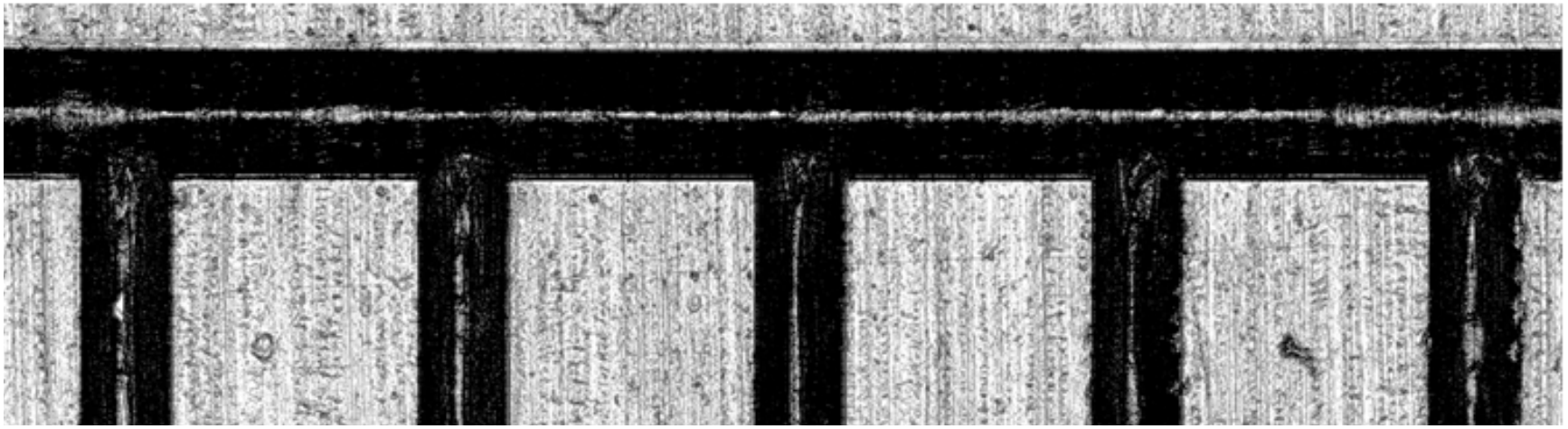
Electromagnetic embossing and forming of optical microstructures

I2FG

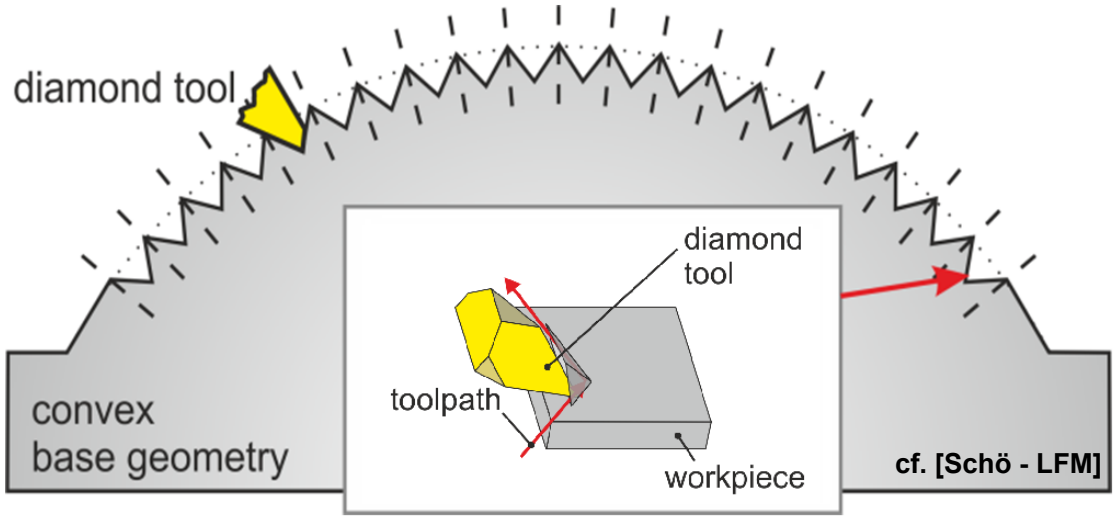
workshop on impulse metalworking

2nd December 2016 - Nantes

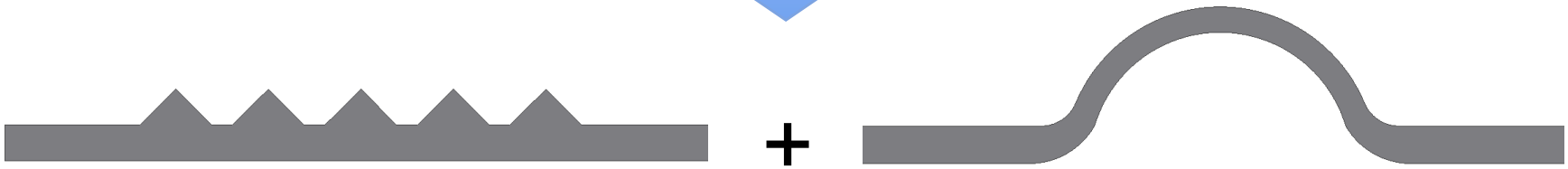
L. Langstädtler – bi**me** – University of Bremen



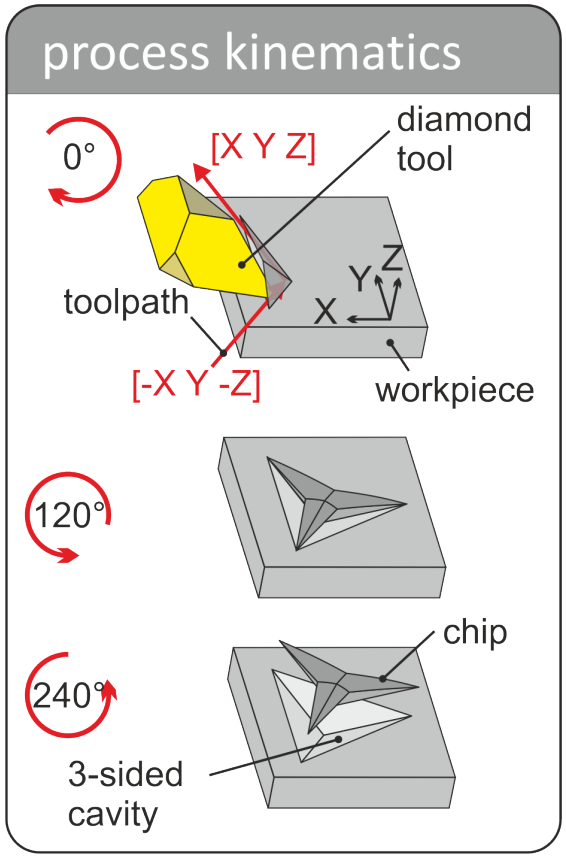
Motivation

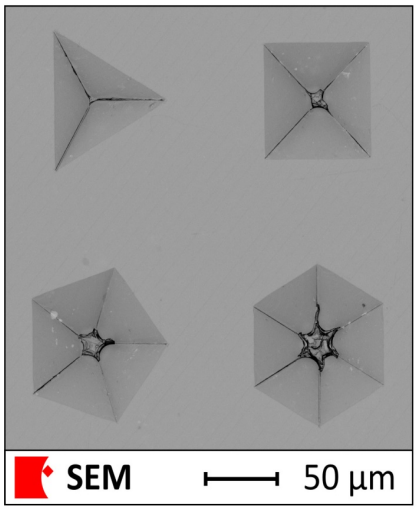


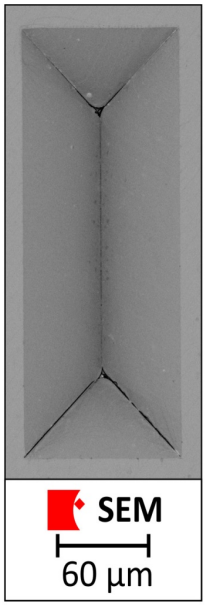
IDEA

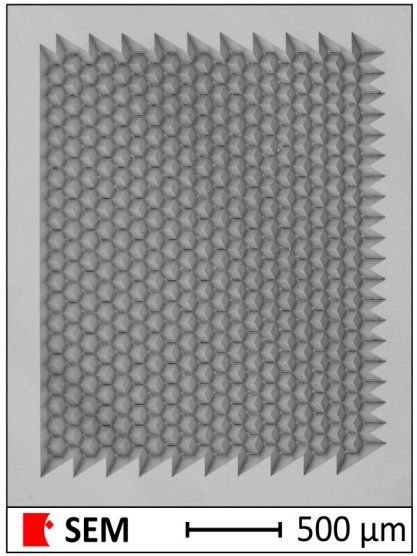


Diamond micro chiseling (DMC)







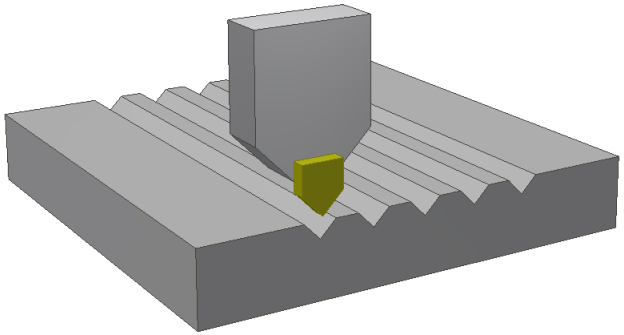


→ conventional process

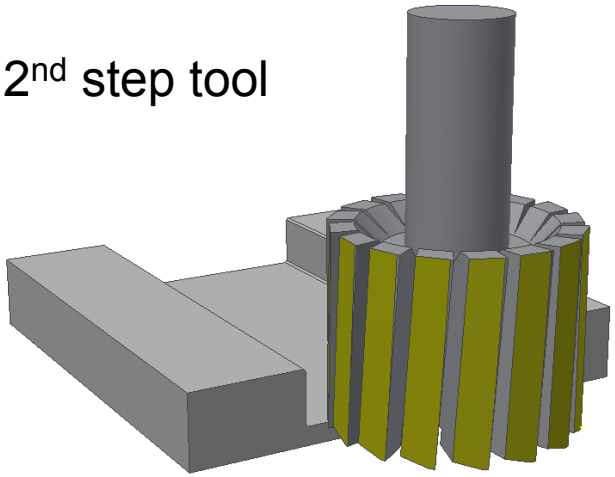
reference: Schönemann - LFM

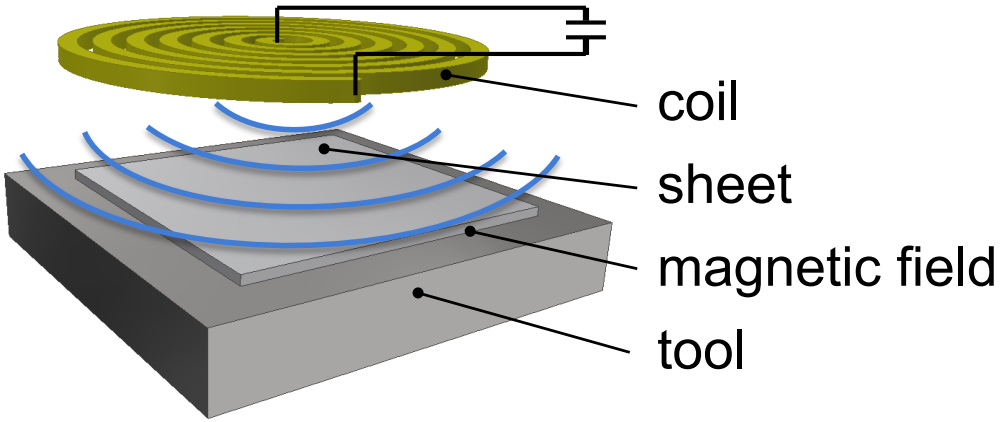
Technology

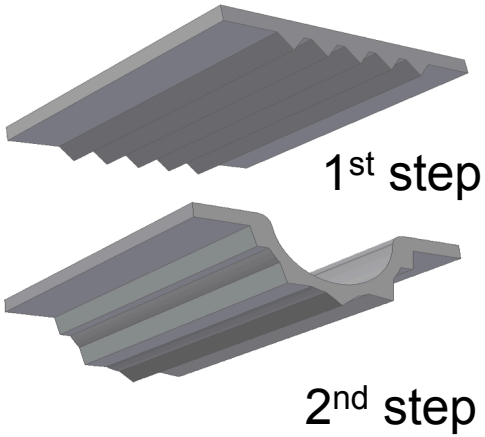
1st step tool



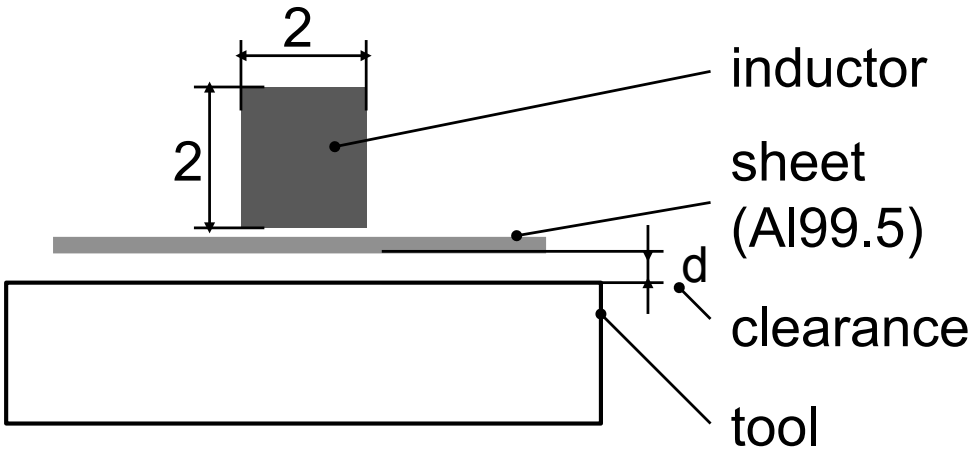
2nd step tool

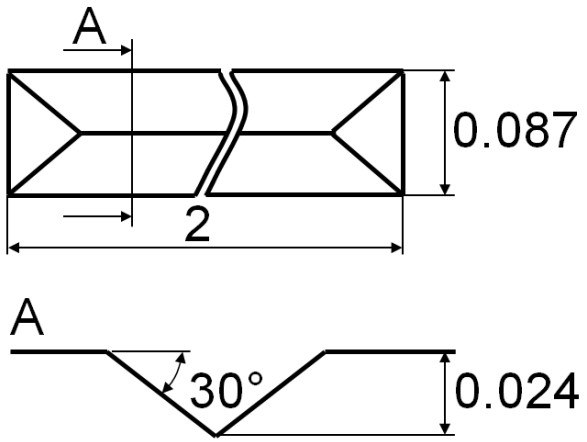


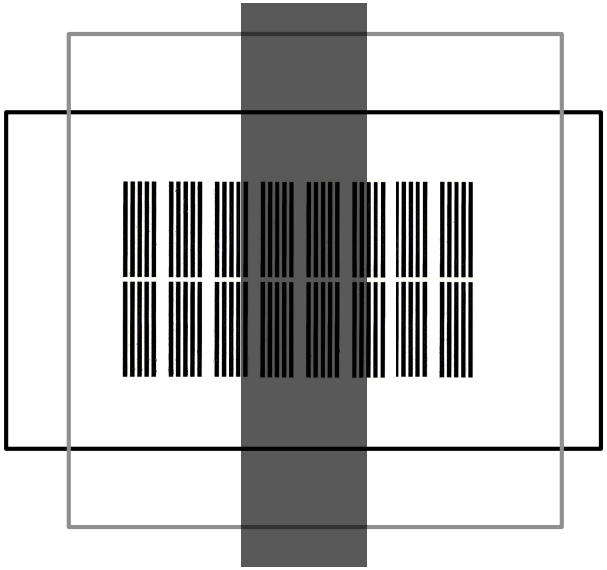




Experimental set up

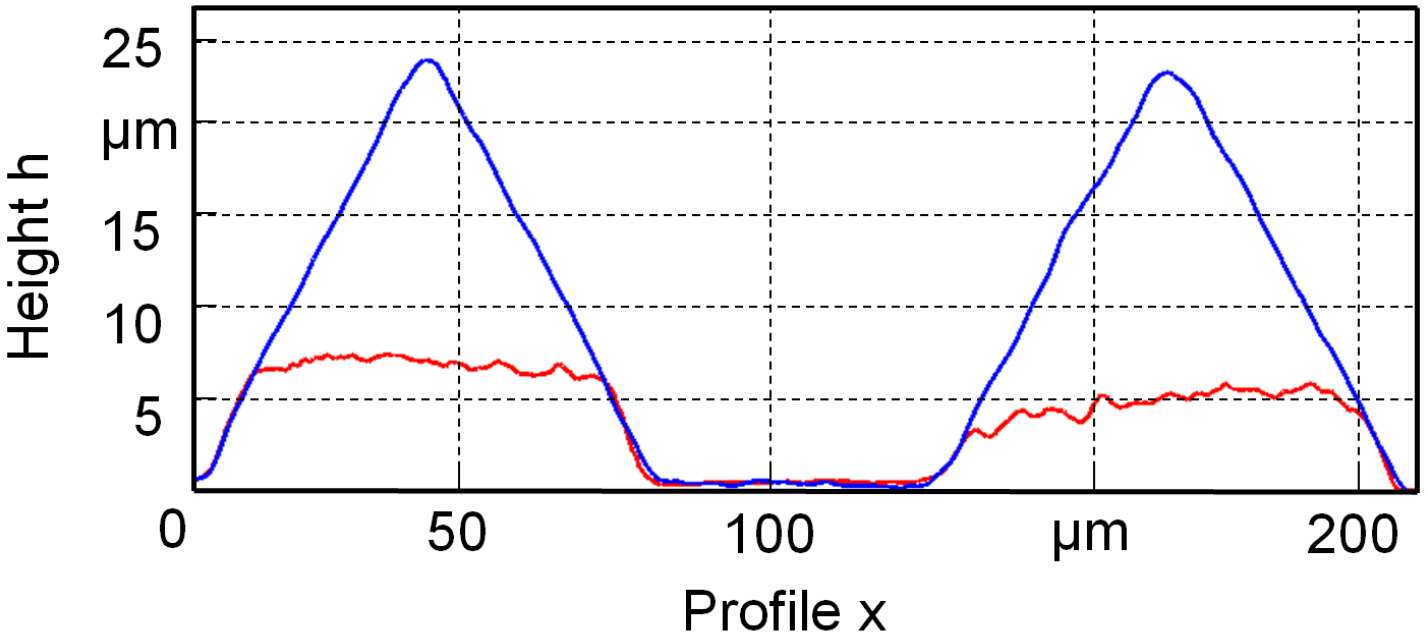




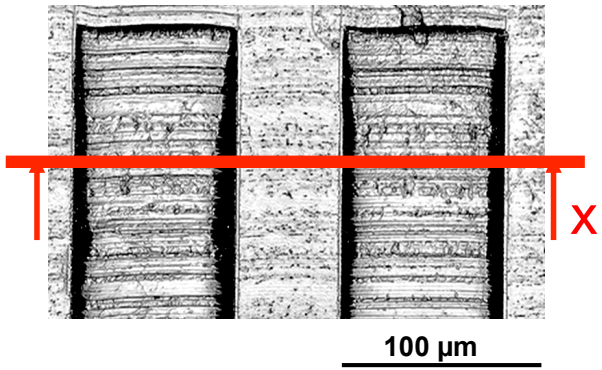


Energy E_c	1.8	kJ
current I_{max}	70	kA
frequency f_0	22	kHz
workpiece velocity	200	m/s
impact pressure	500	MPa

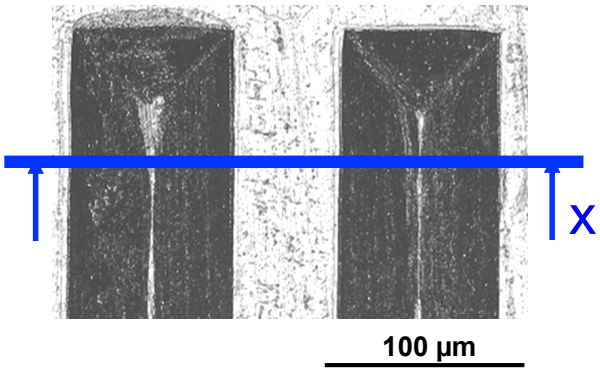
Structural deformation behavior



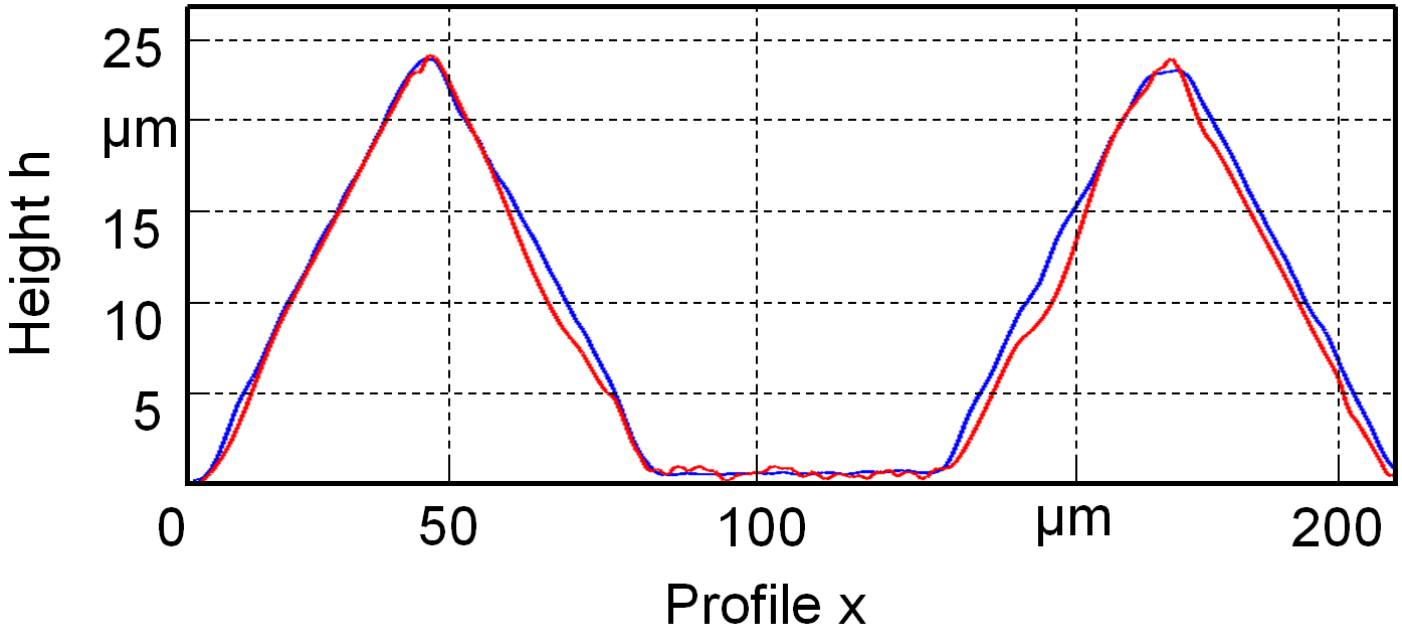
s_0 = 50 µm



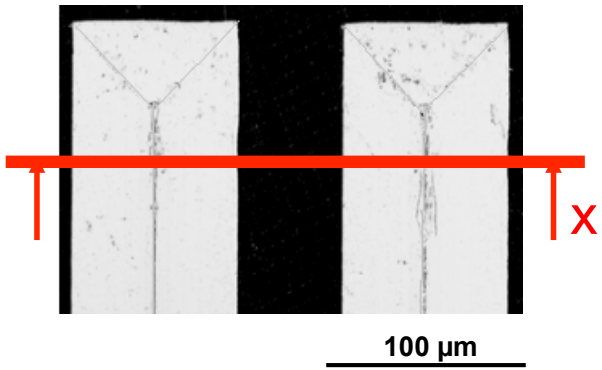
s_0 = 300 µm



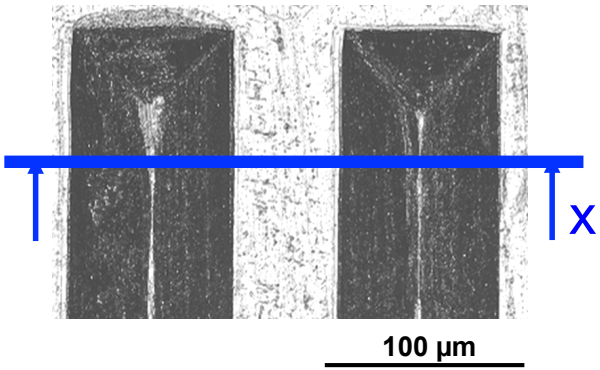
Quality of embossed structure



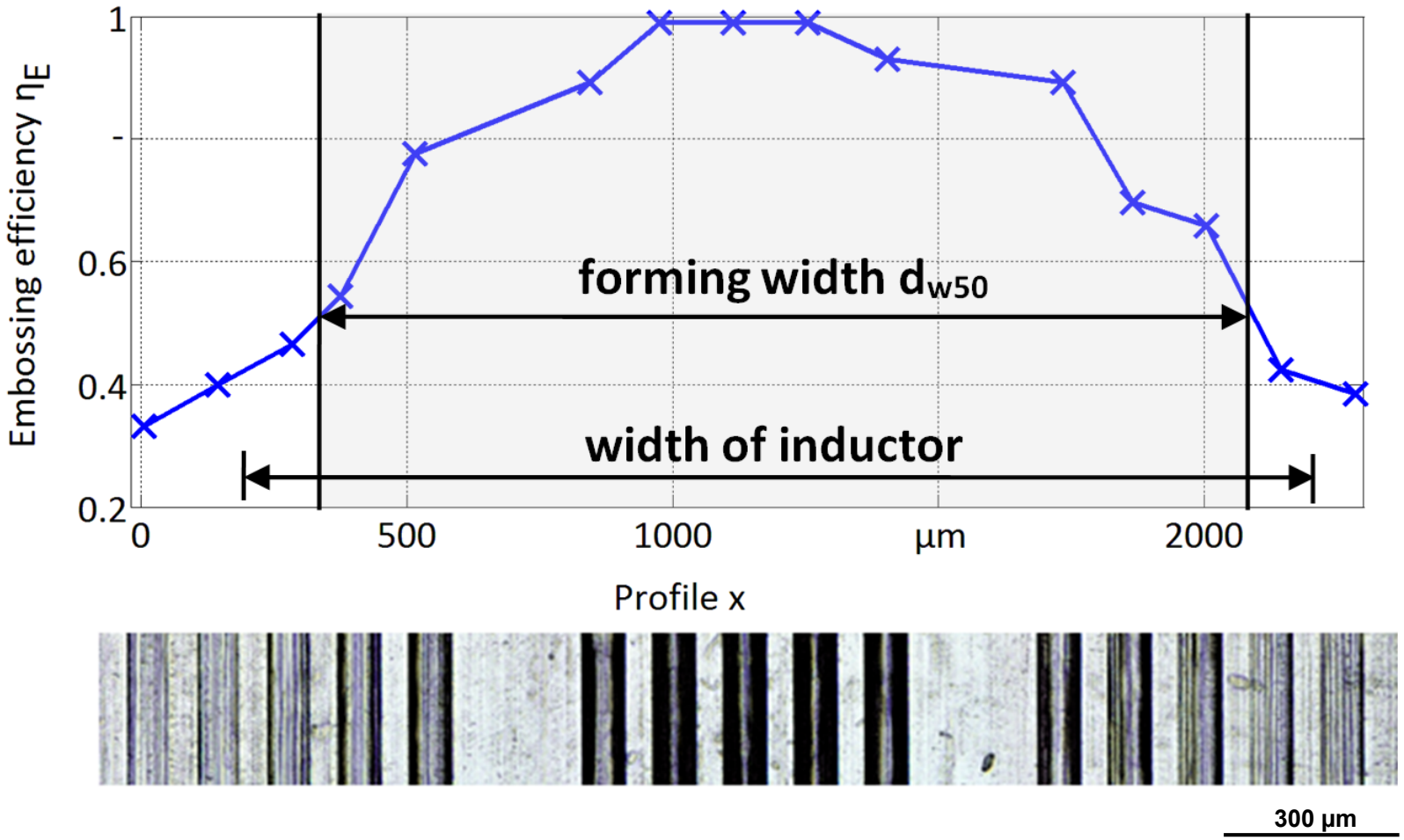
tool



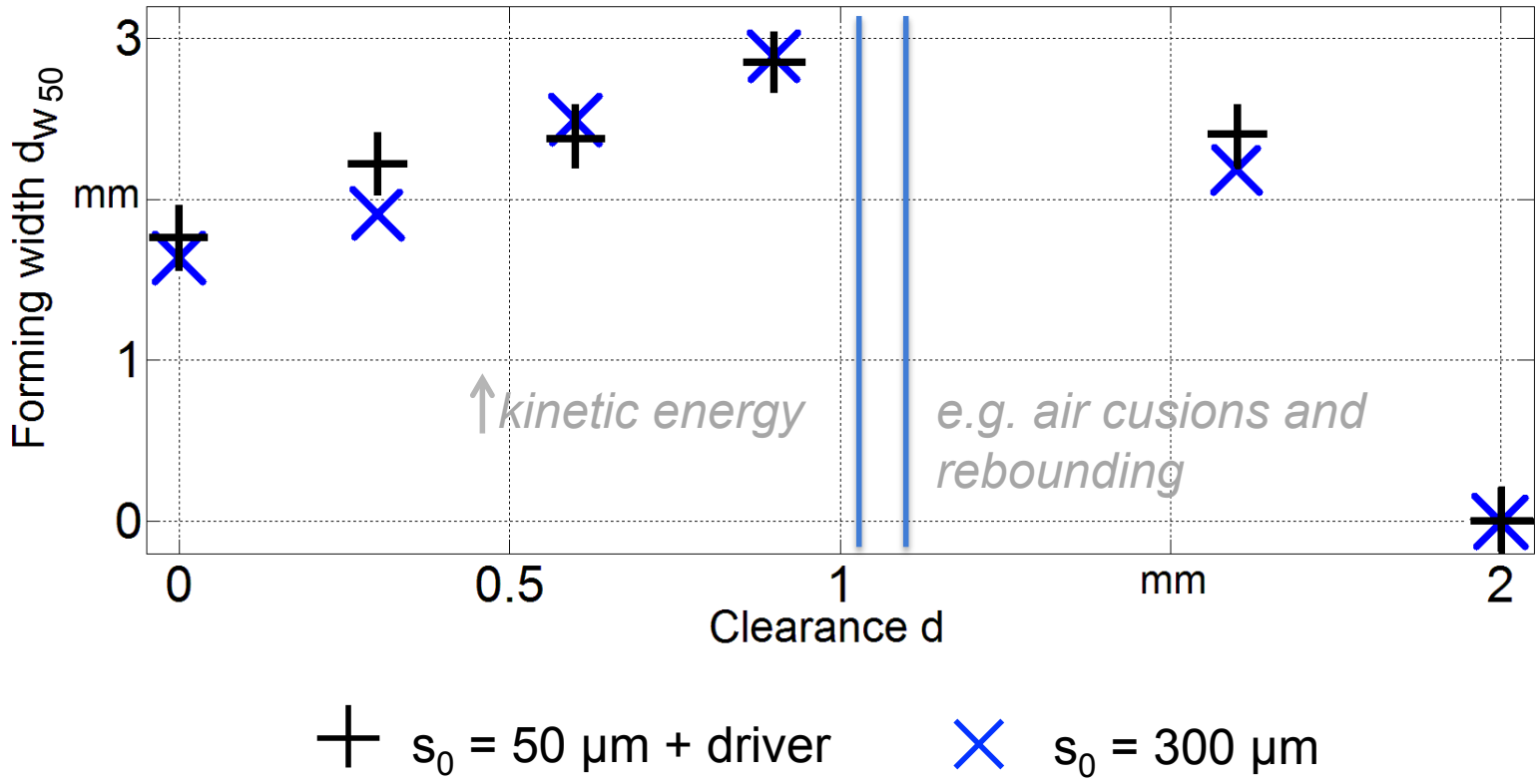
sheet (s_0 = 300 µm)



Embossing efficiency



Lateral deformation behavior

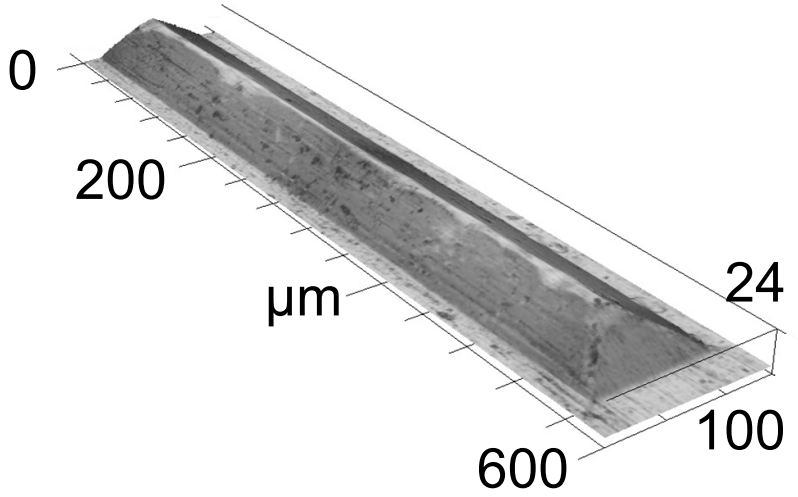


Quality of embossed surface

probe initial surface
Sa = 1000 nm

tool surface
Sa = 20 nm

probe embossed surface
Sa = 44 nm



s_0 = 0.3 mm

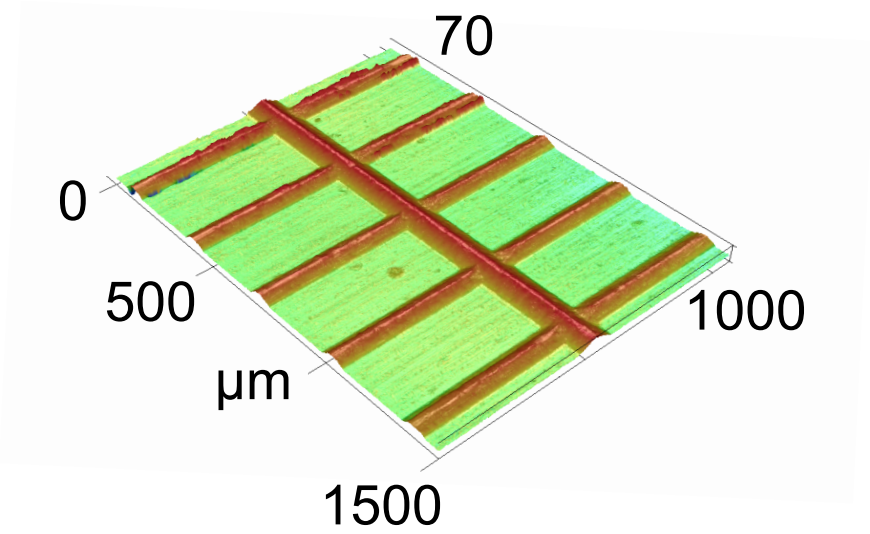
d = 0.9 mm

E_C = 1.8 kJ

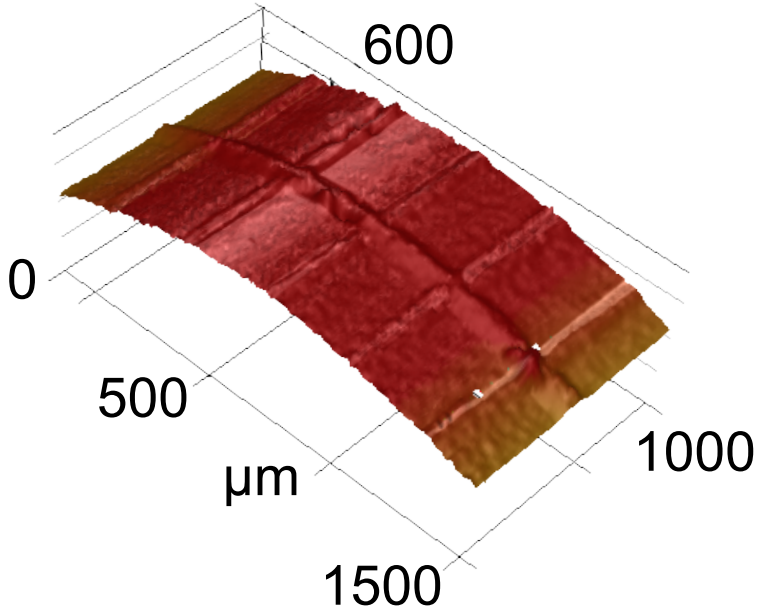
probe

Sequenced forming

1st step
embossing
d = 0.9 mm; E_C = 1.8 kJ



2nd step
free forming
d = 0 mm; E_C = 0.6 J

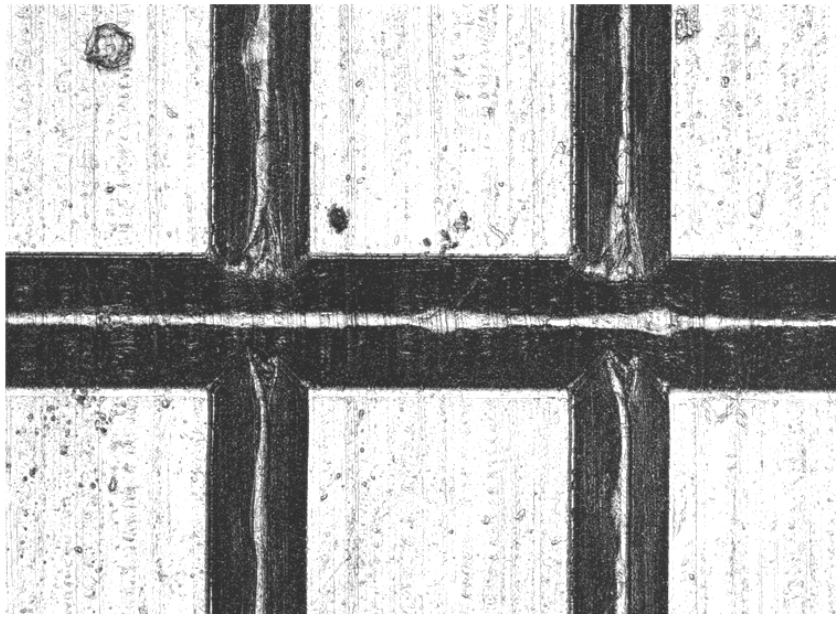


microstructure can be inside or outside of the freeformed macrogeometry due to the application of the formed part

Cross structure – 1st step

tool

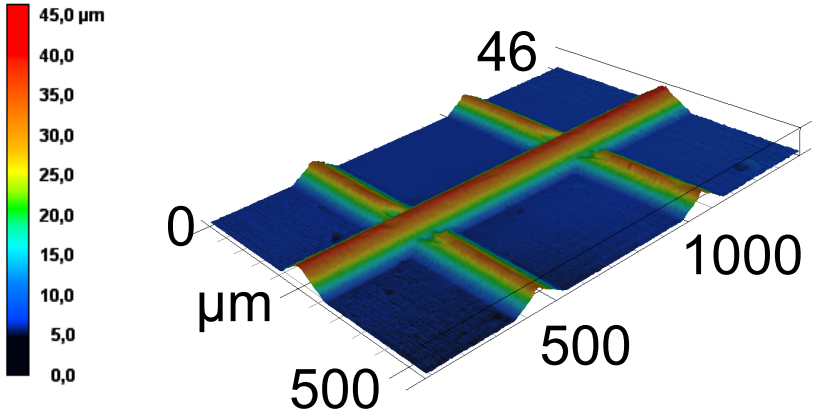
sheet



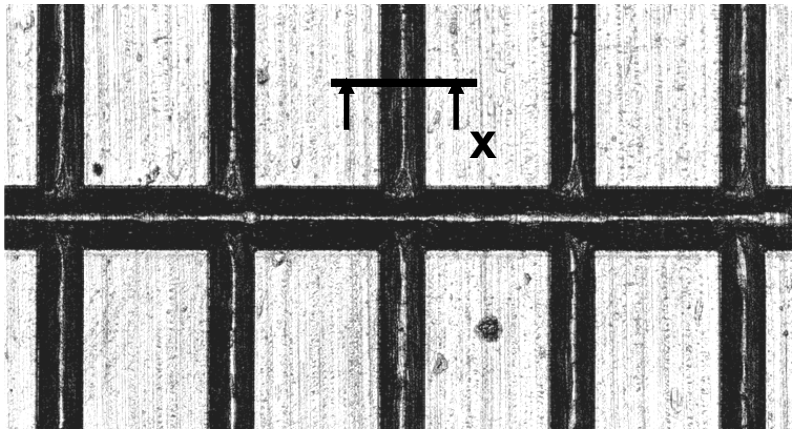
s_0 = 0.05 mm + driver

d = 0.9 mm

E_C = 1.8 kJ



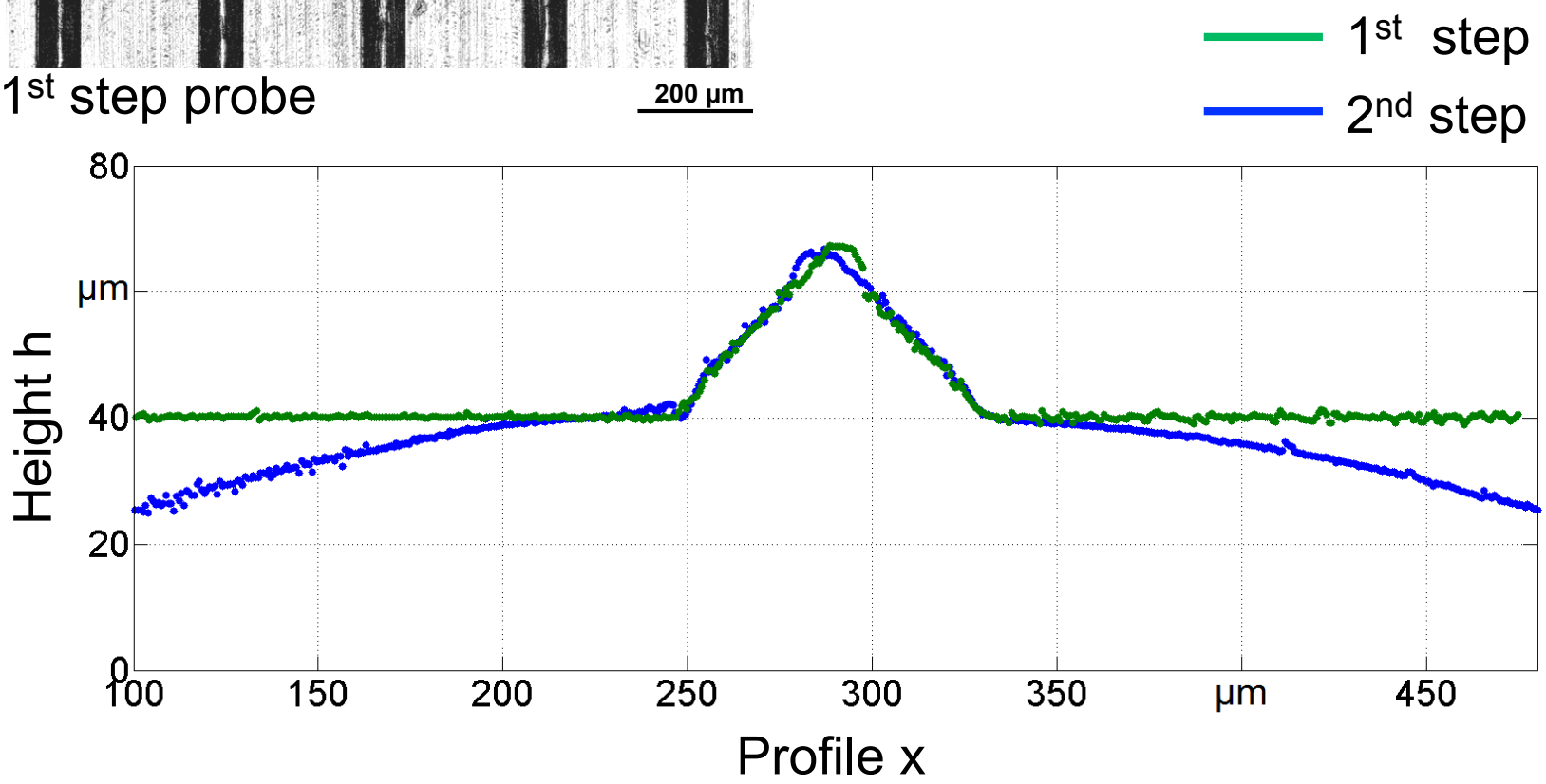
Cross structure – 2nd step



1st step probe

200 µm

microstructure deformation:
with 20 % strain in the makro geometry no influence on width



Conclusion

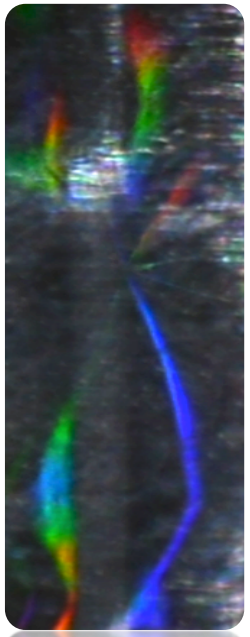
- replication of microstructures
- replication of surface quality with near optical finish
- embossing thin micro metal sheets
- free forming of structured sheets
- complex optical geometries realizable
- shorter manufacturing times
- lower invest (tools)

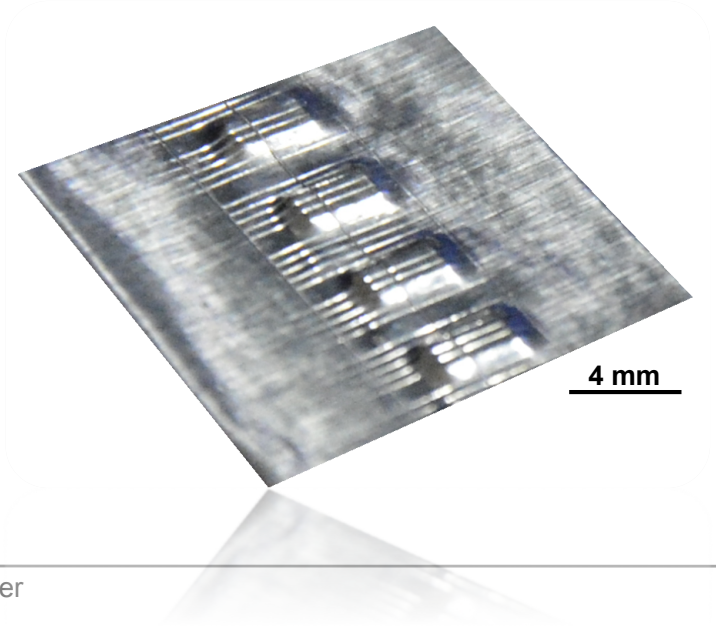
Future work

1st step
- embossing of more complex micro structures
- embossing of optical diffractive structures

2nd step
- controlling macro geometry and shape

  by adapted micro structures





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Thanks to…

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