Laser Material Processing

Short technology description

An appropriate choice of laser and process parameters is used to control the interaction between laser radiation and material on µm- and nm-scale. The types of material processing which can be carried out are micro- and nanostructuring, microdrilling, cutting, microwelding, laser transmission welding, laser brazing, surface modification, laser cladding and laser alloying, respectively. The actual smallest structure size which can be achieved, each according to the process and material, lies in the range of 100–400 nm using femtosecond laser radiation or laser interference methods. Aspect ratios up to a maximum of 50 can be realized. Ultraviolet laser radiation and short pulse laser radiation have a particularly high potential for precision micro- and nanoablation, due to its selective material removal with very low thermal load.

Special features

- Structuring of polymer materials and thin films with high repetition rate and short pulse laser radiation
- Structuring of metals and ceramics
- Cutting of metals, ceramics and polymers
- Laser welding of polymers and metals
- Laser brazing
- Laser LIGA
- Laser alloying and cladding of ceramics
- Surface modification of polymers and thin films

Limitations/constrains

- Structure size 200 nm; AR=50 for drilling; AR=10 for ablation and cutting
- Resolution 2–10 µm
- Cutting width ≥ 5–50 µm
- Covering of microstructured polymers (structure size ≥ 20 µm); joining of thin metal foils with small weld seam width (100 µm, AR=3–5)
- Ceramic-ceramic or ceramic-steel joints; thickness of brazed seam 10–300 µm
- Surface roughness Ra=60 nm; edge radius of 1 µm; AR=5
- Structure width ≥ 300 µm
- Adjustment of wettability/surface energy/biocompatibility with structure width ≥ 200 nm

Design rules

- PMMA, PS, PEEK, PI, PSU, thin films (amorphous carbon, SnO_2, $LiCoO_2$)
- Steel, Ni, brass, WC, Al_2O_3, ZrO_2, SiC
- Steel, Ti, NiTi, quartz, Al_2O_3, PMMA, PI, PS
- PMMA, PS, aluminum, steel, titanium
- Ceramics: Al_2O_3, Al_2O_3-ZrO_2, SiC; Steel: 100Cr6, C45E
- Nickel
- Substrate: Al_2O_3, Cordierite, LTCC; Additives: W, Cu, Ni, Ni/Cr
- PS, PC, PMMA, amorphous carbon thin films

INFORMATION

Karlsruhe Nano Micro Facility (KNMF)
Laboratory for Micro- and Nanostructuring
Head: Prof. Dr. Volker Saile
Phone: +49 7247 82-2740
Fax: +49 7247 82-4331
E-mail: Volker.Saile@kit.edu

Contact

Institute for Materials Research I
Building 681

Dr. Wilhelm Pfleging
Phone: +49 7247 82-2889
Fax: +49 7247 82-7288
E-mail: Wilhelm.Pfleging@kit.edu

Technology

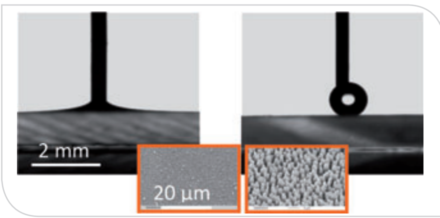
Laser Material Processing

Structuring/Modification/Bonding

Manufacturing/Fabrication

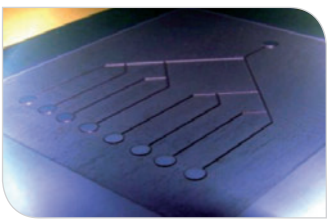
Material class

Silicon	Polymer	Metal	Ceramic
X	X	X	X
Glass	**Organic**	**Other**	
X	X		



Hydrophilic (left) and superhydrophobic (right) behaviour of laser modified polymer surfaces

Typical structures and designs



Laser structured mould insert made of steel for replication of microfluidic chips (channel structure width 50 µm)

Laser modified cordierite: heating element (width 300 µm) made of tungsten

Laser structured fluidic chip (left) and cross section (right) of laser welded microchannel