

Laser zur Funktionalisierung von Oberflächen

Auch in der Textilindustrie?

Nanoworkshop Hohenems 11.12.2014

Was kann man tun – Anhand von zwei Beispielen

Material abtragen

- Erzeugen definierter Oberflächengeometrie
- Erzeugen definierter Rauigkeit
- selektiver Abtrag

Material verändern

- Modifikation im Volumen
- chemische Modifikation der Oberflächen, z.B.
 - Hydrophilie
 - Hydrophobie
 - Silanisierung

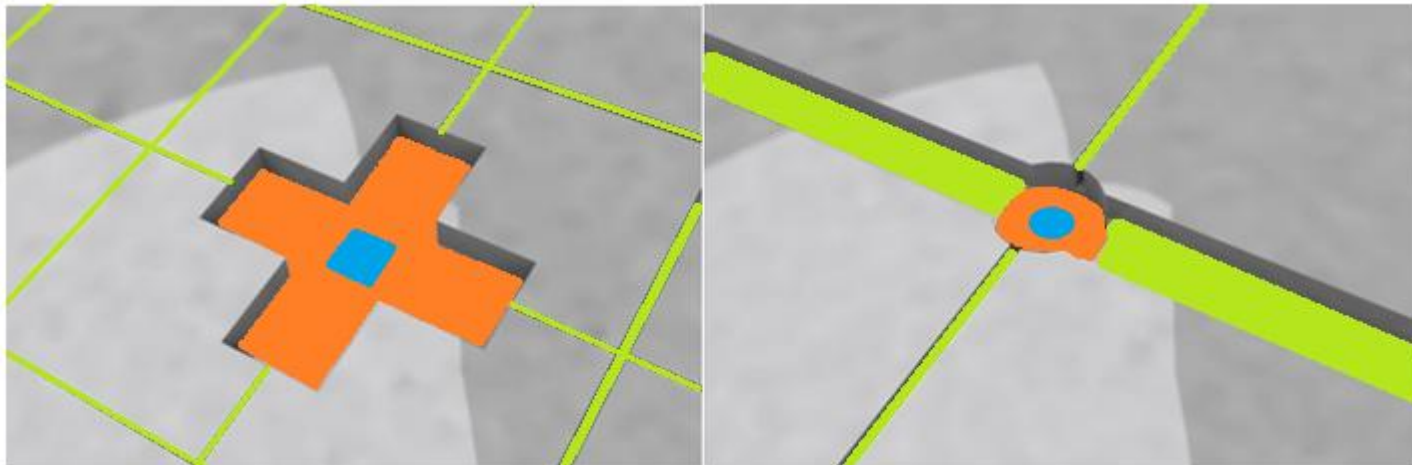
Besonderheiten der Bearbeitung mit Laserstrahlung:

- Räumliche Auflösung
- Thermische/nichtthermische Wechselwirkung

Ist so ein Verfahren für die Textilindustrie interessant?

- Gibt es Nischen?
- Durchsatz?
- Geometrie?

Aim: Selective structuring of photoresist with femtosecond laser pulses in combination with conventional UV photolithography



Rendered design of a structure containing both micro- and millimeter patterns



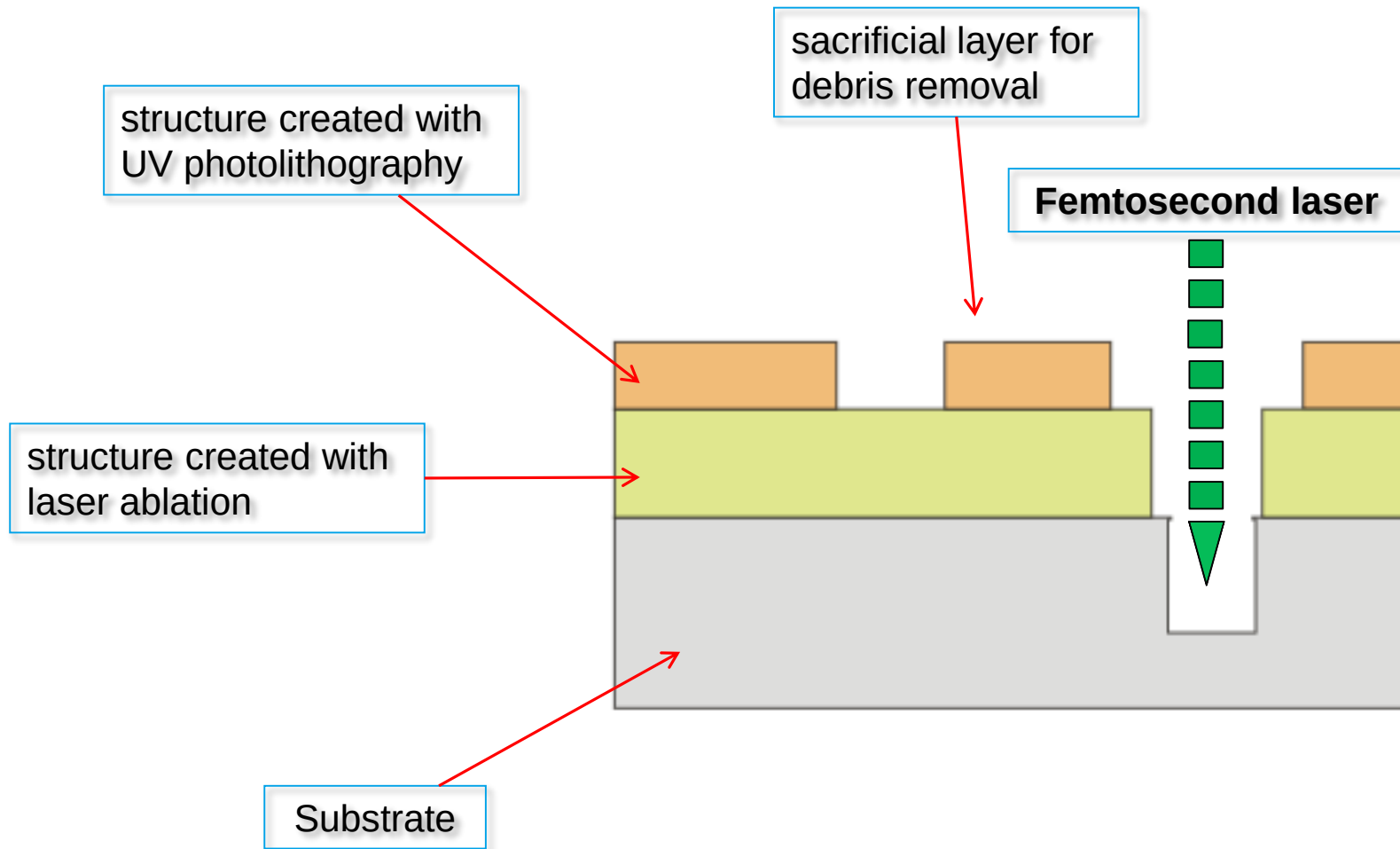
Selective laser ablation

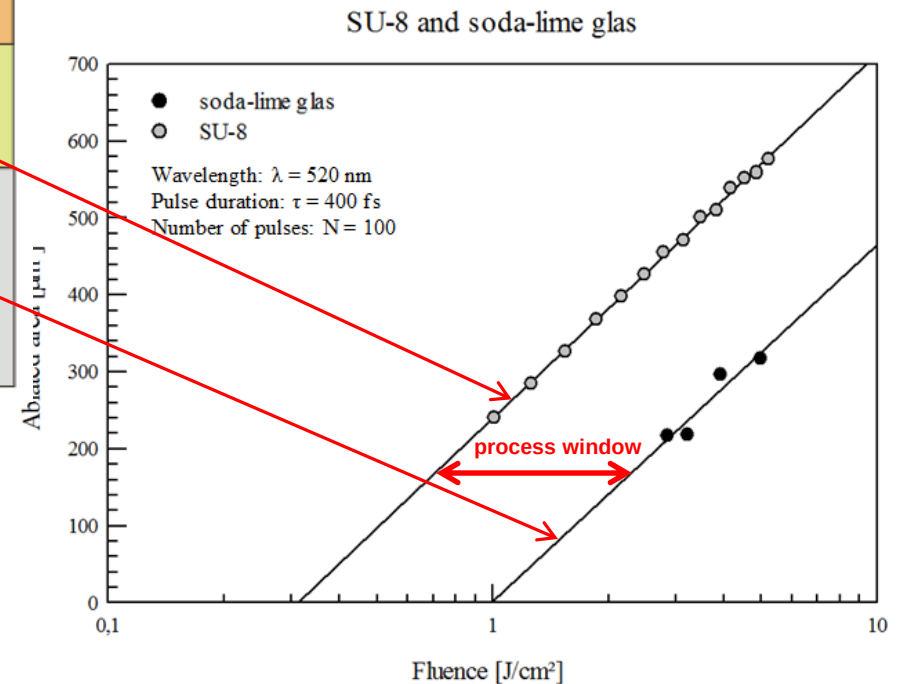
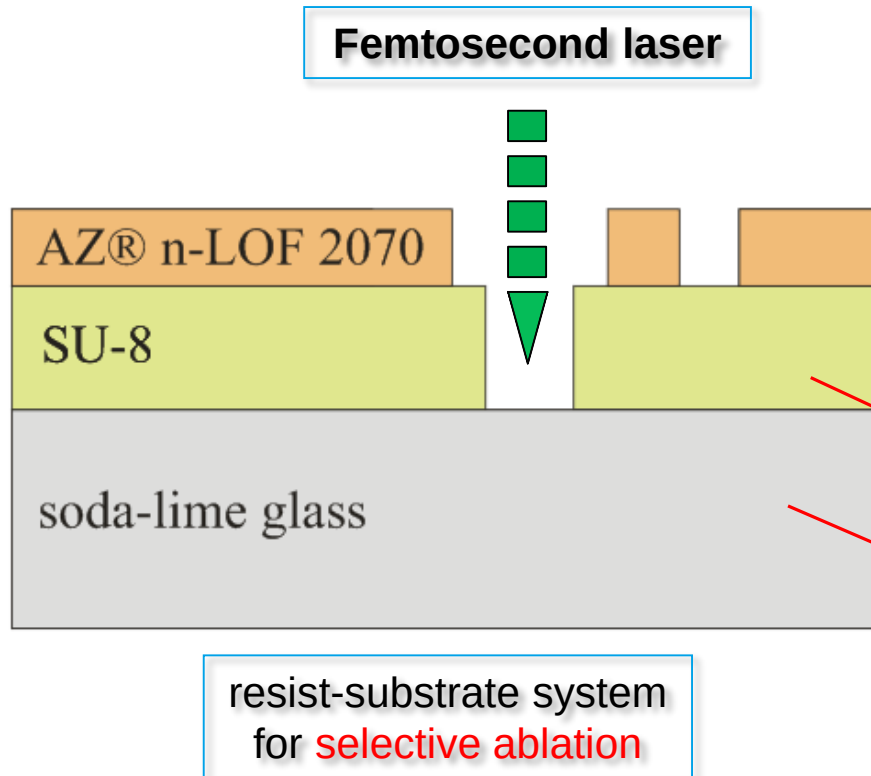


Laser ablation substrate



UV photolithography



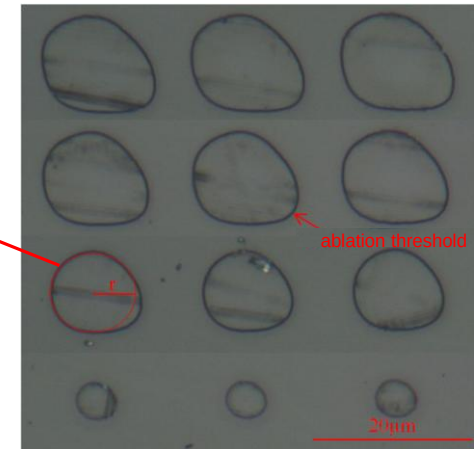
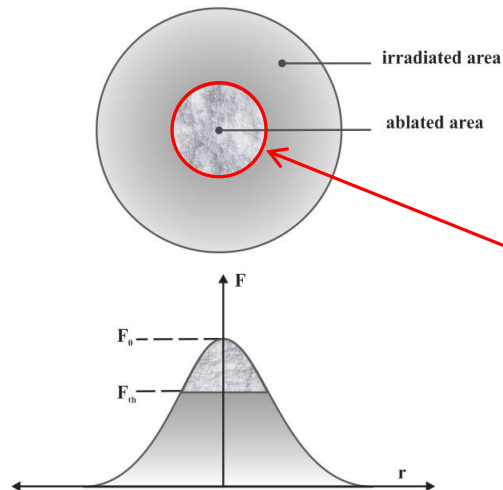


$$F_{th} = F_0 e^{-\frac{2r_{abl}^2}{w^2}}$$

solving the equation for A_{abl}

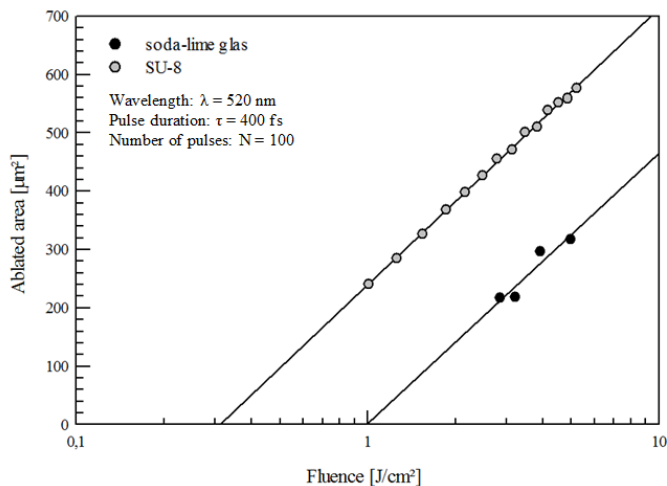
slope

$$A_{abl} = \frac{A_l}{2} \cdot \log\left(\frac{F_0}{F_{th}}\right)$$



Decrease of power

SU-8 and soda-lime glas



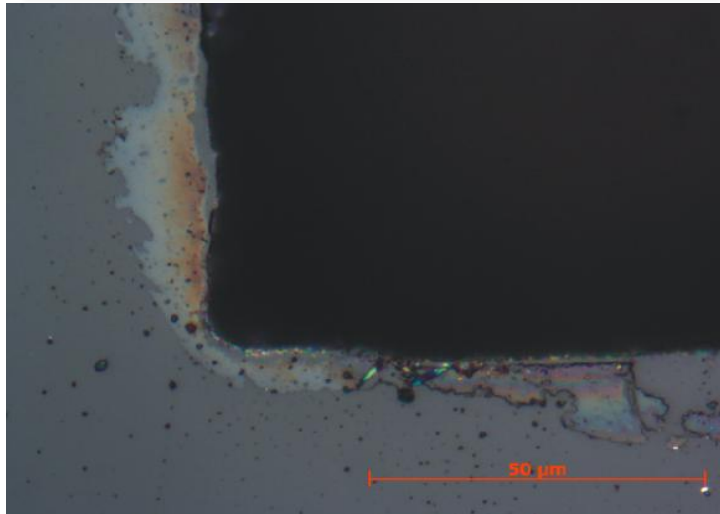
Multipulse threshold fluence

SU-8: $0.3 \text{ J}/\text{cm}^2$

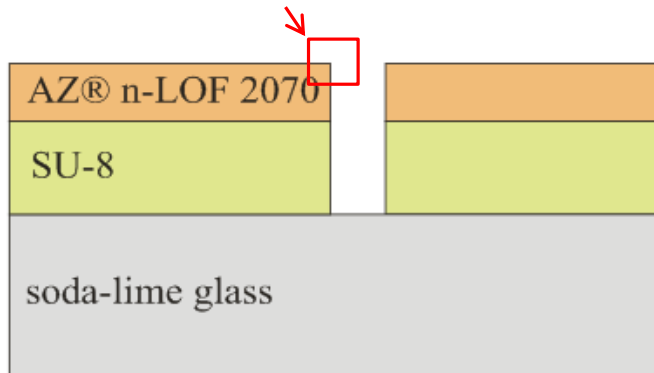
Soda-lime glass: $0.99 \text{ J}/\text{cm}^2$

for $F_{th} = F_0 \rightarrow A_{abl} = 0$ (point of intersection with the x-axis)

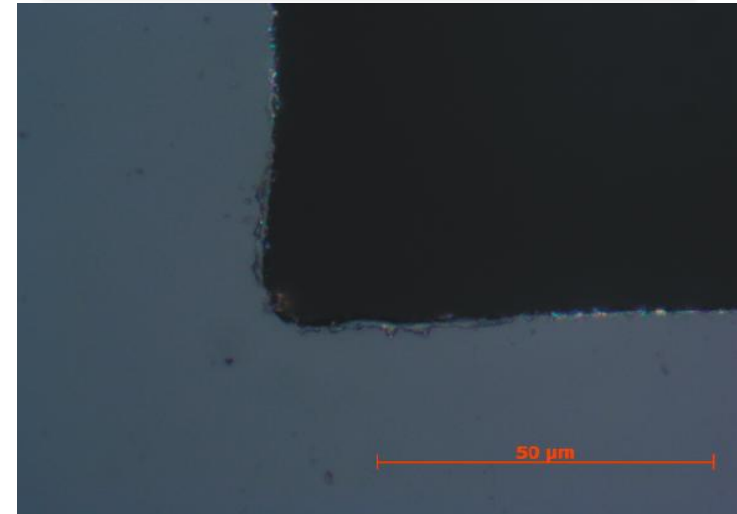
Without protective layer



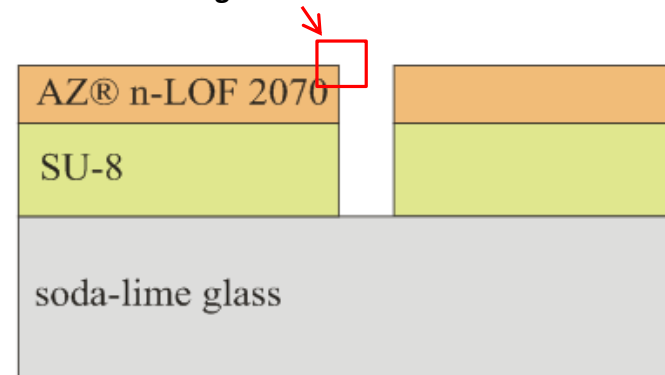
Structure created with laser ablation, edge damage caused by the debris



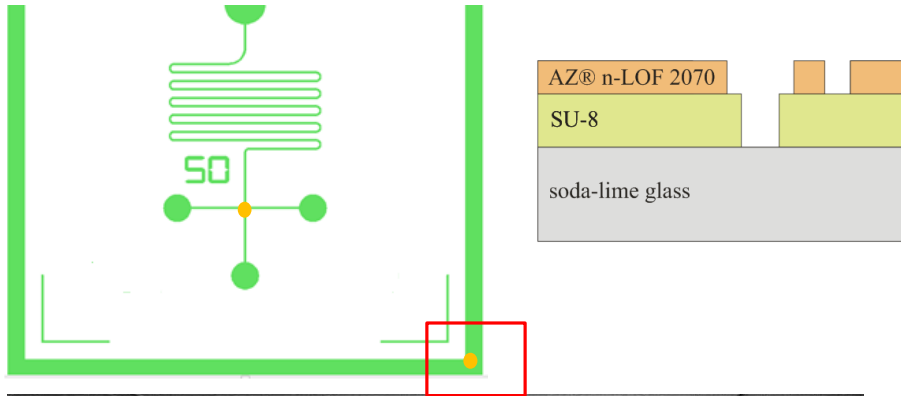
With protective layer



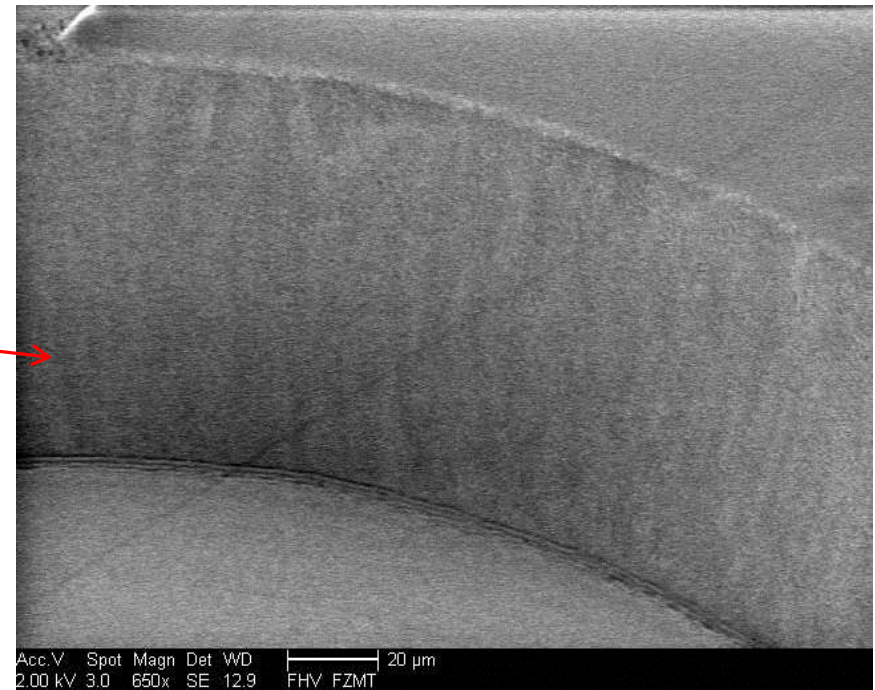
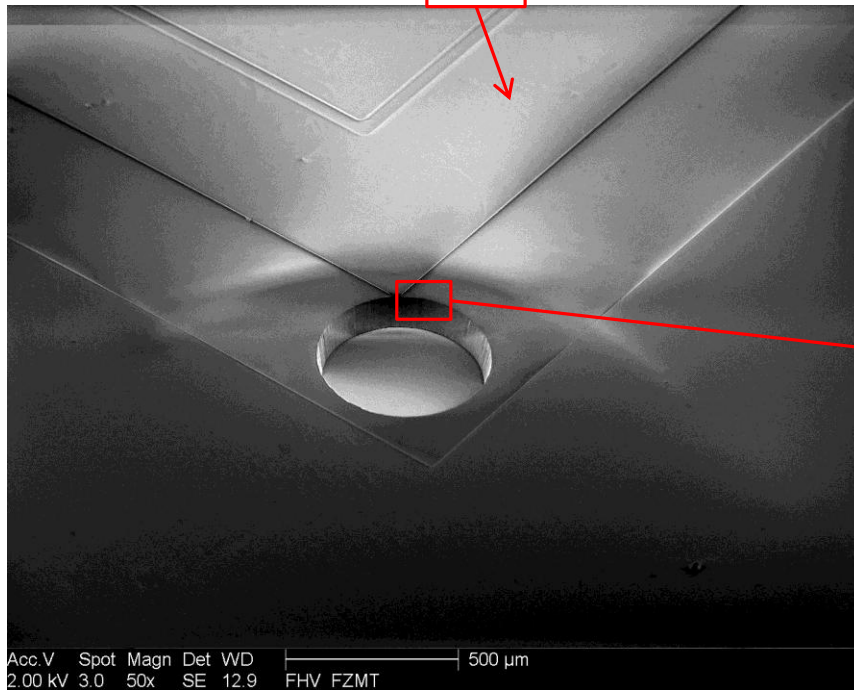
Structure created with laser ablation after removing the PVA with warm water



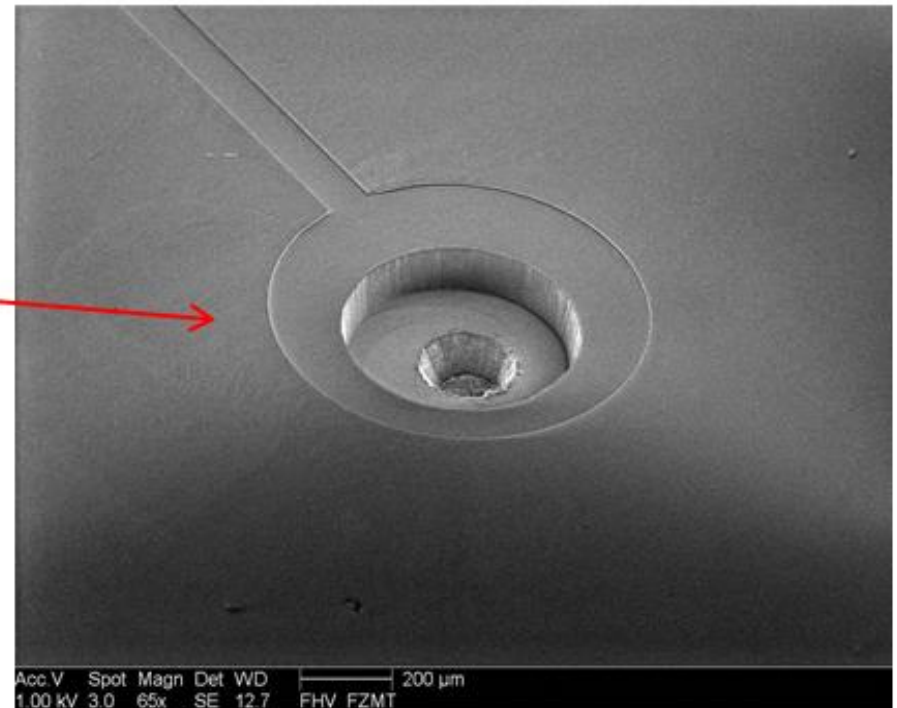
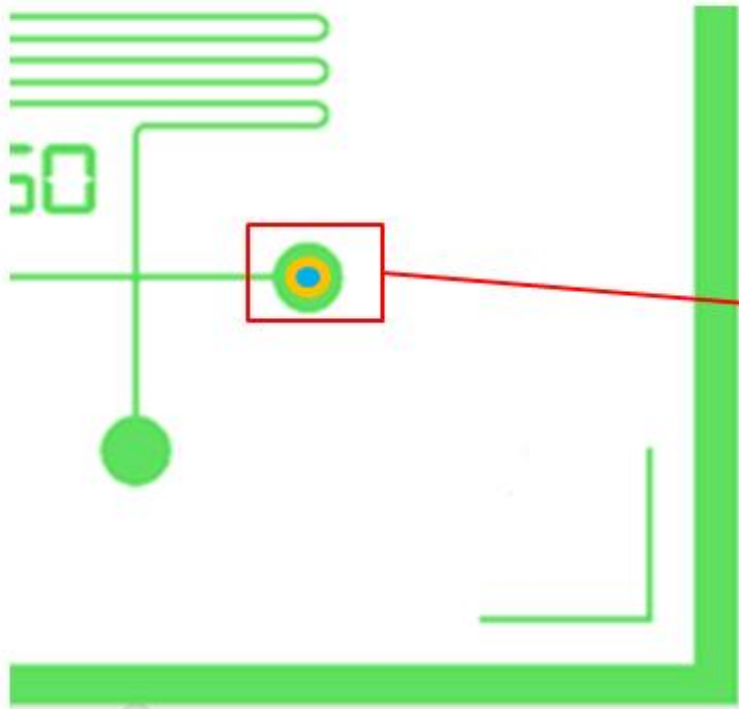
Results selective laser ablation



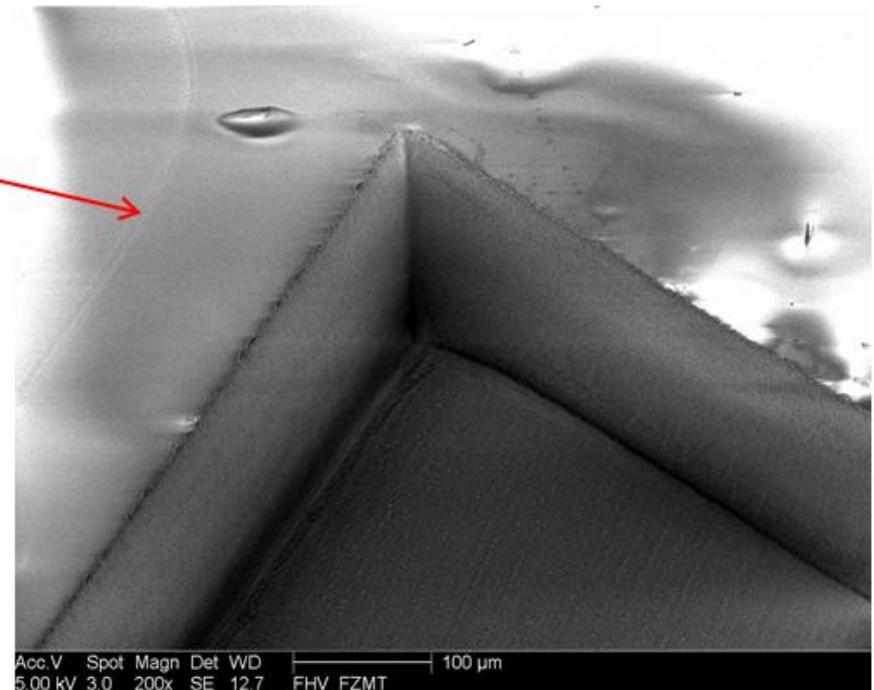
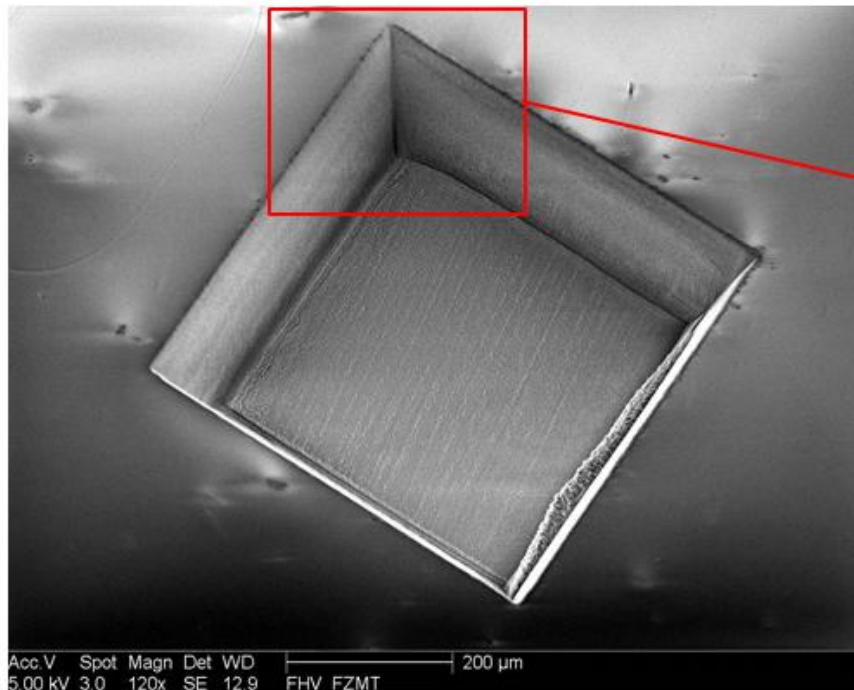
Parameter	Step no. 1		Step no. 2	
	Value	Unit	Value	Unit
Repetition rate	500	kHz	500	kHz
Fluence	0.876	J/cm ²	0.3	J/cm ²
Hatch distance	0.001	mm	0.001	mm
Speed of operation	500	mm/s	500	mm/s
Number of cycles	30	-	30	-



Parameter	Value	Unit
Repetition rate	500	kHz
Fluence	2.23	J/cm ²
Hatch distance	0.001	mm
Speed of operation	300	mm/s
Number of cycles	30	-

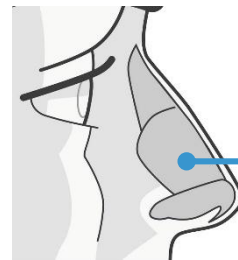


Parameter	Value	Unit
Repetition rate	500	kHz
Fluence	2.23	J/cm ²
Hatch distance	0.001	mm
Speed of operation	300	mm/s
Number of cycles	30	-

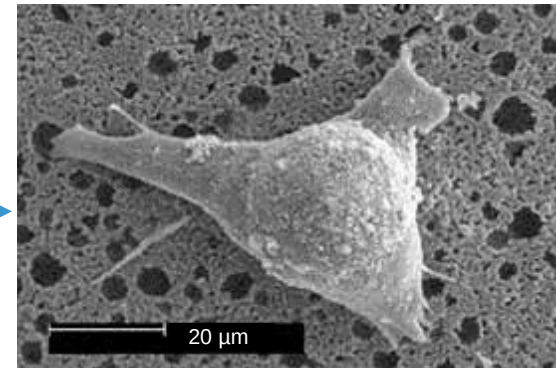


Ultrashort-pulse laser processing of polymers

Surface structuring
cell attachment

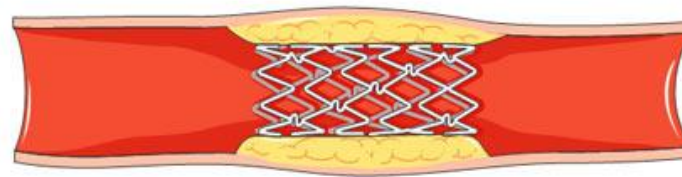


Acredis AG.



H. I. Chang and Y. Wang, "Cell Responses to Surface and Architecture of Tissue Engineering Scaffolds"

Micro structuring
drug coating

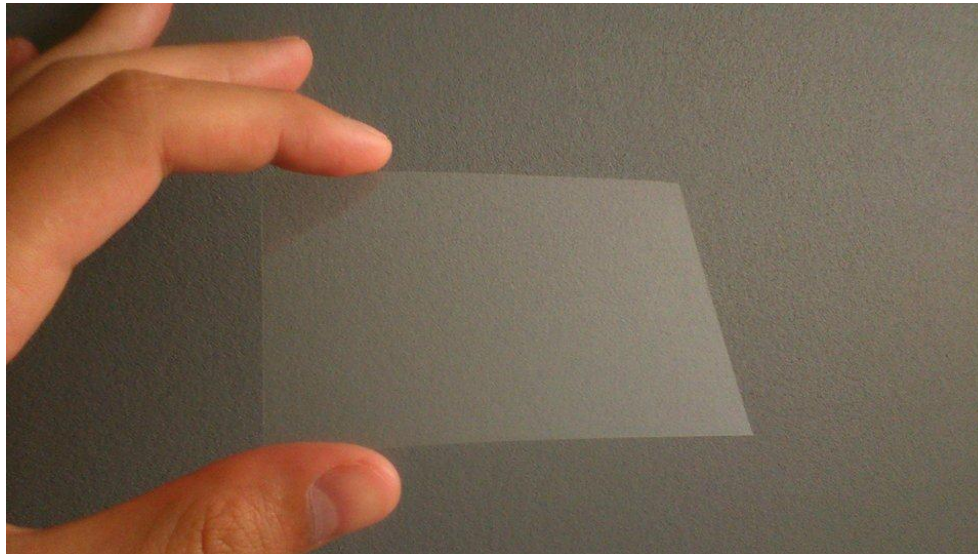


Herz Zentrum Hirslanzen Zürich.

- different applications need different surface textures.
- searching for a process in which this can be specifically influenced!

Material - poly(Lactic acid) (PLA)

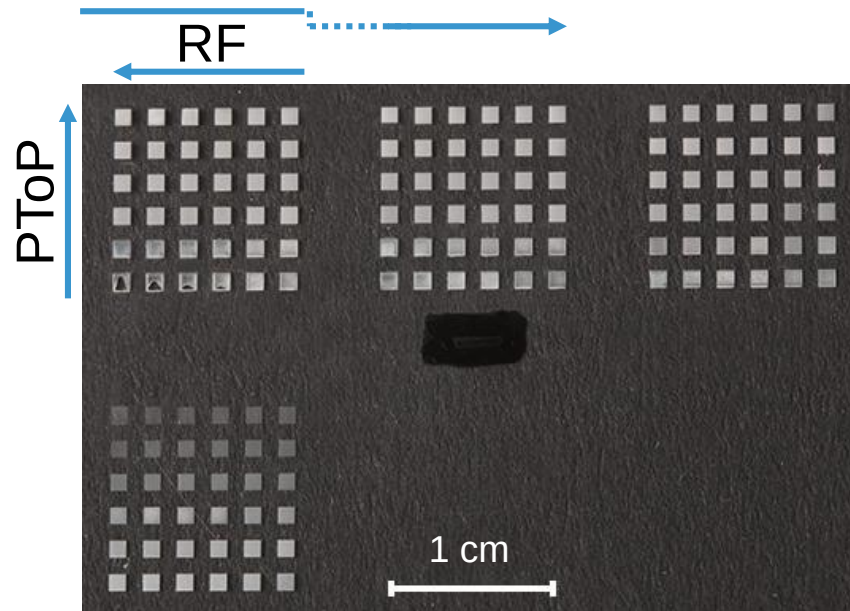
- BJE Kunststoffe, Diepoldsau, Switzerland
- 200 μm thick sheet
- molar mass-average 139 g/mol
- molar number-average 69 g/mol



A machined sample shows the design of the experiment

Single-pass machining

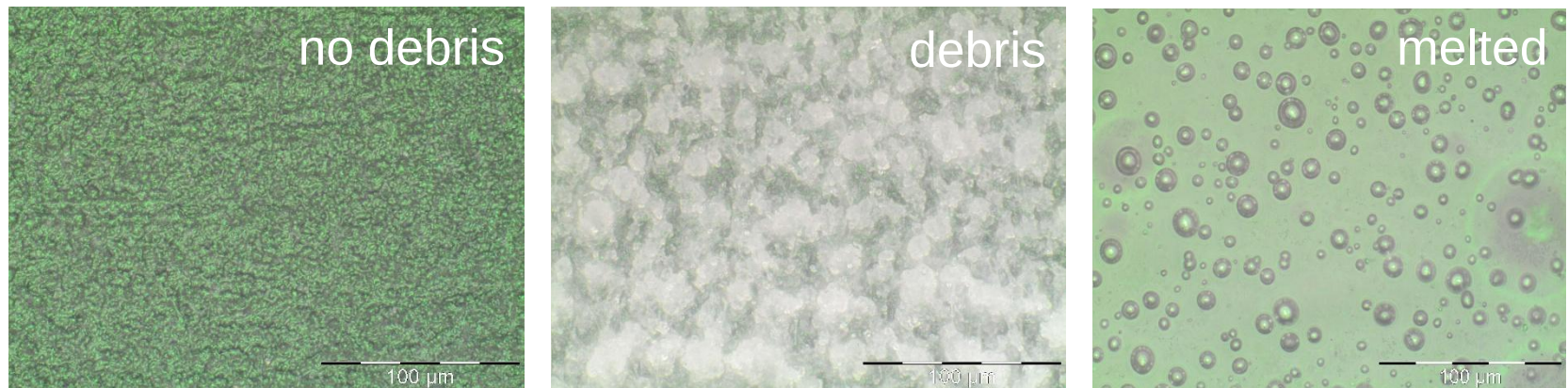
Pulse energy



Machining parameters	Matrix/Column/Row					
	1	2	3	4	5	6
Laser power in W measured at 200 kHz (change in matrices)	1.60	1.15	0.68	0.24		
PToP in μm (change along columns)	10	8	6	4	2	1
RF in kHz (change along rows)	100	50	33.3	25	12.5	6.25

Optical microscope examination

This examination was carried out to detect possible thermal effects.

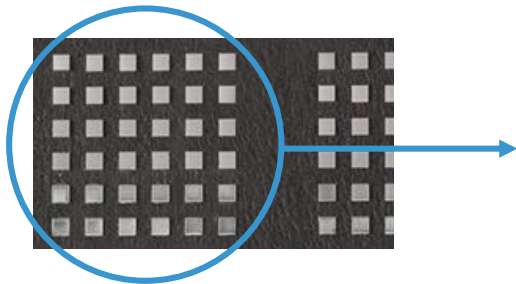


Optical microscope images of pocket surfaces.

→ melted pockets are not considered in further investigations.

Optical microscope examination

Single-pass machined sample classification

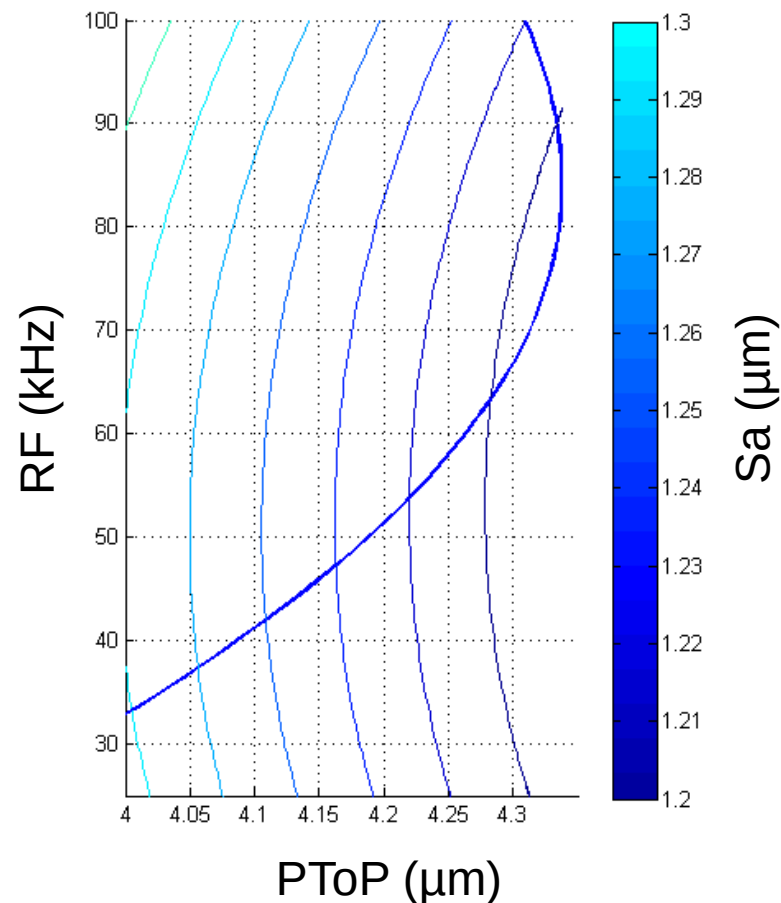


		RF in kHz					
		100	50	33.3	25	12.5	6.25
		Laser power 1.60 W					
PToP in μm	10	no debris					
	8						
	6						
	4						
	2	melted				debris	
	1	Burned through					

Discussion of the data: single-pass machining

Image section shows the possibilities in roughness variation for a fixed depth.

For single-pass machining it is not possible to choose depth and roughness independently!



Acknowledgement

The financial support by the Austrian Federal Ministry of Economy, Family and Youth and the National Foundation for Research, Technology and Development is gratefully acknowledged.



Laserablation: Equipment

Laser

Spirit™ – HighQLaser

Ausgangsleistung: 4 W

Pulsdauer: 400 fs

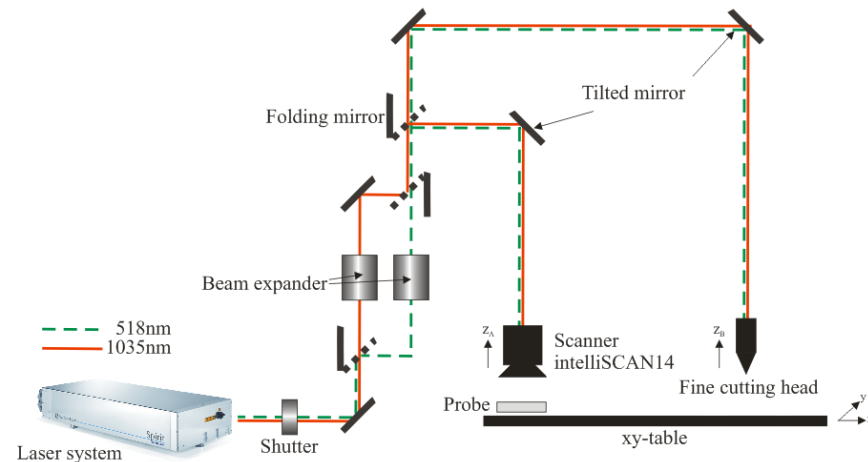
Wellenlänge: 1040 nm, 520 nm

Pulswiederholfrequenz: bis 1 MHz



HIGH Q LASER
THINK ULTRAFAST™

Strukturierungsanlage



Danke für ihre Aufmerksamkeit
