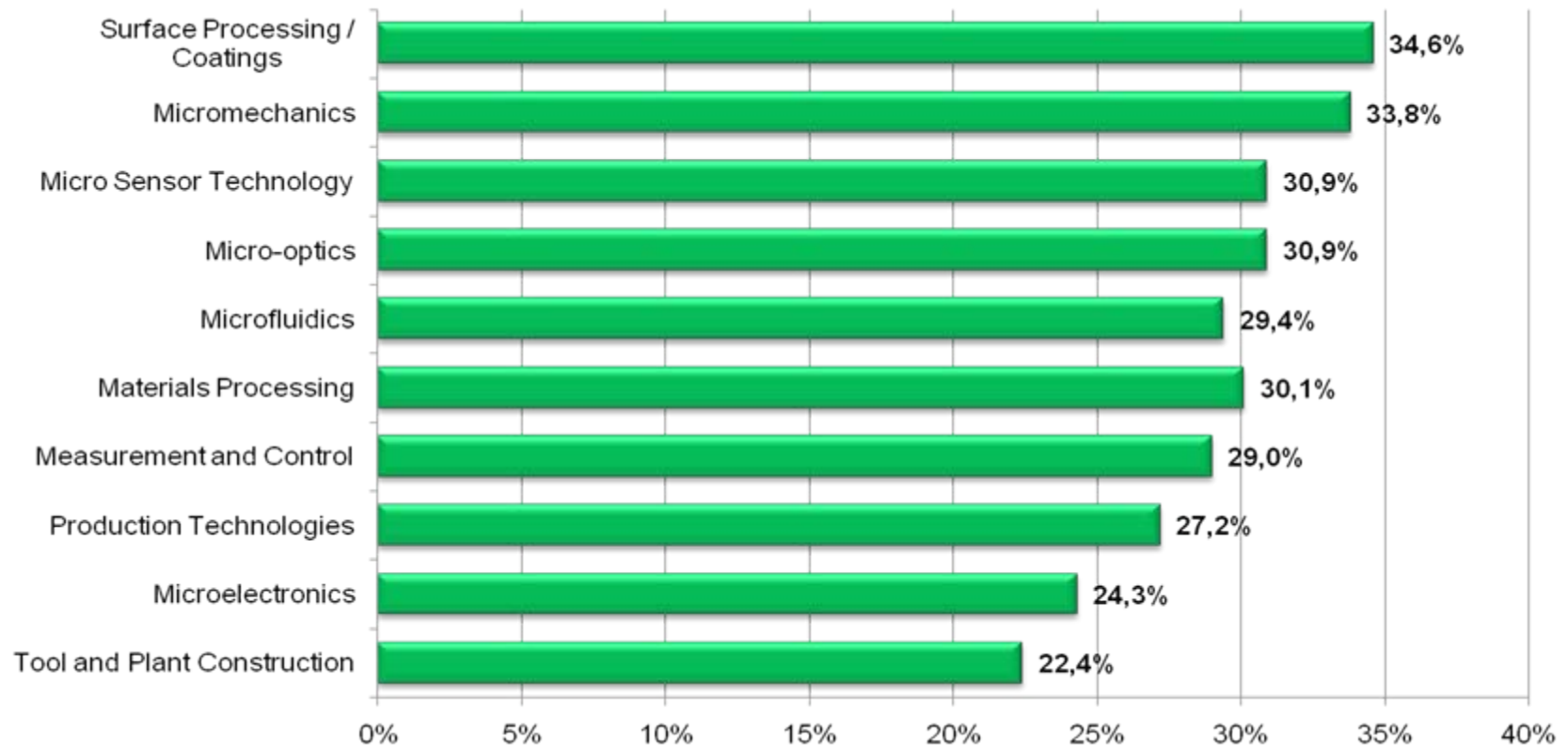


- IVAM is growing continuously!
- Currently about 300 members from 19 countries put their trust in IVAM!

Target markets of IVAM members (Top 10)



Technologies of IVAM members (Top 10)



Content

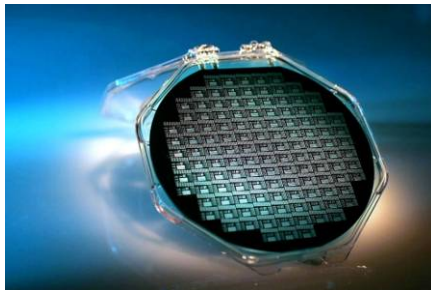
- Introduction IVAM Microtechnology Network
- **Micro Structuring Processes**
- Summary

Evolution of a Key Technology

Trigger:
chip development
(Integrated circuits)

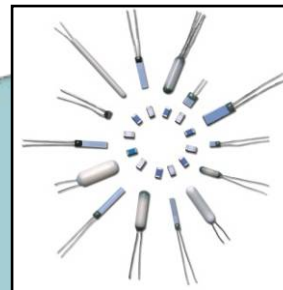


Micro electronics

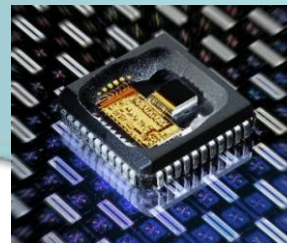


Source: Okmetic

Micro sensors

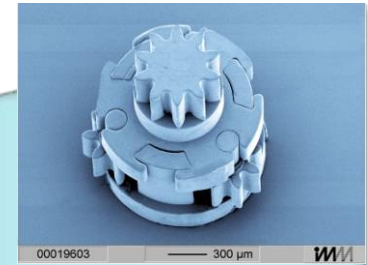


Source: UST



Source: Bosch

Micro mechanics



Source: IMM

Micro fluidics



Source: Bartels

Micro optics

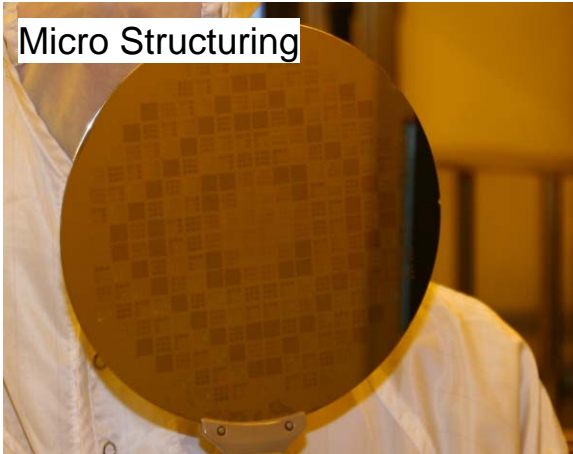


Source: LIMO

Processes for Micro System Manufacturing

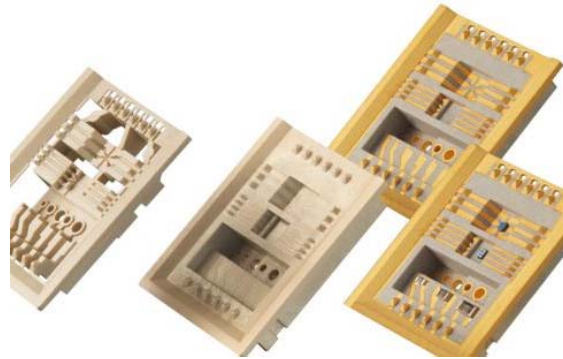


Micro Structuring



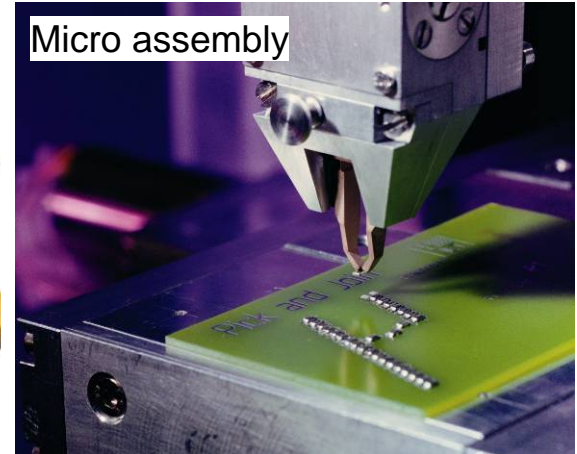
Source: Leister Technologies GmbH

Packaging



Source: Harting AG

Micro assembly

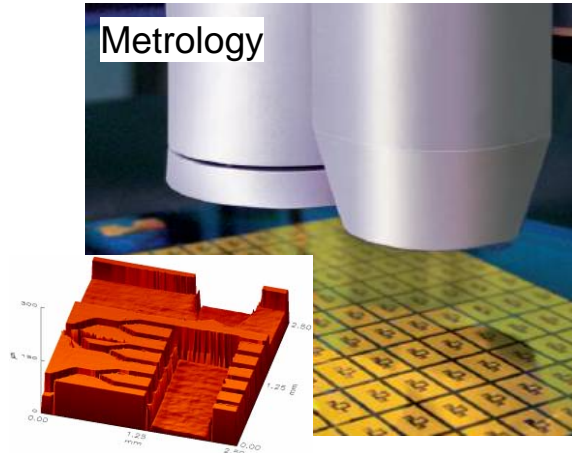


Source: Fraunhofer IPT

Key technologies in micro structuring:

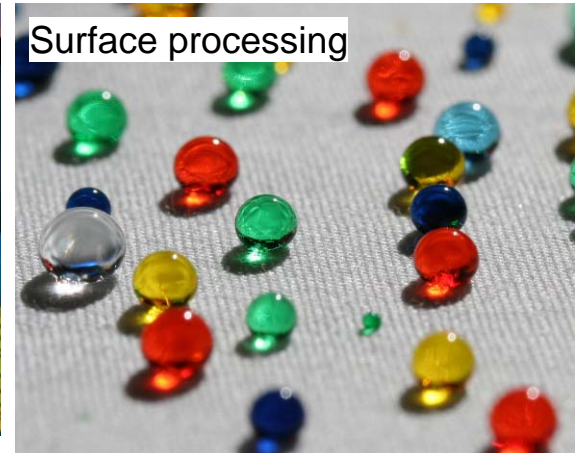
- LIGA
- Laser structuring
- Micro chipping

Metrology



Source: FRT GmbH

Surface processing



Source: Diener Electronic GmbH

LIGA – Process

UV- Lithography



**Resolution of
UV lithography
< 50 nm**

1. Substrate

- Silicon wafer
- Glass wafer
- Stainless steel plate

2. Coating

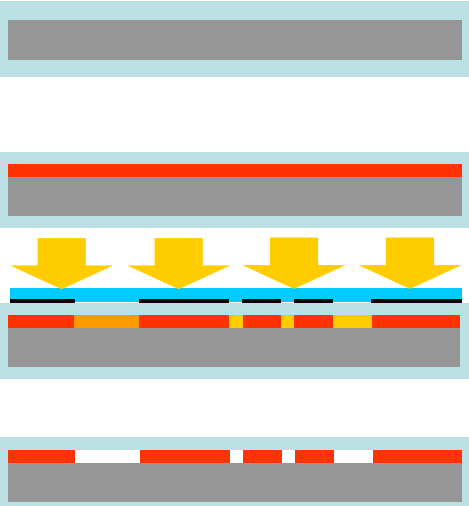
- Spin coating
- Laminating

3. UV-Exposition

- Mask Aligner

4. Development

- Micro structure



Electroforming



1. Starting layer

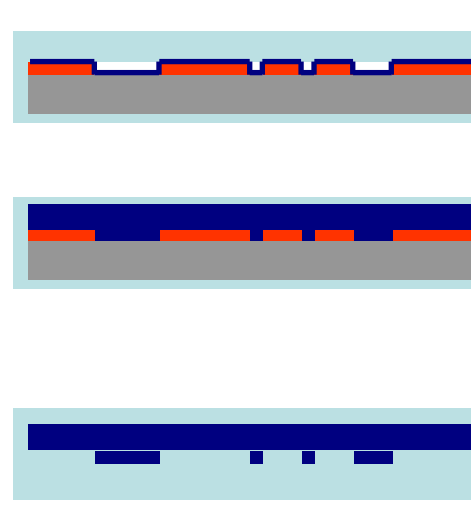
- Ni sputtering

2. Electroforming

- Nickel
- Hard nickel
- Nickel alloys

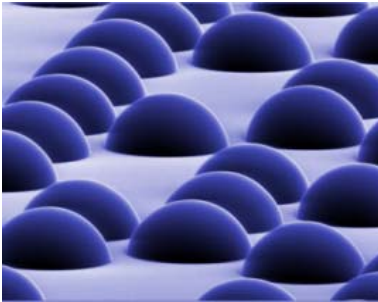
3. Separation and cleaning

- Chemical treatment
- Plasma cleaning

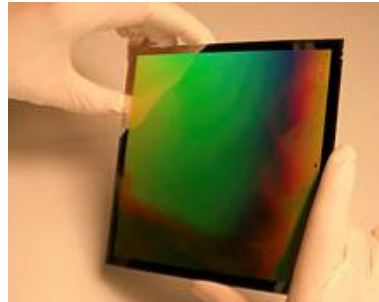


Source: TU Dortmund, Temicon

LIGA – Products and Markets



Micro lens arrays

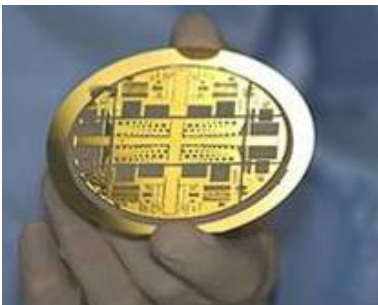


Micro structured display master

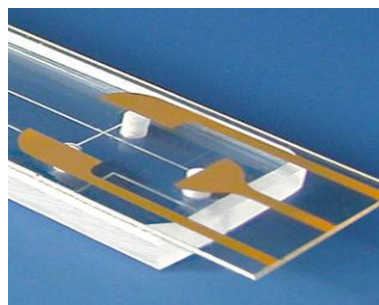


Micro an nano structures for display technologies:

- Backlight-systems
- 3D-Displays

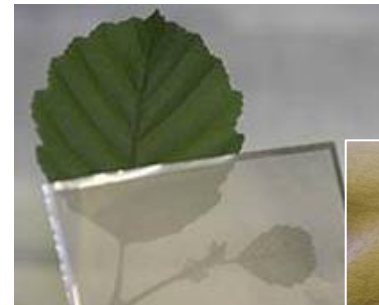


MEMS – micro electro mechanical systems



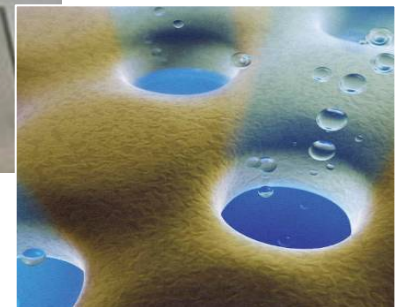
Bio medical devices

- Micro fluidic chips
- Molecule analysis



Fluid technologies

- Filtration
- Separation
- Dosing



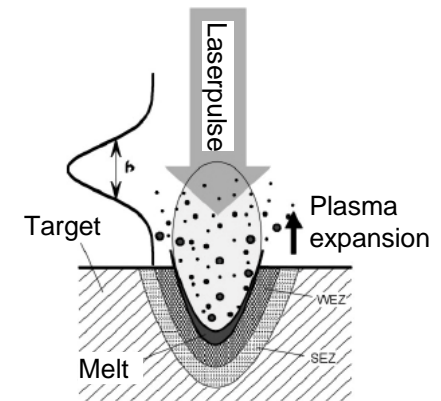
Source: Temicon, TU Dortmund

Laser Structuring – Working Principle



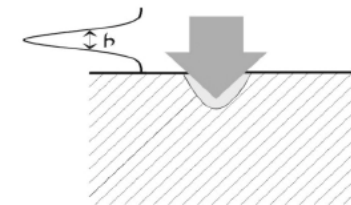
- Heating of the substrate beyond the evaporation temperature using a high pulse energy ($> 1 \text{ Joule/cm}^2$)
- Optimization of the laser wave length (355 nm; 532 nm; 1064 nm) for high energy absorption in the substrate
- High ablation speed (mm^3/min) requires a high pulse frequency (kHz, Mhz)
- High geometrical resolution (5 – 20 μm) requires:
 - Small laser spot size
 - High evaporation rate

ns-Ablation: $t \gg t_{e-ph}$



fs-Ablation: $t \ll t_{e-ph}$

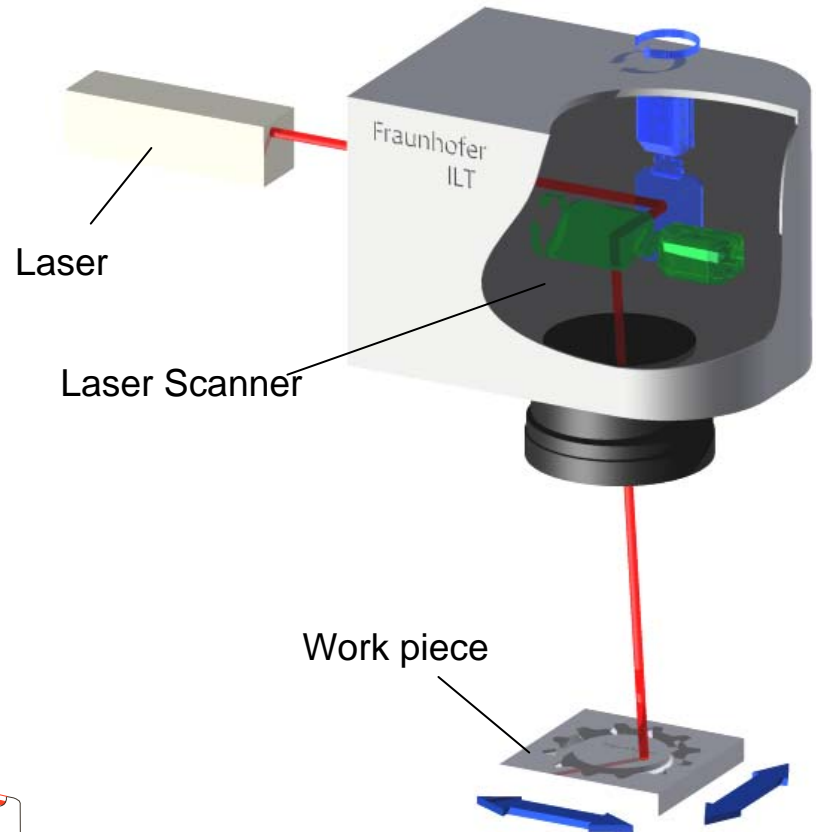
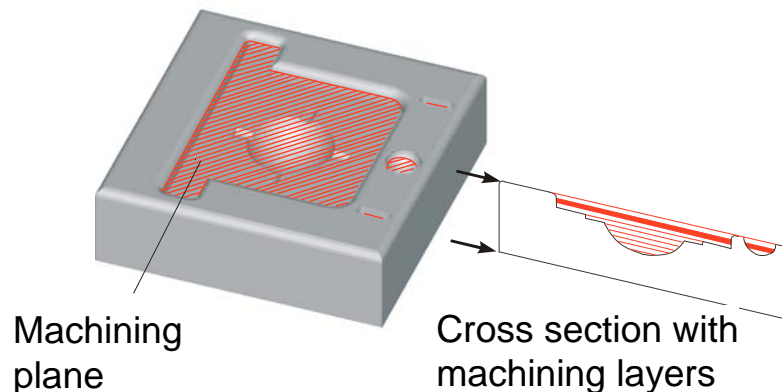
$t \cong 0$...



Source: Fraunhofer ILT

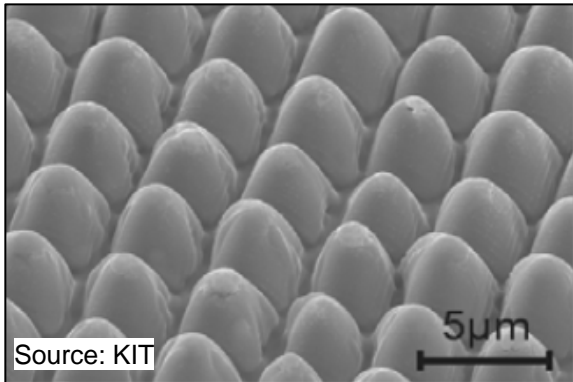
Laser Structuring – Process

- Structuring of user-defined geometries
- 3D structuring in layers without distinguishable steps
- Typical parameters:
 - Spot diameter: 5 - 20 μm
 - Pitch: 5 - 10 μm
 - Line thickness: 0.1 - 1 μm

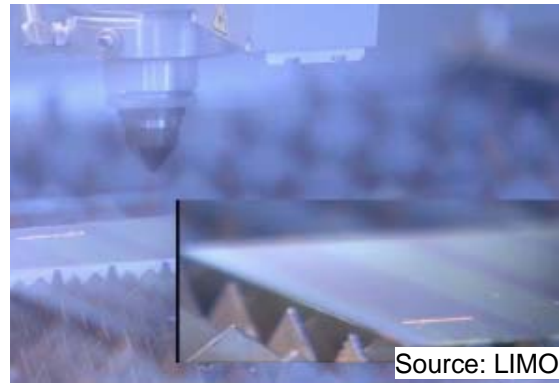


Source: Fraunhofer ILT

Laser Structuring – Products and Markets



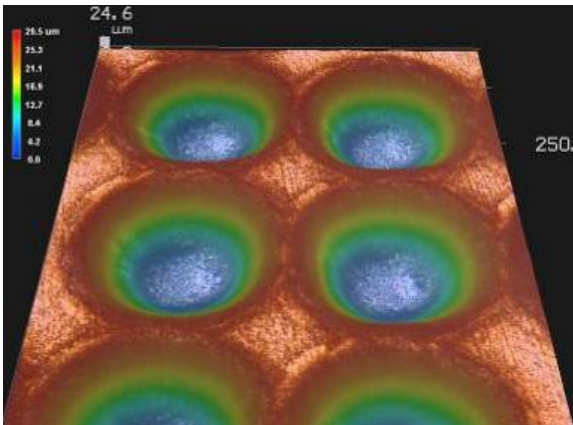
Laser structured SnO₂
battery electrode



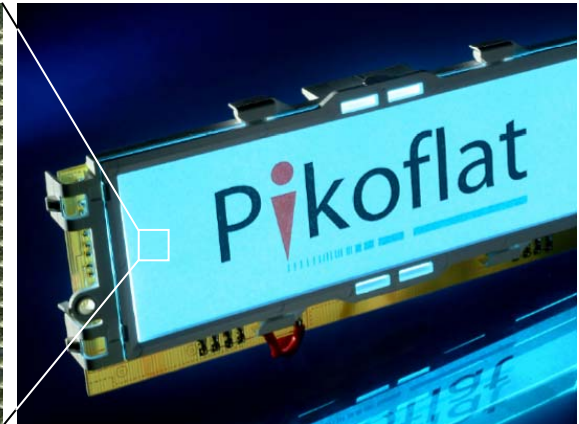
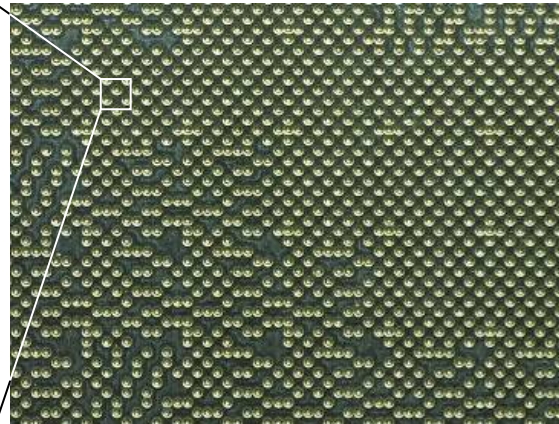
Large scale parallel processing
for display technologies



Micro structured replication tools

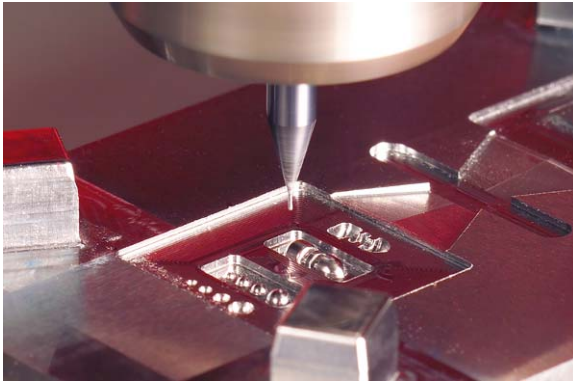


Micro lens array for display technologies

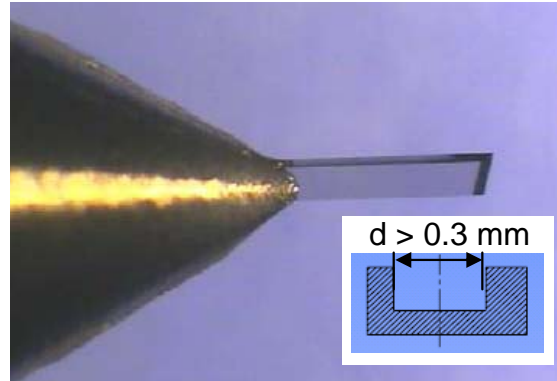


Source: Fraunhofer ILT

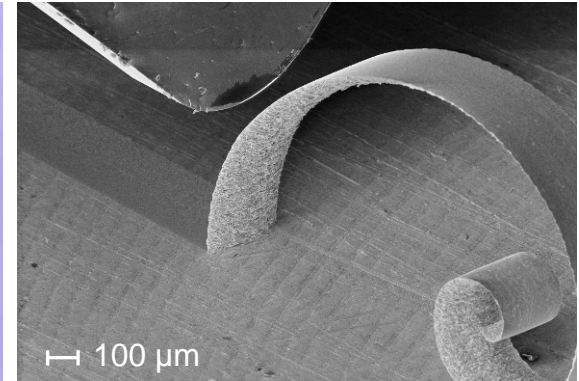
Micro Chipping – Processes



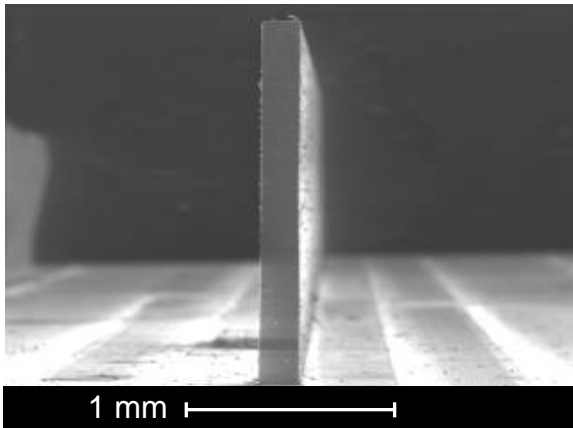
Milling of a die for micro injection molding



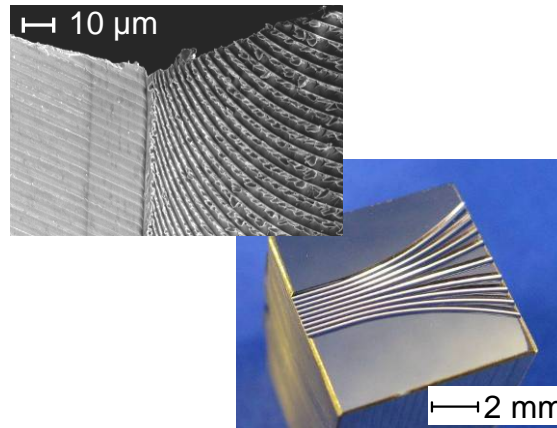
Single crystal diamond milling tool



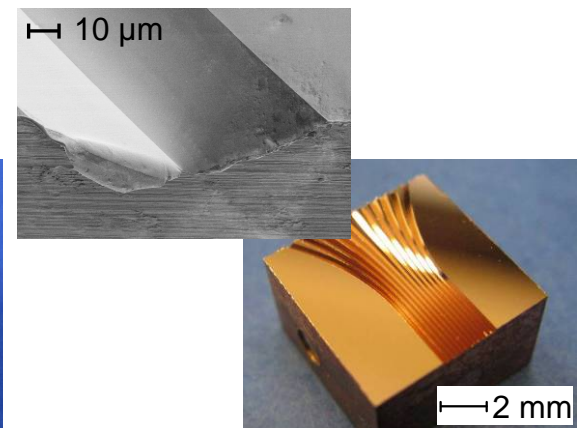
SEM image of a diamond chipping process



High aspect ratio micro structure



Diamond end-milling



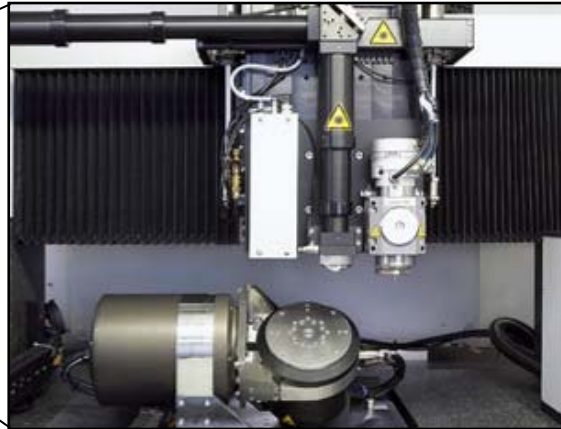
Ultraprecision

Source: Fraunhofer IPT

Micro Chipping – Machines



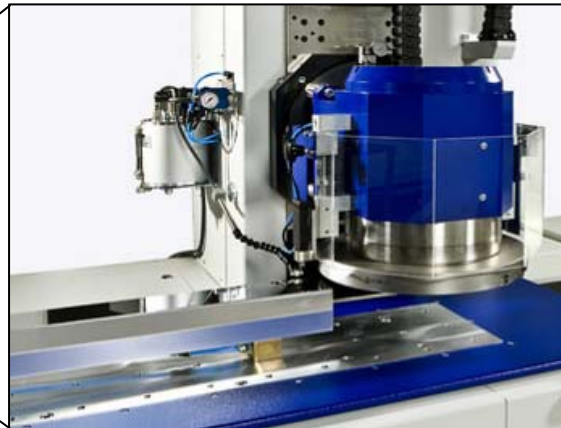
Kugler MICROGANTRY® nano5X



- Natural granite machine bed
- Air bearing guideways
- 5 axis machining
- Positioning accuracy: ± 500 nm
- Linear run out: ± 150 nm
- Max. feed rate: 12000 mm/min



Kugler Flycutter F3000-2X



- Natural granite machine bed
- Air bearing guideways
- 2 axis machining
- Max. travel: 3000 mm
- Max work piece width: 600 mm
- Obtainable surface planarity: $< 0.5\mu\text{m} / \text{Ø}100$ mm

Source: Kugler GmbH

Micro Chipping – Products and Markets



Metal mirrors for laser applications



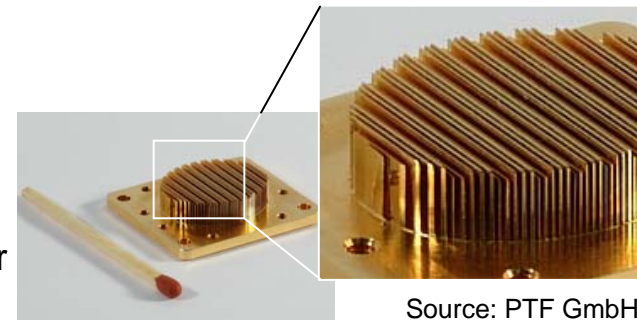
Source: Kugler GmbH



End effectors of a surgery tool



Torlon support for laser optics



Bronze cooler for medical lasers

Source: PTF GmbH

Comparison of the Micro Production Technologies



- LIGA:
 - Structure resolution of less than 50 nm
 - Cost efficient high volume production
 - Limited flexibility due to masking process
- Laser structuring:
 - Structure resolution down to 100 nm
 - Nearly no material limitations
 - No tools needed
- Micro chipping
 - Structure resolution down to 100 nm
 - Full 3D machining
 - Micro structures with optical surface quality

Content

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Summary

- Micro production processes are essential for micro system engineering
- The processes are well established for accuracies down to the nanometer range
- Micro production has a wide range of applications (electronics, optics, biotechnology, ...)
- The choice a suitable micro structuring process enables:
 - A cost efficient high volume fabrication of micro components
 - Customized and flexible micro manufacturing is possible

IVAM Product Market – Micro, Nano & Materials



- The IVAM product market “Micro, Nano & Materials” provides solutions for any kind of micro manufacturing needs



- Experience high-tech in Hall 6, Booth H18 / A-G