Digital Printing on 3D Printed Surfaces

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Add+it 2016, Steyr

LEADING
INNOVATIONS

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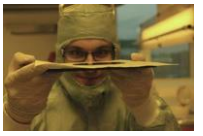
Content

- Background
- Motivation – Why inkjet printing on 3D printed surfaces
- What is necessary to do so?
  - Rough surfaces
  - Curved surfaces
  - Finding the right spot
- What else could be done?
- Outlook and Vision

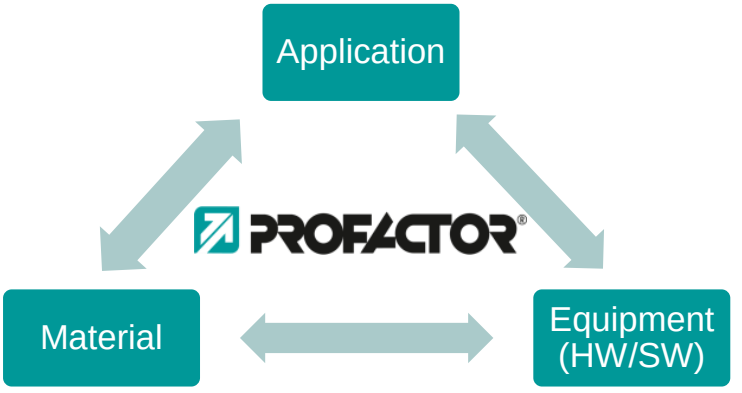
Our Research Topics – Research for Industries

Industrial
Assistive Systems

Additive Micro/Nano
Manufacturing



Additive Micro/Nano-Manufacturing



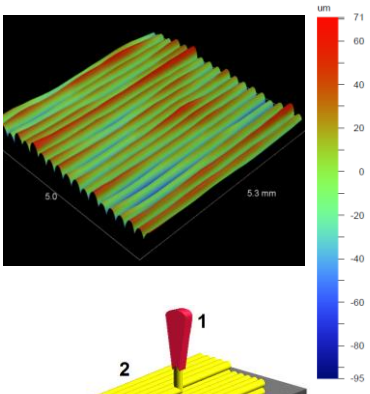
Surface Finishing of Additively Manufactured Objects ?

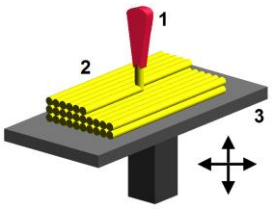
- Surface finishing is almost always necessary in additive manufacturing
  - Layer-by layer buildup
  - Wires

  - Sand blasting
  - Solvent treatment
  - Polishing
  - Painting, …

  - Why not add functionality in the same step?

- *Why not inkjet print on such a 3D printed object ?*





What Could be the Benefits?

- 3D Printing provides individualized objects
- Surface finishing should also have the possibility of be individualized
  - Digital inkjet printing

- Put different materials on different positions of the objects
  - Chemical properties
  - Mechanical properties
  - …

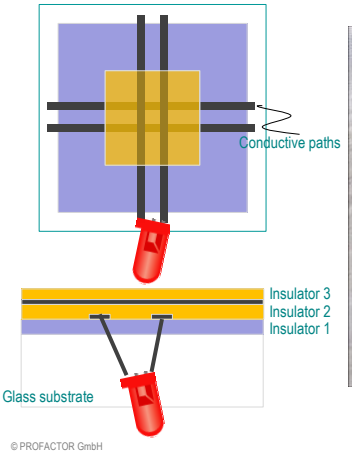
- Include additional functionality!

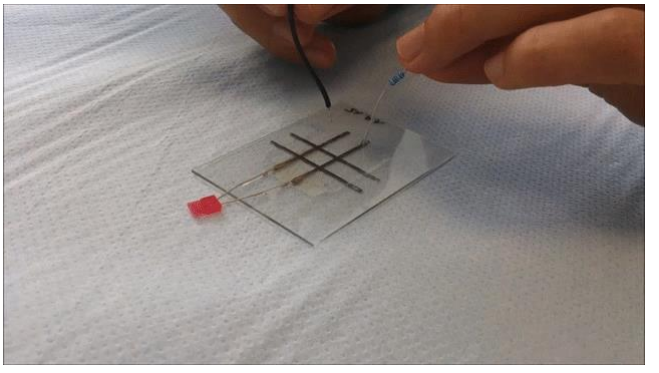
Additional Functionality ??

- Inkjet Printing of functional materials

Multimaterial, Multilayer Inkjet Printing

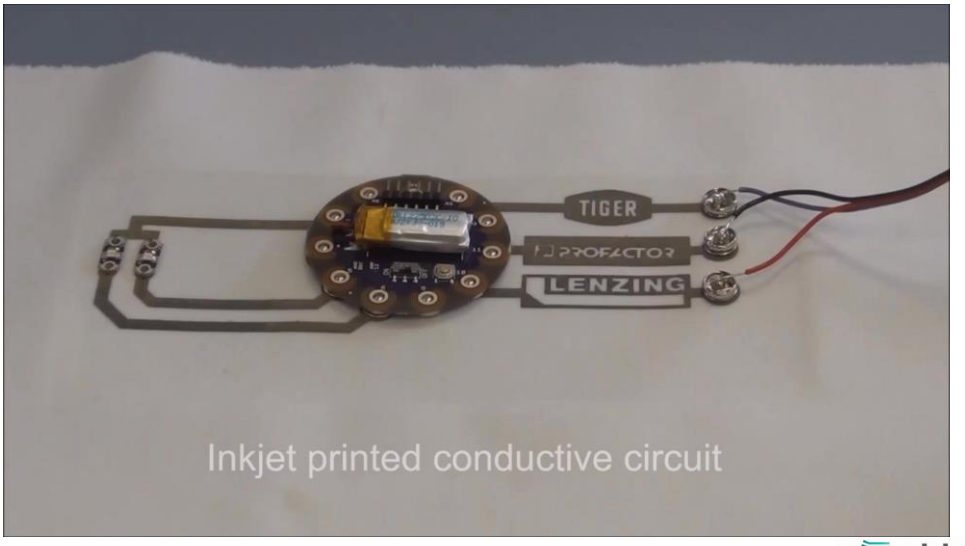
- Inkjet printed modified OrmoComp
- Silver nanoparticle inkjet ink





Inkjet Printing of Conductive Lines on Textiles

iTextil FFG

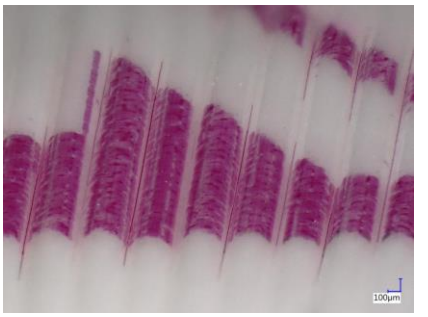


What is necessary to be able to inkjet print on 3D prints?

- Inkjet Printing ôn rough surfaces
- Inkjet Printing on curved surfaces
  - Local distance variation between printhead and surface due to finite size of printhead
- Finding the right spot on the curved surface i.e. on the 3D printed object, where to perform the Inkjet Printing
  - Moving the printhead over the 3D object
    - Has something to do with finding the object, knowing where the surface is

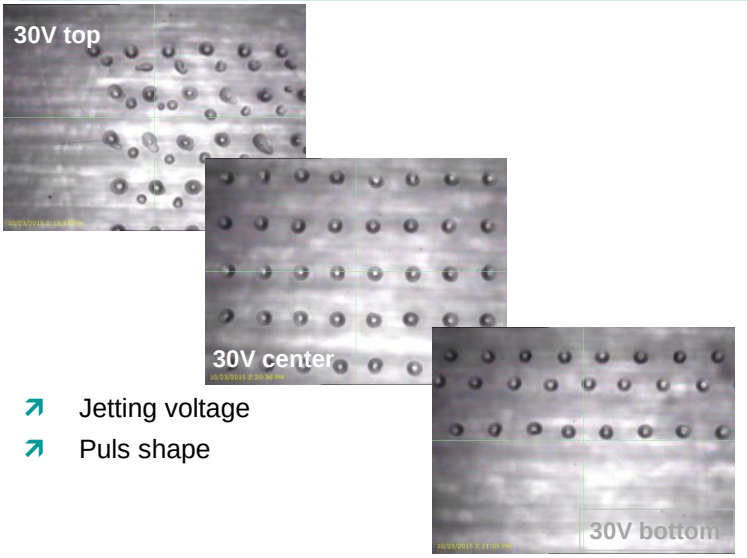
Inkjet printing on the rough and curved surface

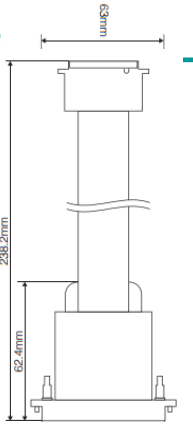
- Rough surface: capillary effects

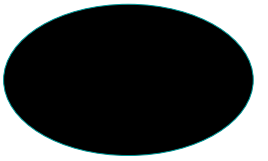


- Fast UV-curing
- Optimize surface tension and viscosity for substrate ..
- However: Inkjet restrictions

variation of distance between printhead and surface



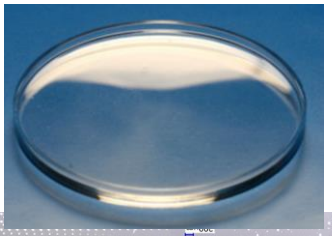


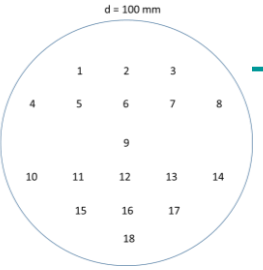


- Jetting voltage
- Puls shape

Inkjet Printing on curved surfaces

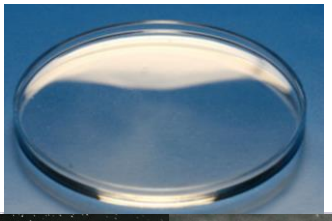
- Watch glass
- 200µm drop spacing
- 20V

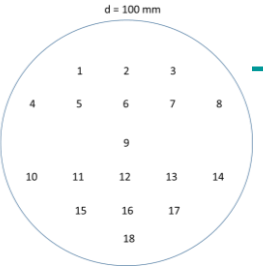


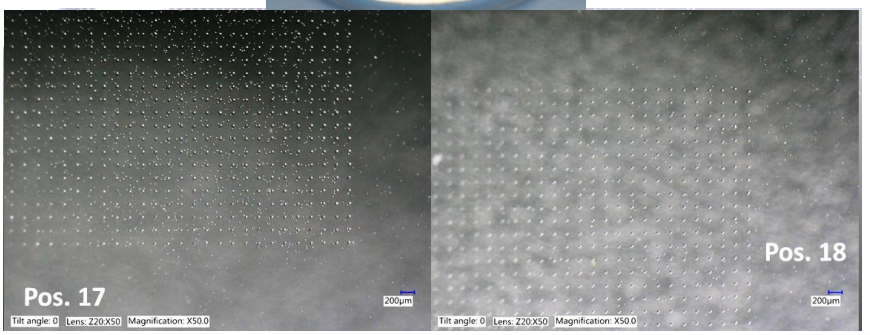


Inkjet Printing on curved surfaces

- Watch glass
- 200µm drop spacing
- 40V



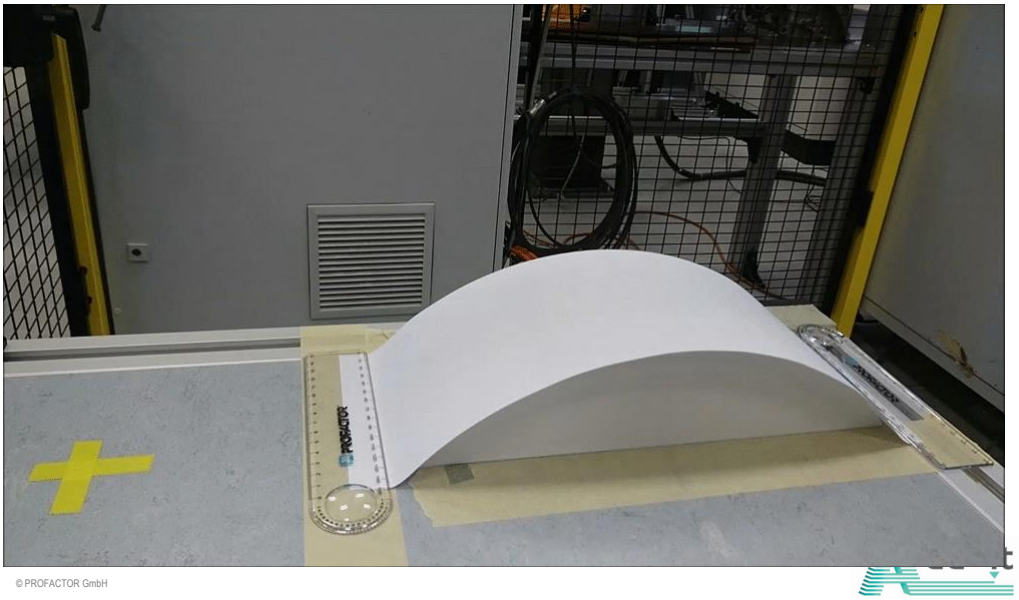




Inkjet Printing Challenges

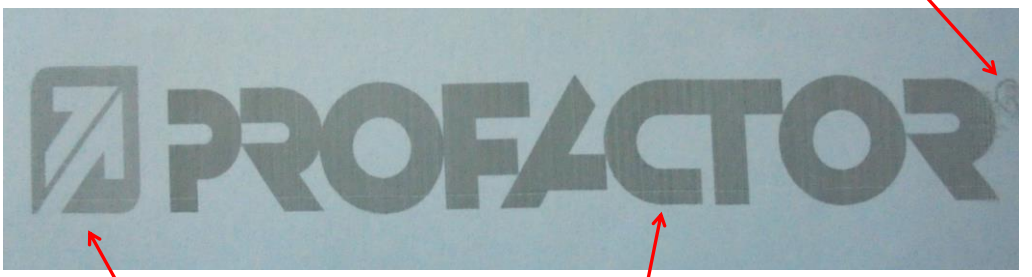
- 3 challenges:
  - Rough surface ✓
  - Local distance variation between printhead and surface due to finite size of printhead ✓
  - Moving the printhead over the 3D object
    - Has something to do with finding the object, knowing where the surface is

Inkjet Printing on Curved Surfaces



Influence of Robot Movement?

Increased distance



Acceleration phase

Non-constant speed
Dot density variation

So … inkjet printing can do nice things

- On rough surfaces
- On curved surfaces
- Printhead moved by robot

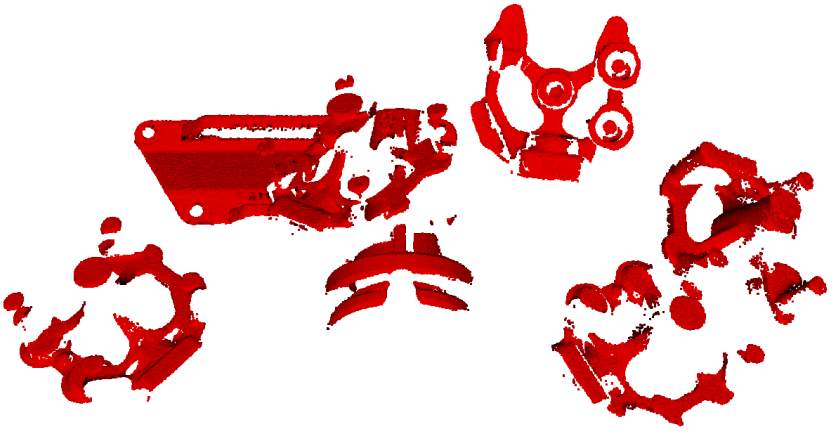
✓ we are working on it

- But … 3D printed objects are individualized … each one is different

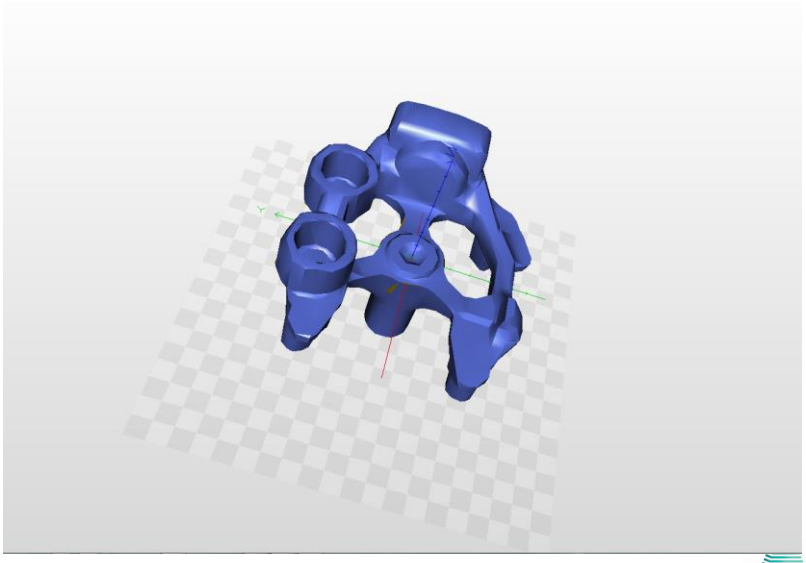
- *Where to print??*

Finding the Objects

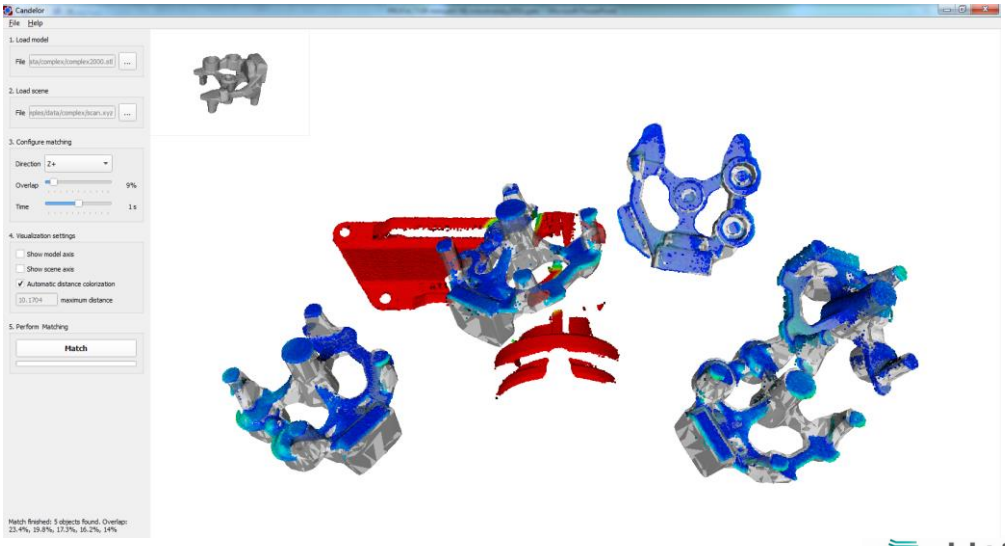
Finding the Objects – 3D vision



Object to be found



candelor



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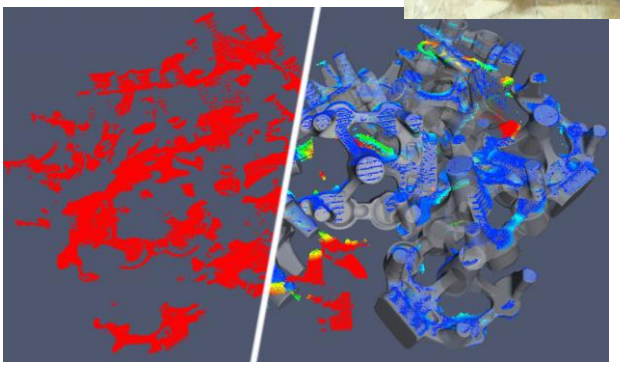
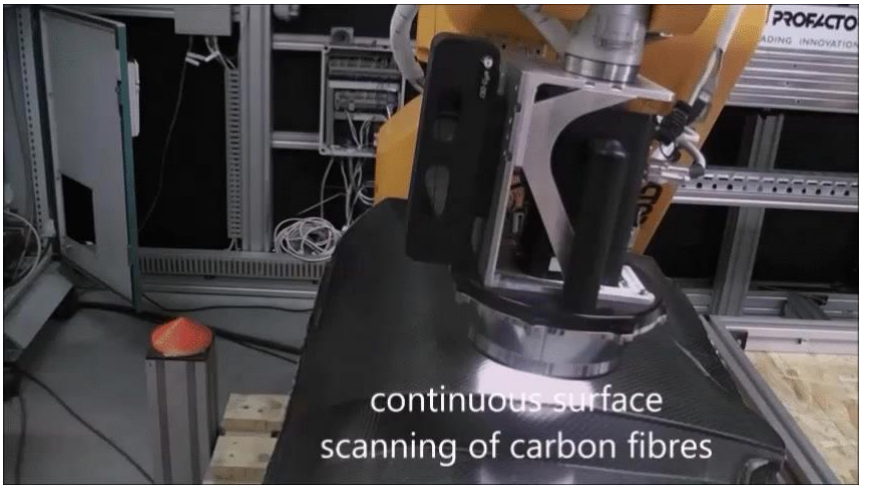
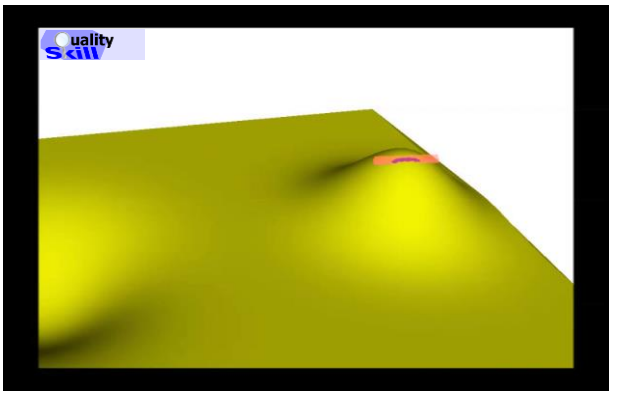


Moving over a scanned 3D surface



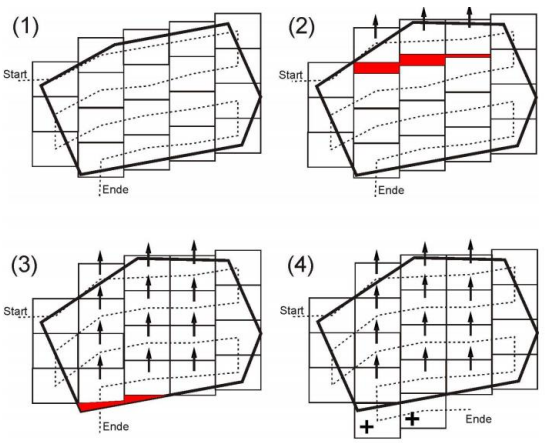
Coverage Planning

- Known, or acquired 3D geometry →
- Evaluate, which area can be reached with the
- Accuracy of acquired 3D geometry ??



Reactive path planning

- Reality … different from the plan
- Visual Servoing



The objects can be found

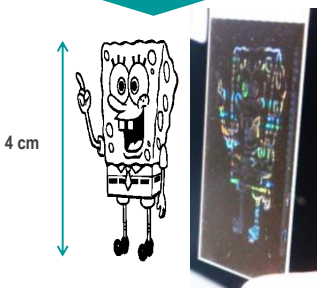
- Using machine vision, it is possible to find known objects in 3D space and move a robot in close vicinity of the surface ✓

Conclusions

- Inkjet printing on curved and rough surfaces ✓
- Getting the ink to the right spot on this curved surface (3D object)
  → Inkjet Printing + Robotics ✓
- Finding the right spot on the curved surface i.e. on the 3D printed object, where to perform the Nanoimprint → 3D Machine Vision ✓
- Basic technology building blocks for Inkjet Printing on arbitrary 3D printed objects are available
- …. more things can be done

Inkjet and NIL combined

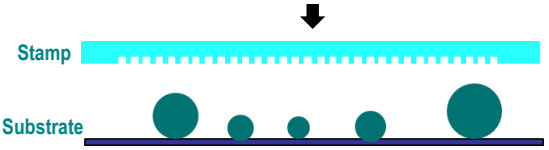
Step 1 – Inkjet printing → **Step 2 – Apply stamp** → **Step 3 – UV illumination** → **Step 4 – Remove stamp**

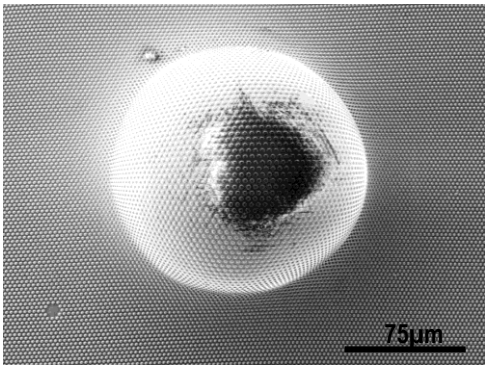


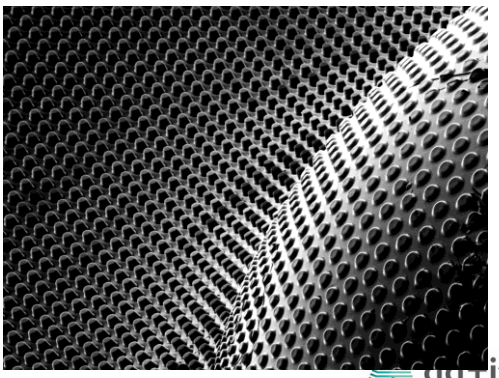
Nanoimprinting on the rough and curved surface

Pattern deformation on small objects

- Sphere 160µm diameter
- Hole pattern:
  - P= 2,75 µm Ø 2,2 µm

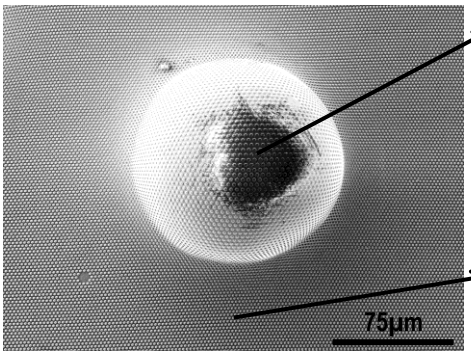






Pattern deformation on small objects

- Sphere 160µm diameter
- Extension in x- and y-direction
- Compression in z-direction



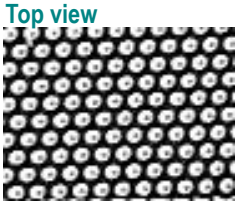
Structure on Top: Period 4.4µm D= 2.96µm

Top view

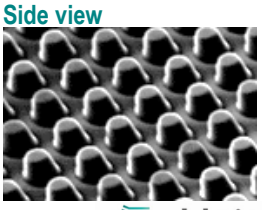
Side view

Bottom: Period 2.75µm D = 2.27µm

Top view

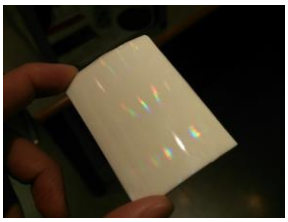


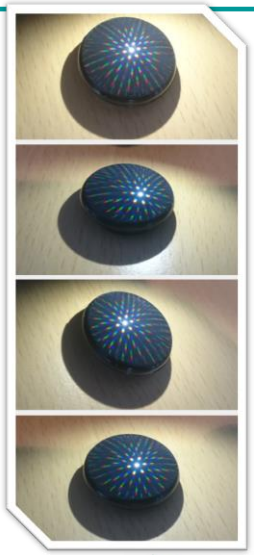
Side view



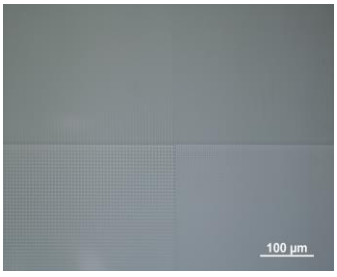
Nanoimprint on curved surfaces

- Single layer imprint using different resins
- FDM samples of PLA (R = 20 mm)

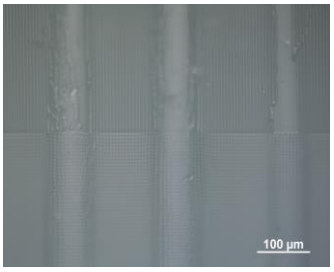




OrmoComp®



OrmoStamp®



3D printed by Stratasys on a Connex 3 printer

Designed by Sebastian Schuster

Outlook and Vision

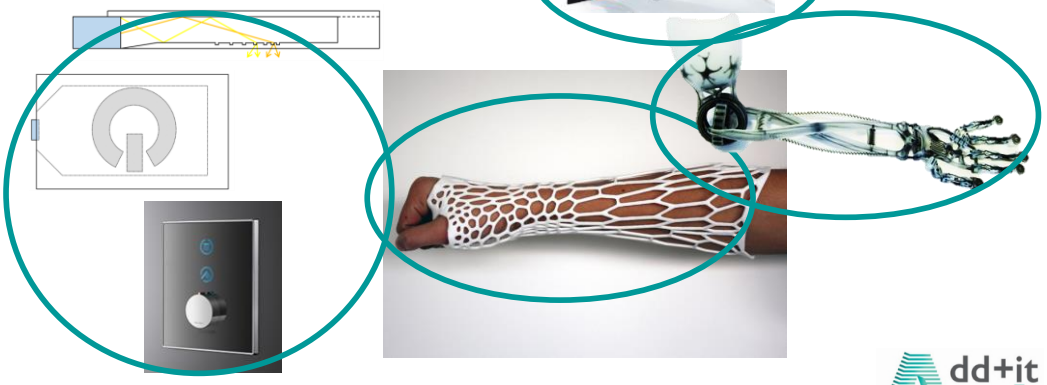
- Combine all these technologies
- Lots of interesting challenges !!
- Lots of challenging applications !!

Multifunctional individualized curved surfaces

- Nanoimprint combined with inkjet
- Functional materials
- On 3D printed and conventional surfaces

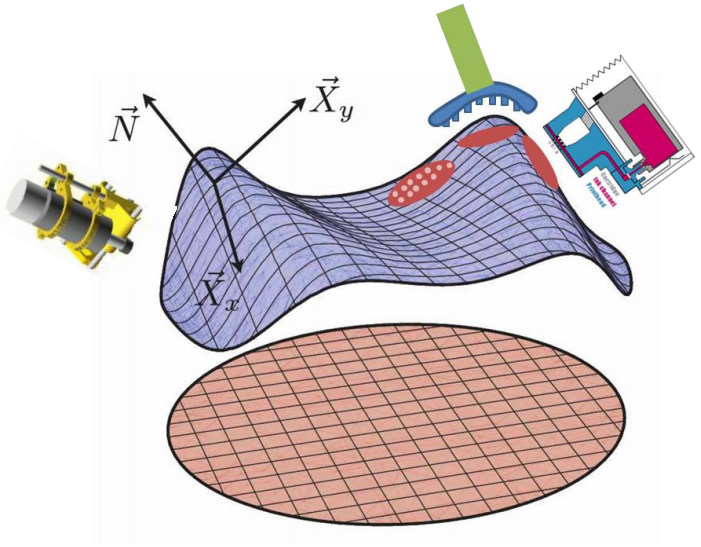
Multifunctional individualized curved surfaces

- Nanoimprint combined with inkjet
- Combination of Functional Materials
- On 3D printed and conventional surfaces



PROFACTOR

Hybride Additive Manufacturing of Multifunctional Products



Acknowledgements

- A. Fuchsbauer, M. Ikeda, N. Chitturi Chowdary, T. Köpplmayr, H. Außerhuber … Inkjet on curved surfaces
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- M. Haslinger, T. Köpplmayr … NIL on curved surfaces
- L. Häusler, H. Außerhuber, M. Haslinger … NIL in general
- T. Voglhuber … NIL and inkjet test-setups
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NILaustria

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Thank you for your attention

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