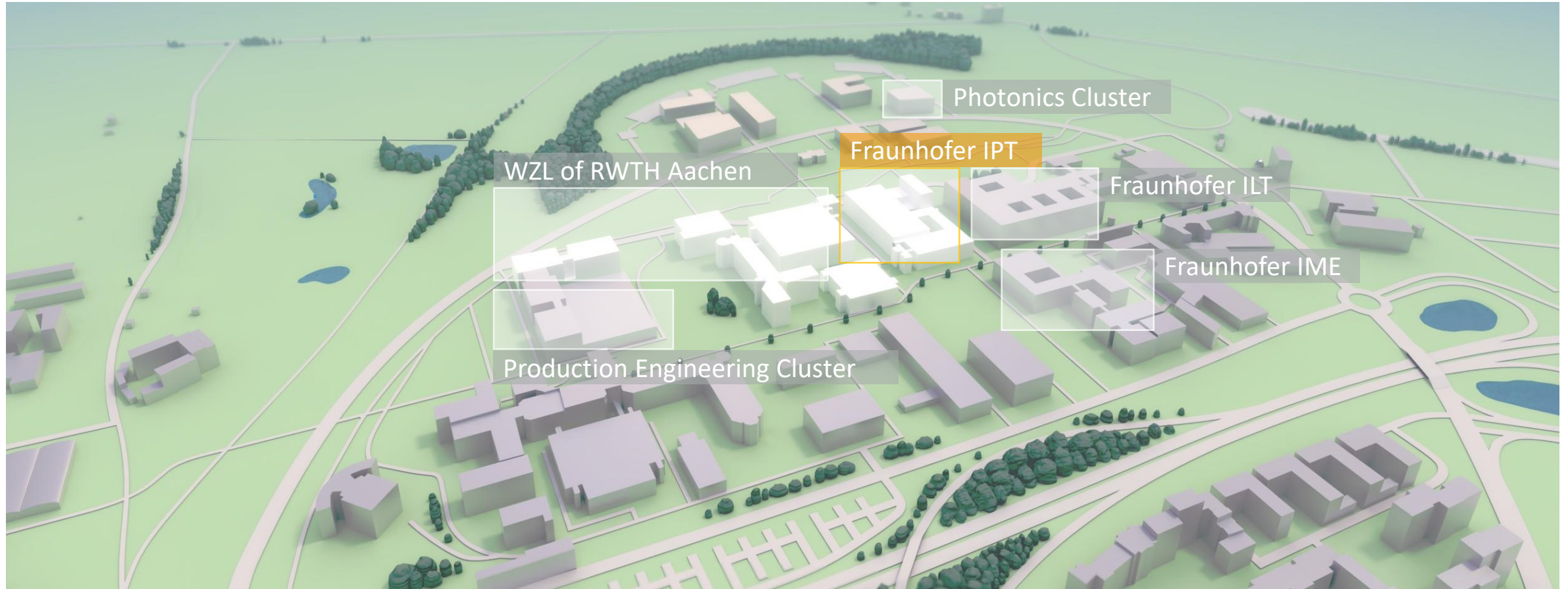

FROM NANOMETER SCALE TO KILOMETER SCALE

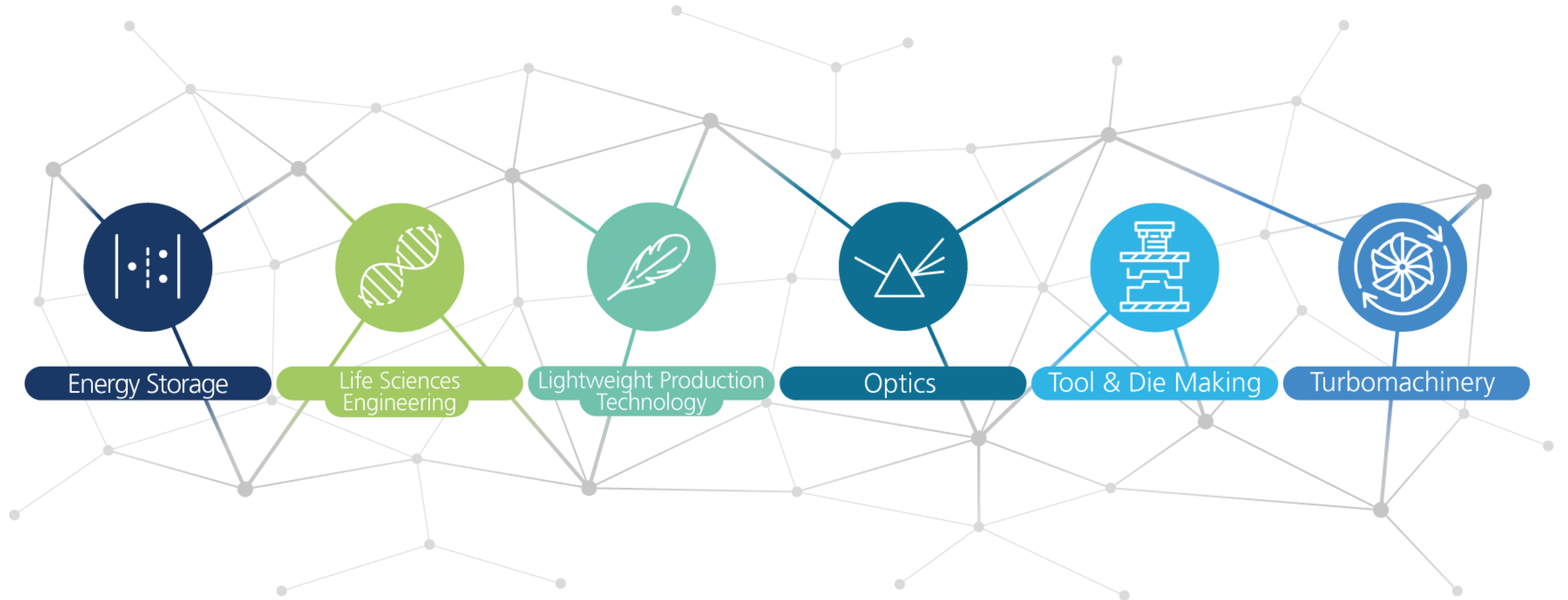
Process Routes from Nanofabrication to Mass Replication by Nanoimprint Technologies



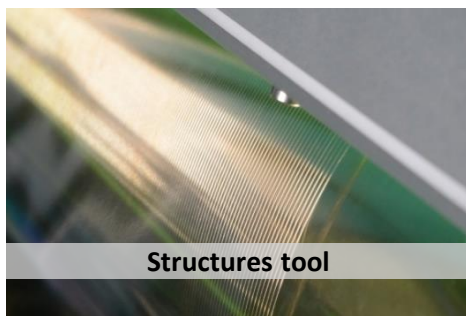
The Fraunhofer IPT is located in Aachen, one of the most important centers of production technology



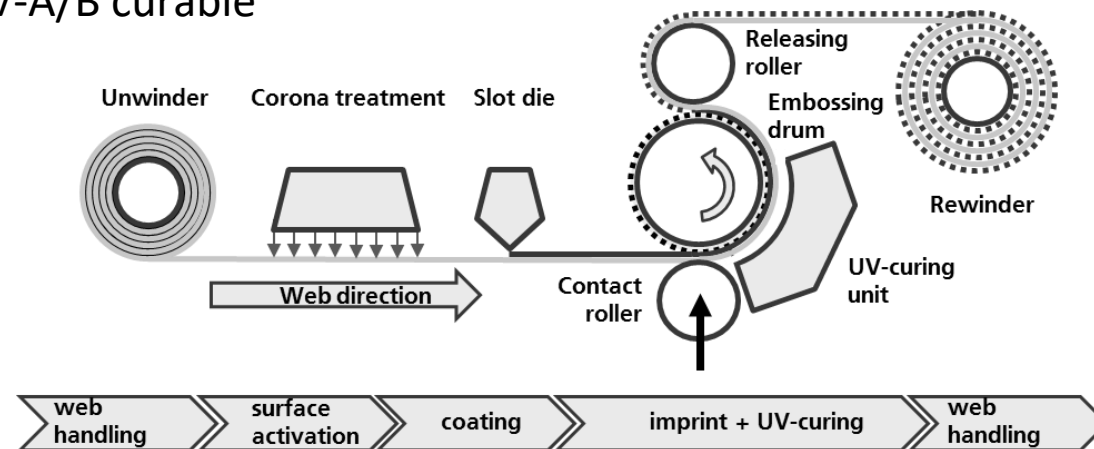
The Fraunhofer IPT uses its know-how to develop system solutions for various industries



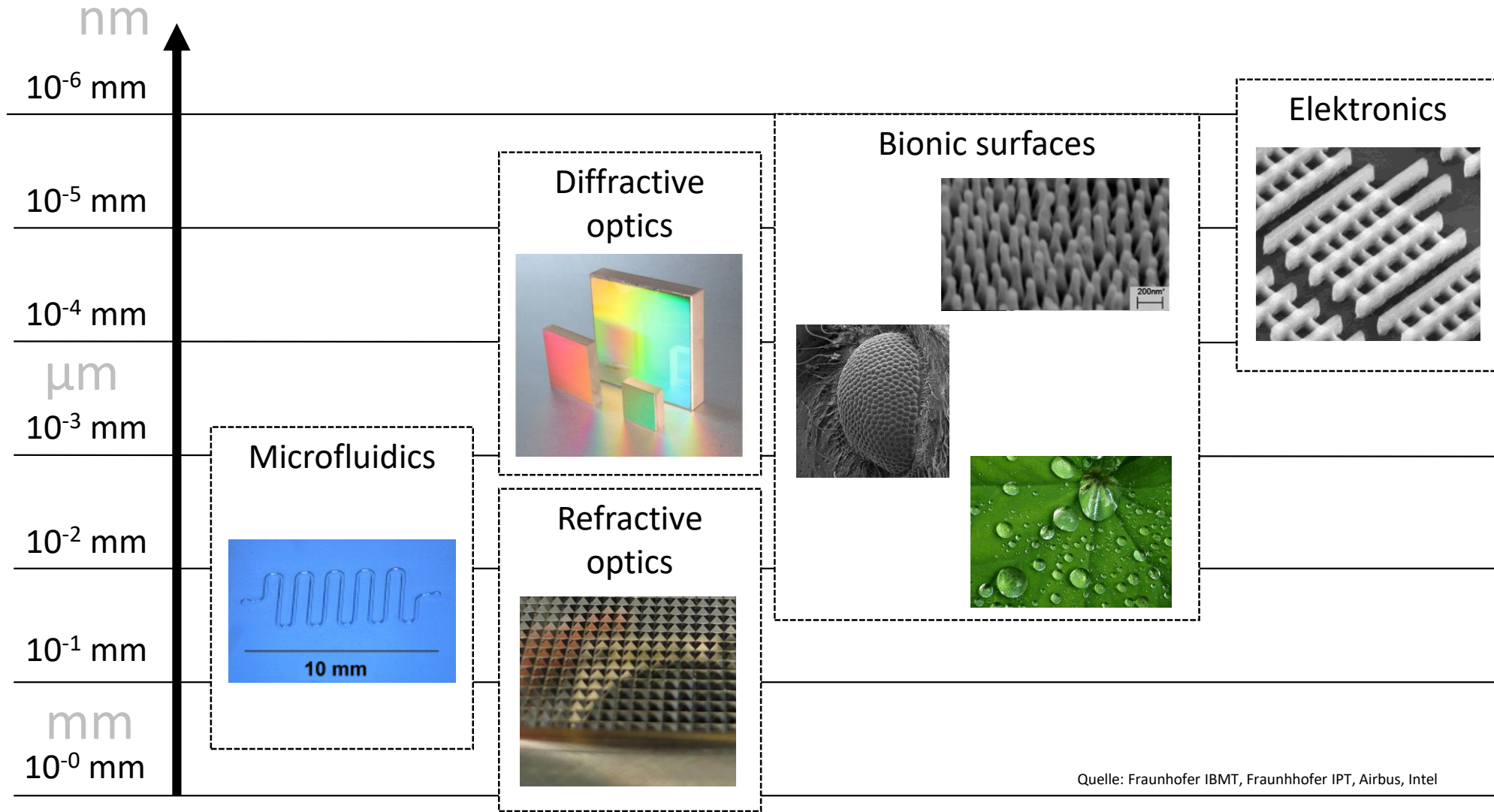
Roll-to-Roll Nanoimprint Technology



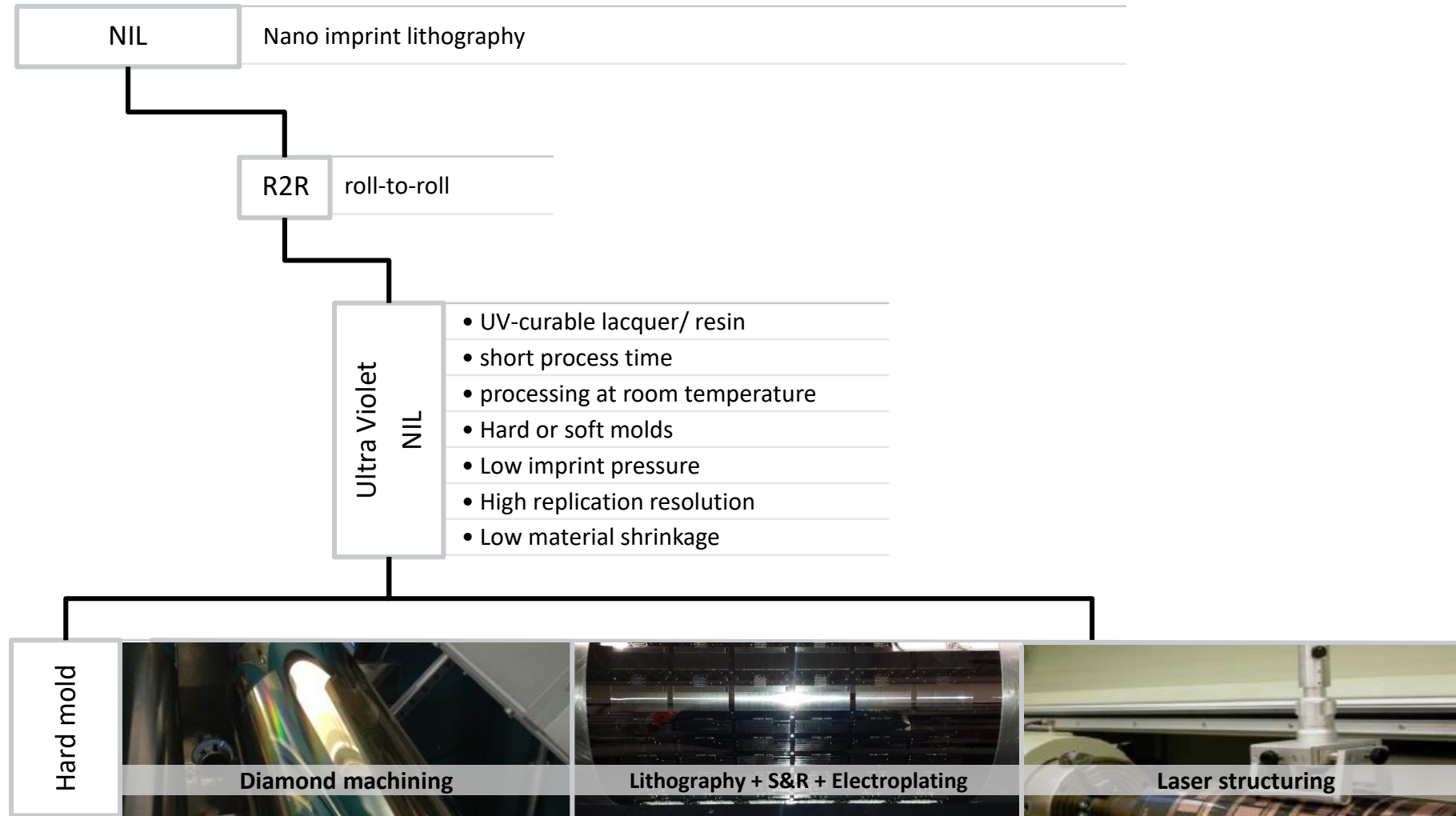
- Substrate
 - Transparent polymer (PET, PC, COC, PMMA)
 - Thickness: 50 – 500 μm
 - max. width 550 mm
- Coating
 - Acrylate based, silicone based
 - UV-A/B curable



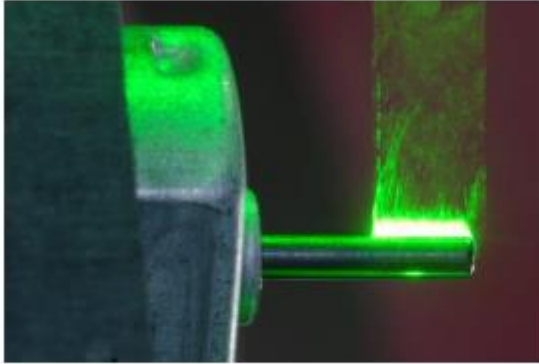
Structure Dimensions



Approaches for Drum Production

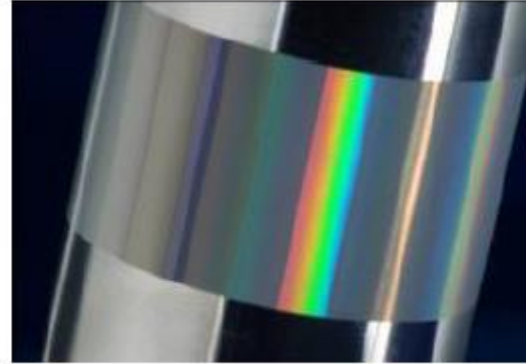


Production of Drums by Ultrashort Pulsed Laser



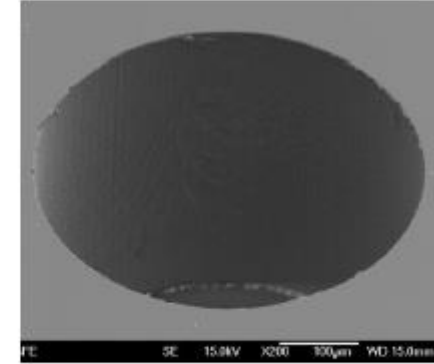
Flexible tool with no material dependence

- Wide bandgap materials (Glass, Sapphire, Diamond)
- Semiconductors (Silicon, GaAs, SiC)
- Metals (WC, Steel, Copper)
- Polymers
- Biological materials



High Accuracy

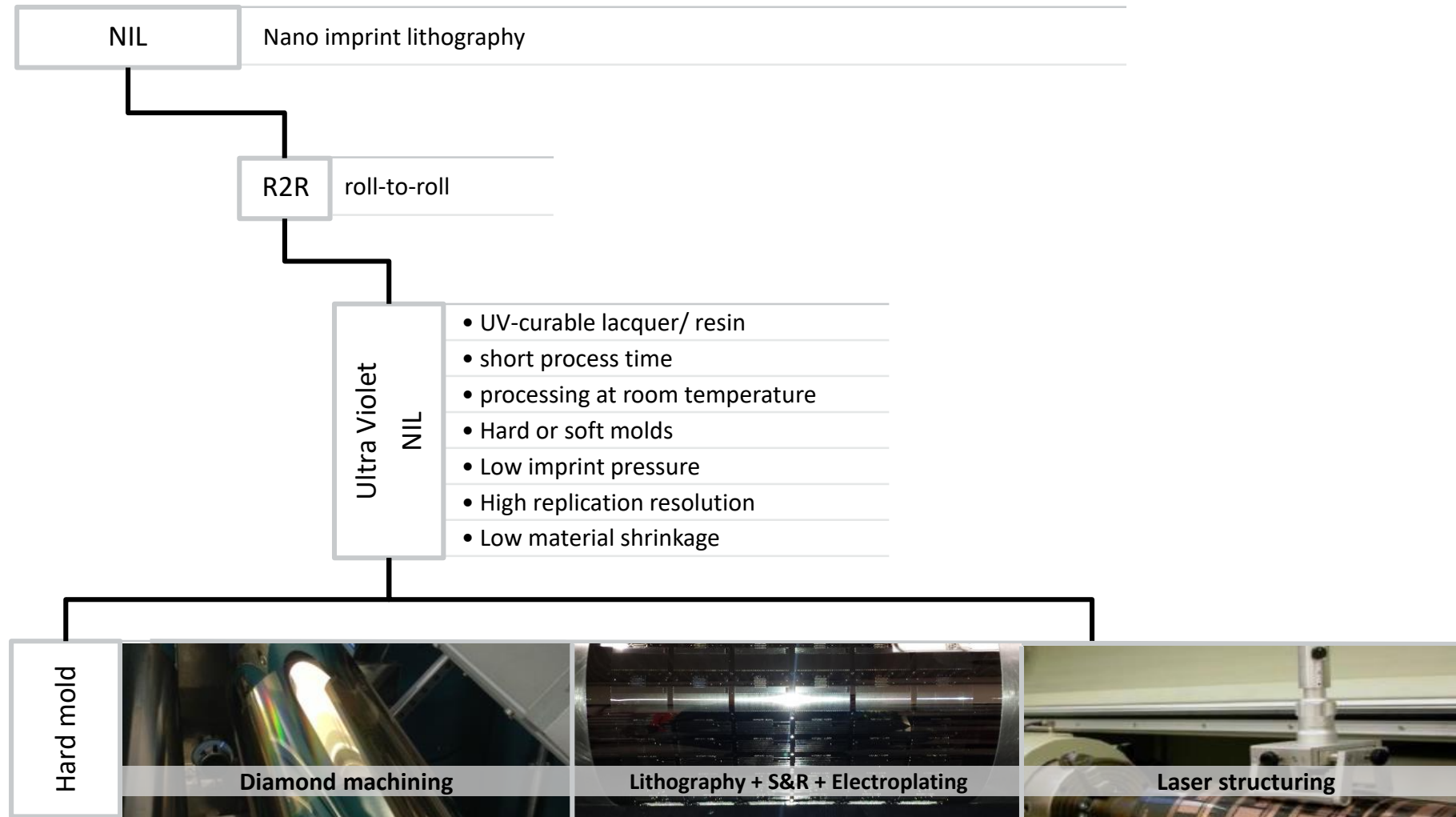
- Sub 100 nm precision in ablation depth
- Material selective processing
- In volume processing



Tool independent processing

- Tool-free, wear-free and resource-efficient
- Almost no lead-time (Digital Photonic Production)
- Universal application (due to high variety of parameters)

Approaches for Drum Production



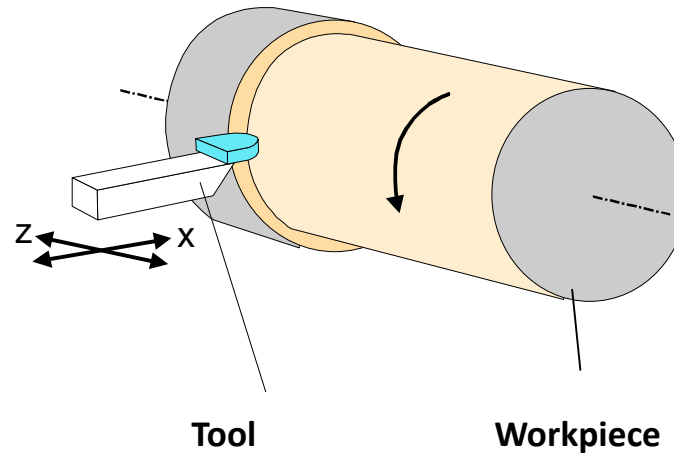
Process kinematics of UP turning

Kinematics

- Translation of the tool
- Rotation of the workpiece
- Continuous cutting or interrupted cuts
- Non-rotationally symmetrical with fast-tool servo

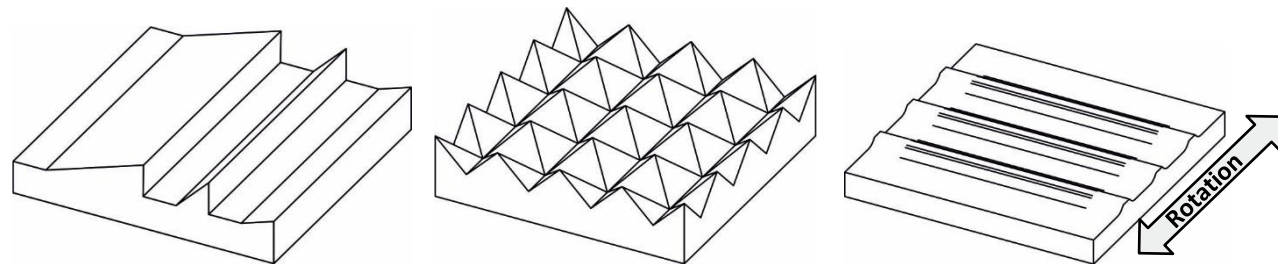
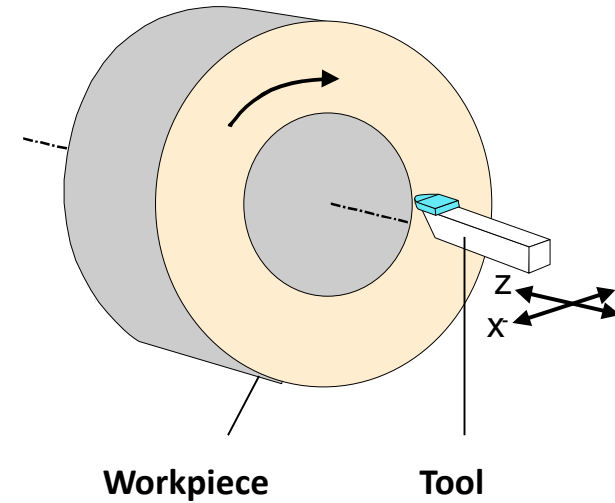
Longitudinal round turning

e.g. drums, ...



Face turning

e.g. Mould inserts, mirrors, ...



Chip formation and surface formation

Flat surfaces

Slow feed speed and big tool radius for flat surfaces

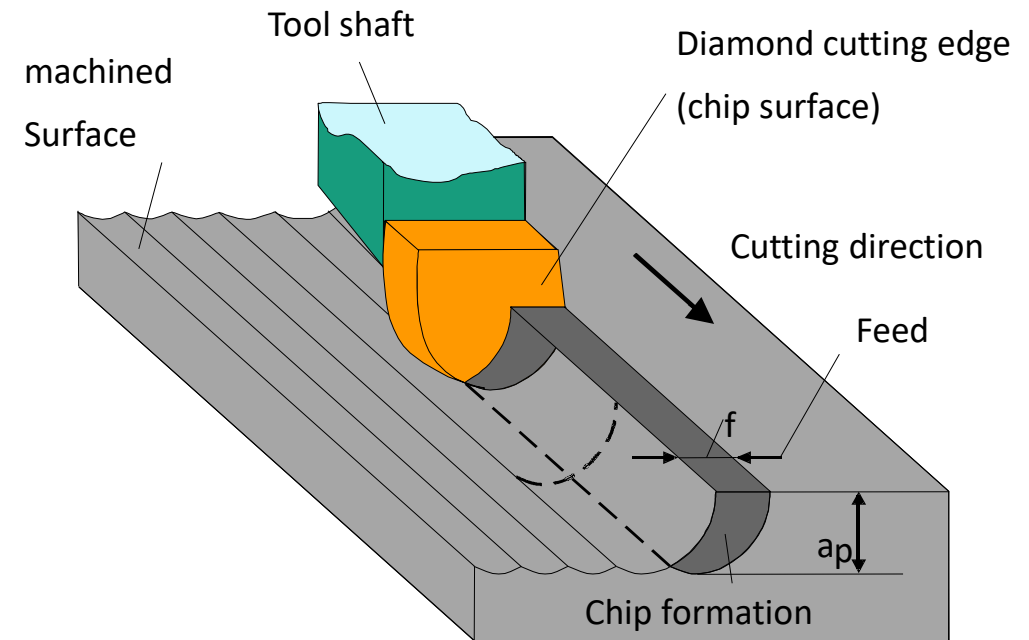
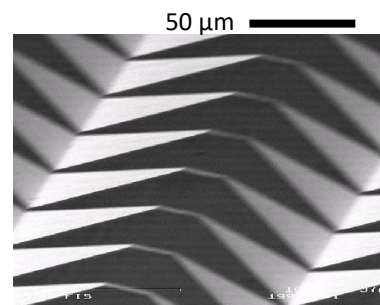
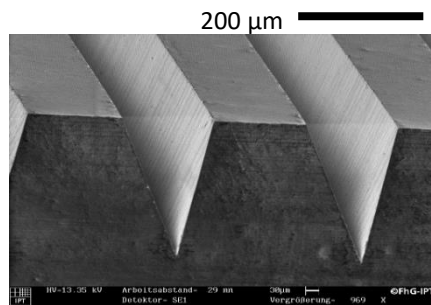
- Theoretical kinematic roughness

$$R = f^2 / 8r_\epsilon$$

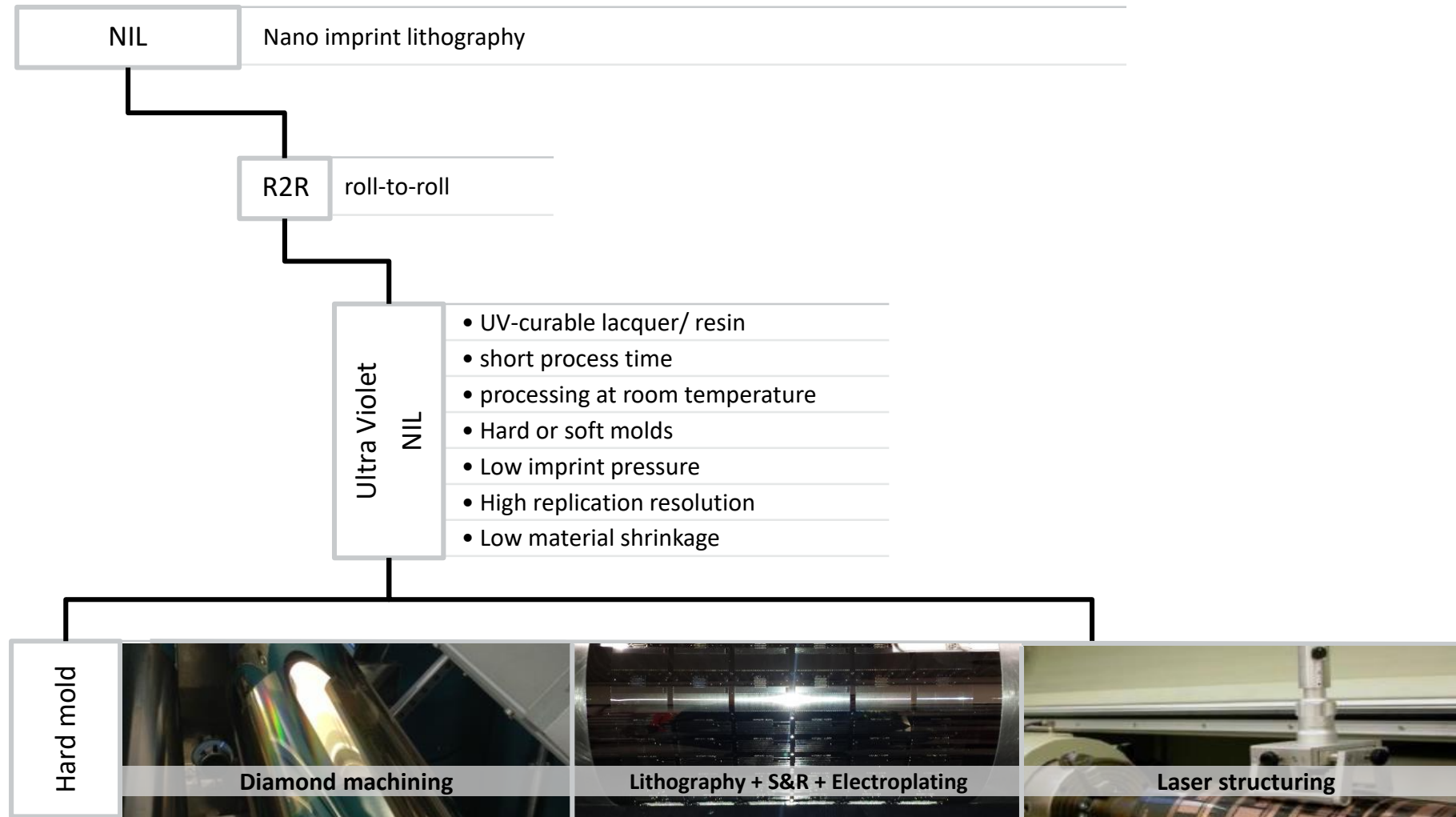
- Typically achievable $R_a > 2 \text{ nm}$

Structured surfaces

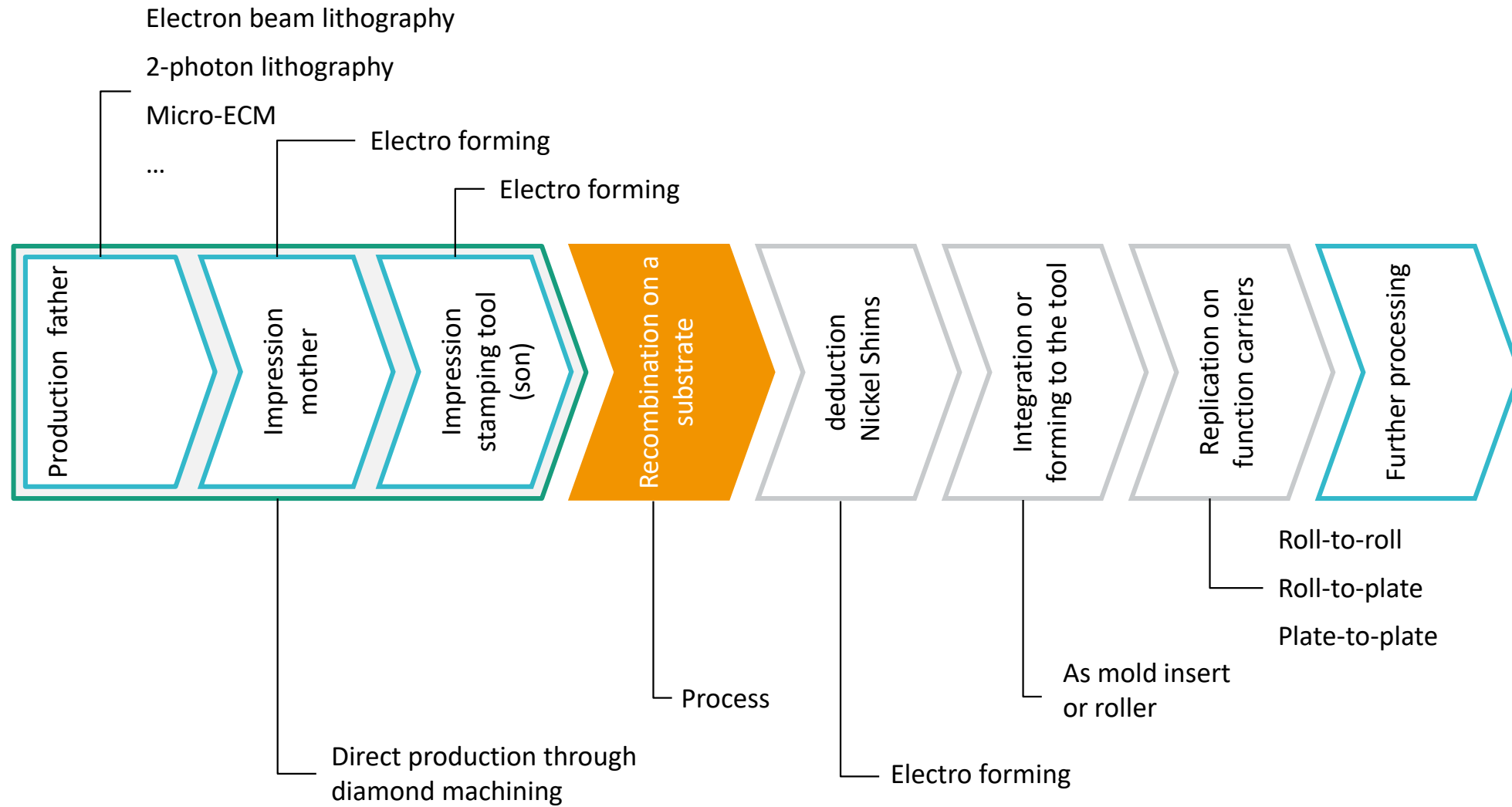
- Shaped diamond tools -> Tool geometry is „copied“ to the drum



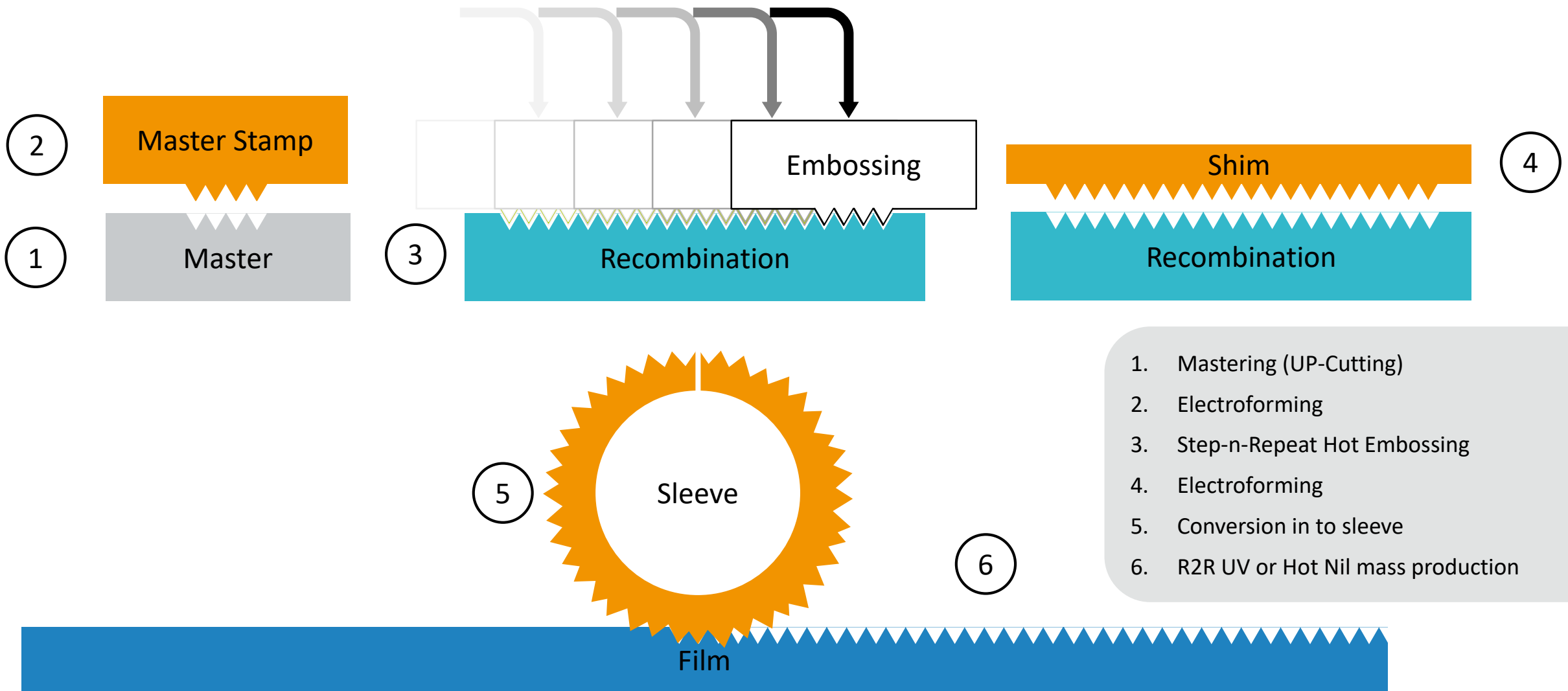
Approaches for Drum Production



Process chain for mass replication

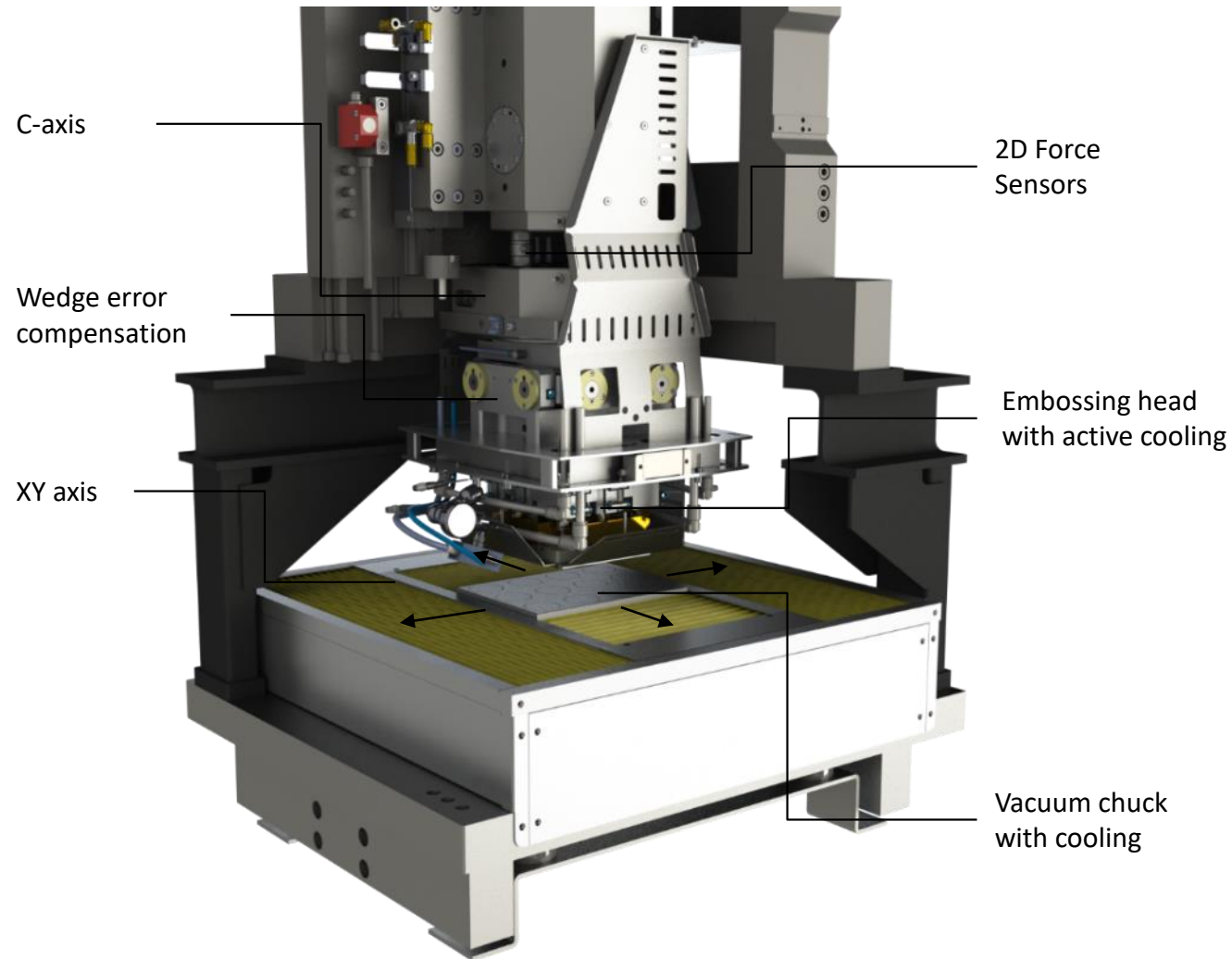


Process chain for mass replication



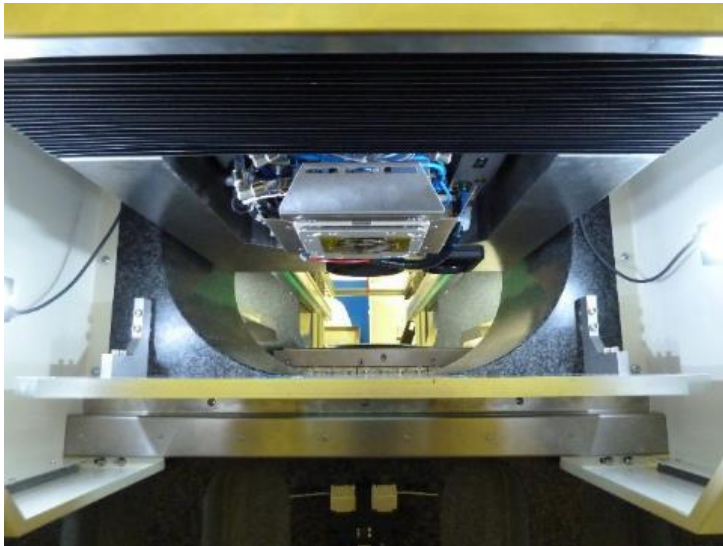
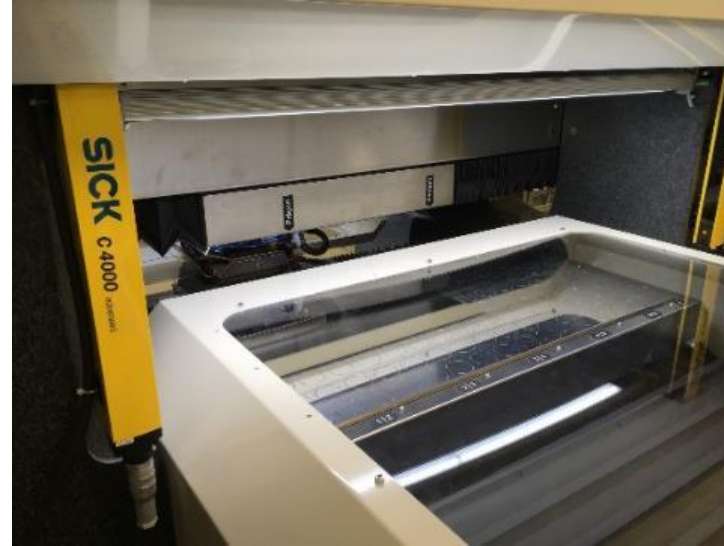
1. Mastering (UP-Cutting)
2. Electroforming
3. Step-n-Repeat Hot Embossing
4. Electroforming
5. Conversion in to sleeve
6. R2R UV or Hot Nil mass production

Recombination System



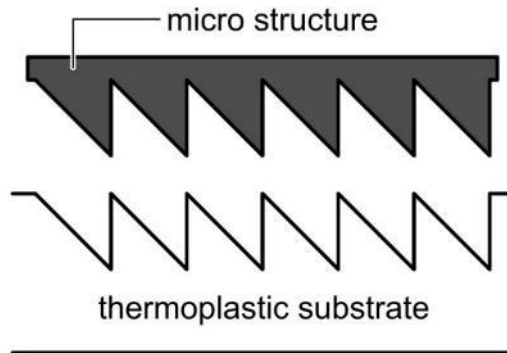
- Machine parameters
 - Max. Embossing force:
100 kN
 - Accuracy:
0,3 kN
 - Substrate size:
220 mm x 160 mm
 - Precision:
0,1 μm/100 mm
 - Volumetric accuracy:
1μm
 - Cycle time:
30 - 60 sec.
 - Motif size:
10x10 to 80x80 mm²
 - Max. Embossing temperature:
230°C
- Structure types:
 - Holograms
 - Binary structures
 - Moth Eyes
 - Spherical and aspherical MLAs
 - Fresnel lenses
 - micromirrors
 - Prisms
 - V-grooves

Machine system: Reko2

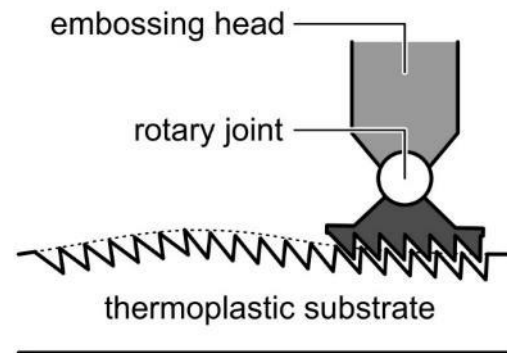


- Machine parameters
 - Max. Embossing force:
100 kN
 - Accuracy:
0,5 kN
 - Substrate size:
1200 mm x 800 mm
 - Precision:
0,5 μm /100 mm
 - Volumetric accuracy:
5 μm
 - Cycle time:
30 - 60 sec.
 - Motif size:
10x10 to 80x80 mm²
 - Max. Embossing temperature:
180°C
- Structure types:
 - Holograms
 - Binary structures
 - Moth Eyes
 - Spherical and aspherical MLAs
 - Fresnel lenses
 - micromirrors
 - Prisms
 - V-grooves

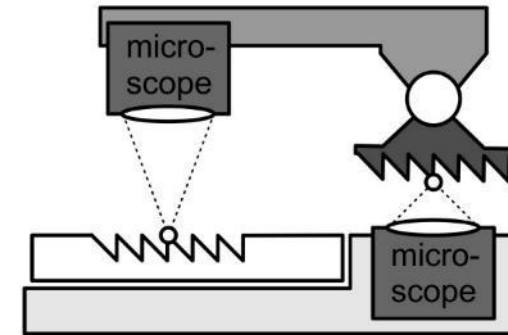
Challenges



- stamping quality
 - Geometric accuracy
 - Non-adhesive demoulding
 - Error-free replication
 - process efficiency



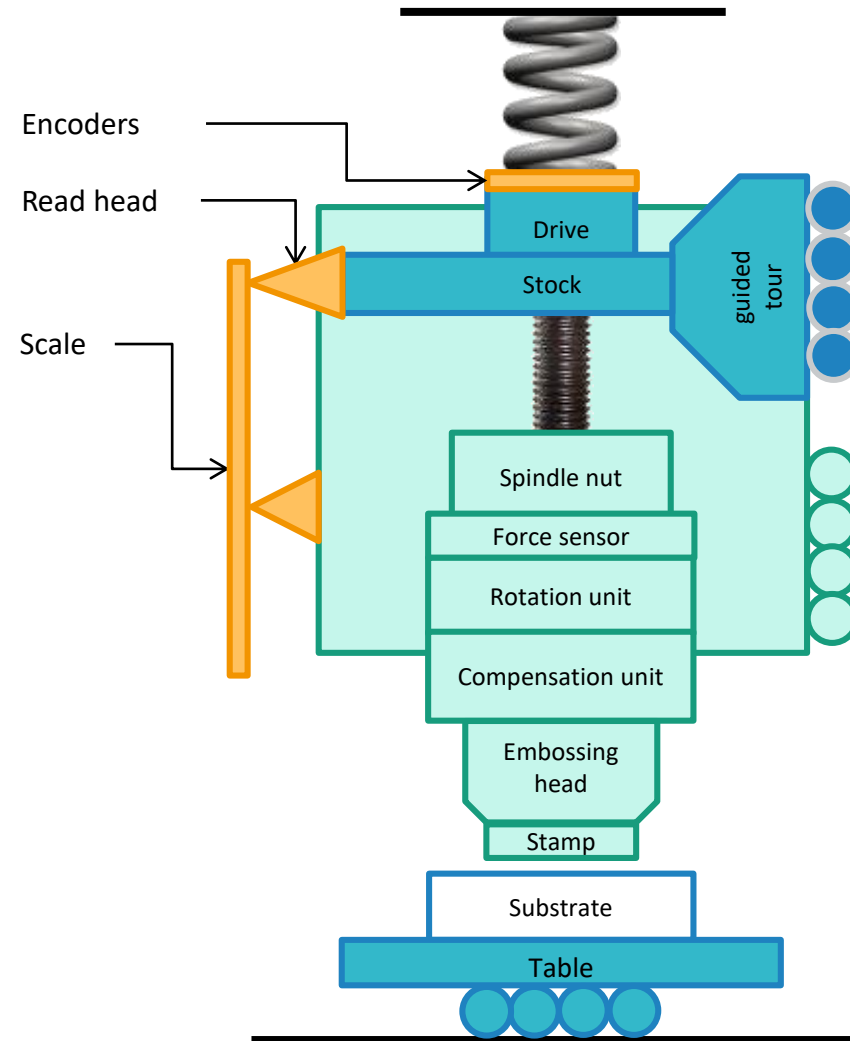
- Form error compensation
 - Homogeneous process parameter
 - Print
 - Temperature
 - Seam defects



- Referencing of
 - Substrate
 - Embossed stamp

Implementation

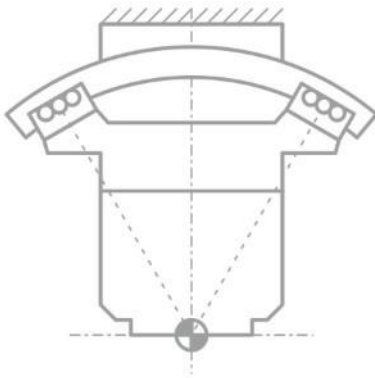
Force control



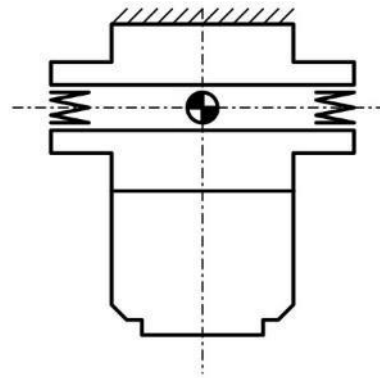
Implementation

Wedge error compensation

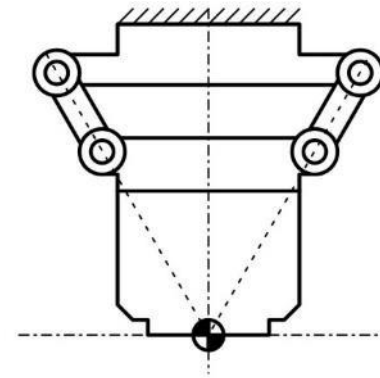
Curved breakfasts



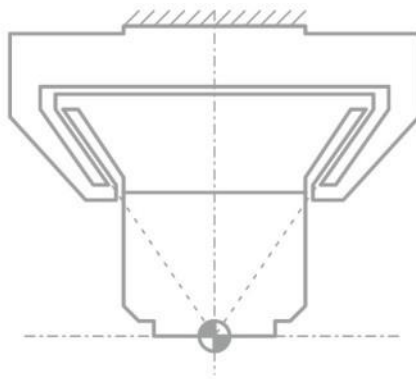
Elastic elements



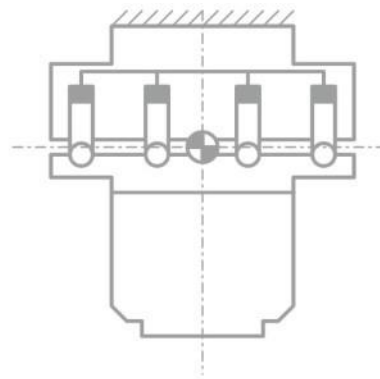
Pairing



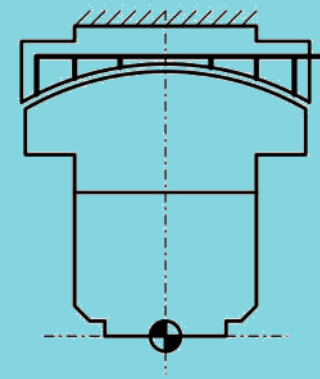
Solid State Joints



Hydraulic cylinders

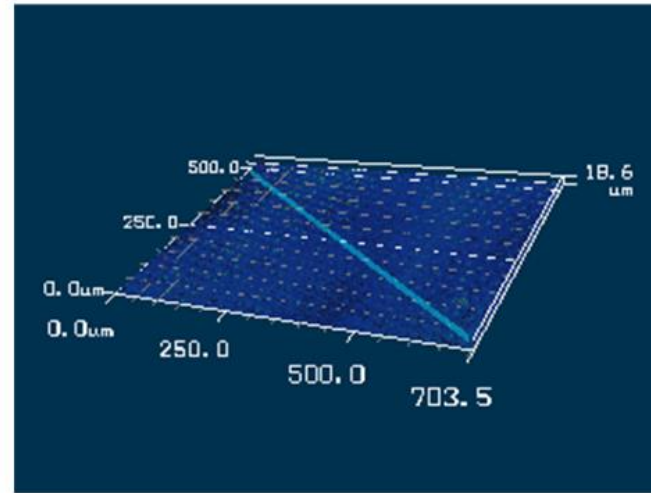
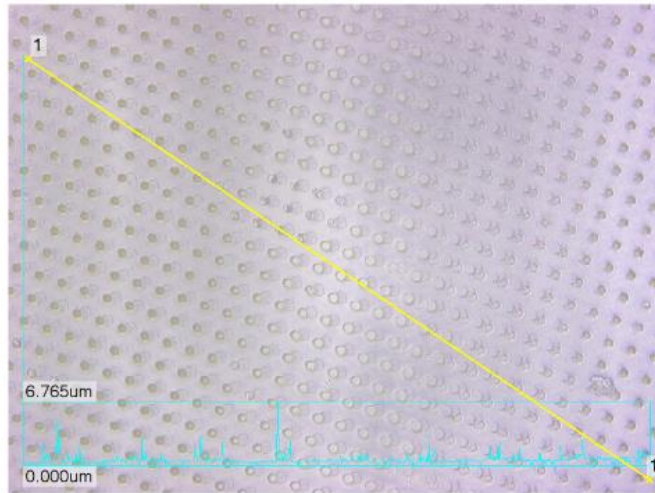


Aerostatics / Hydrostatics

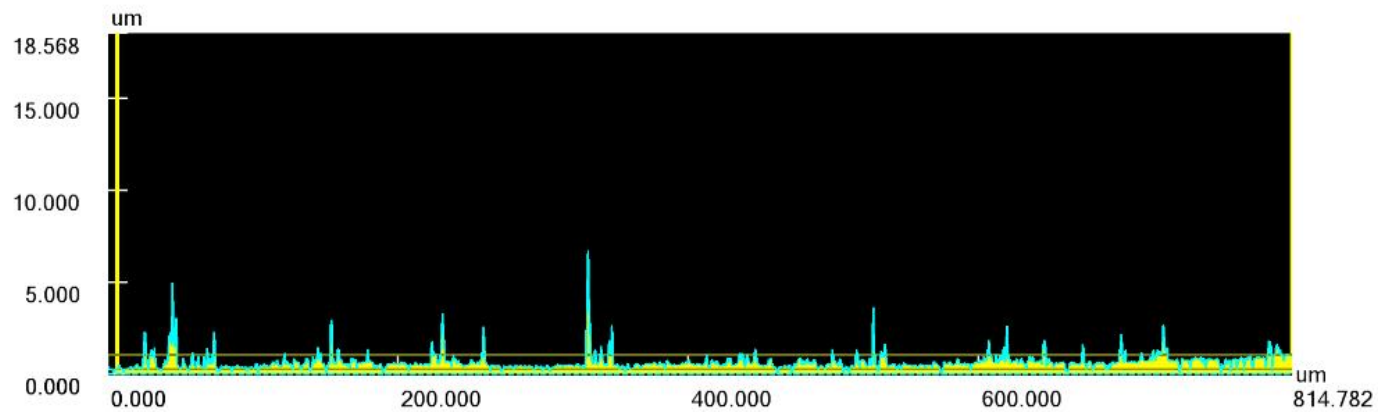


- Characteristics
 - Pivot point
 - Friction
 - Force
 - ...
- Pivots above the embossing contact generate a translational offset when pivoting
- Friction reduces reproducibility
- Embossing force of up to 100kN must be transferable

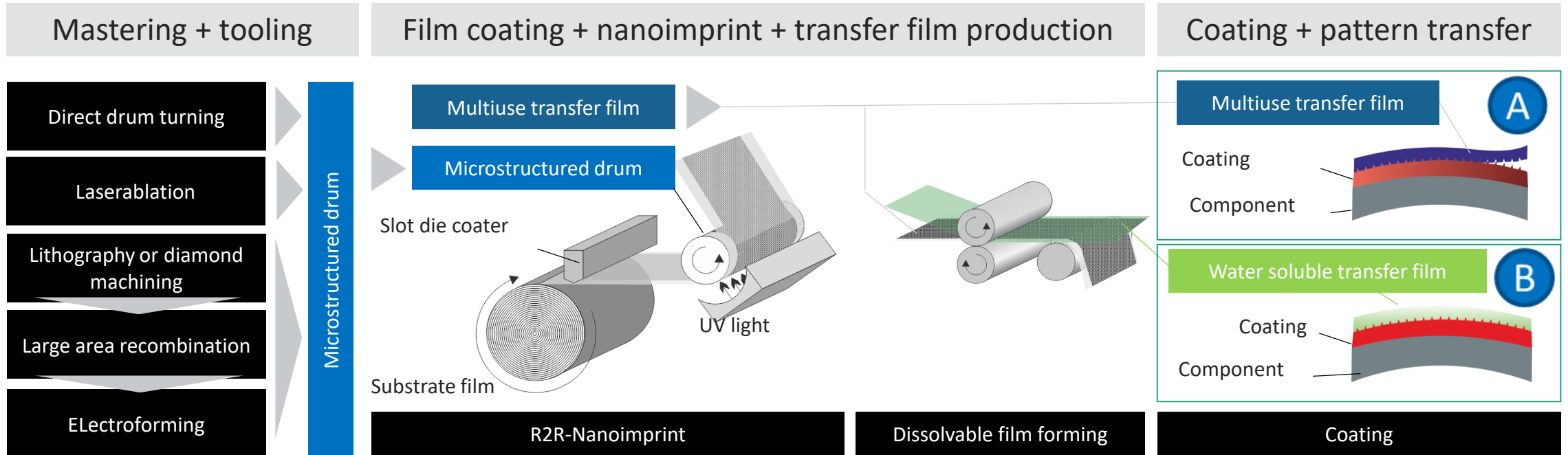
Seam quality



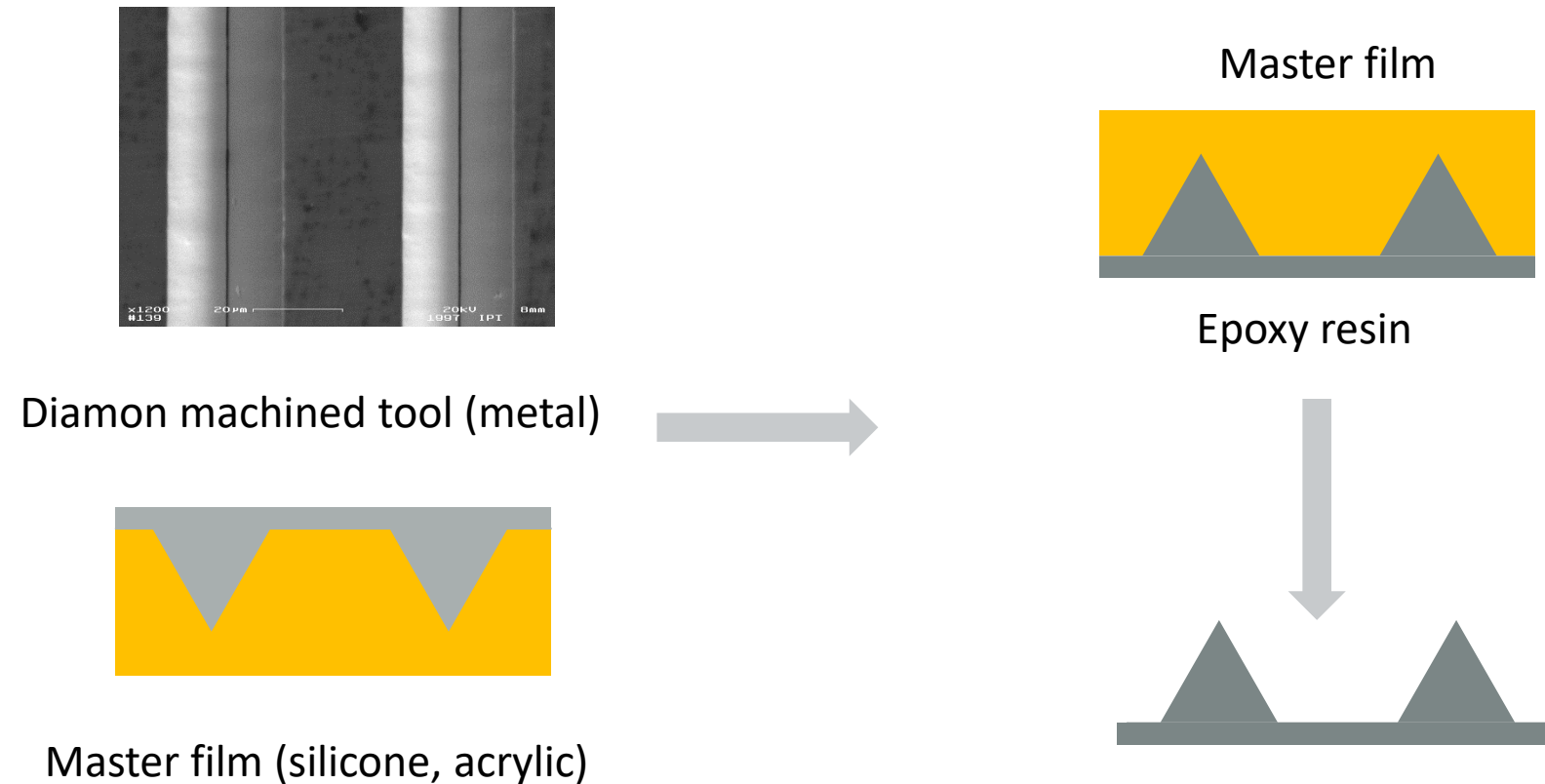
- Confocal image of two overlapping impressions
- Seam area recognizable by the alignment errors
- **No bead formation measurable**



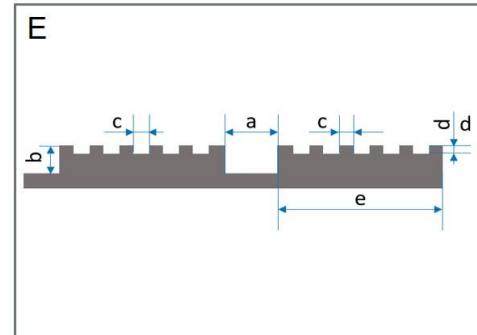
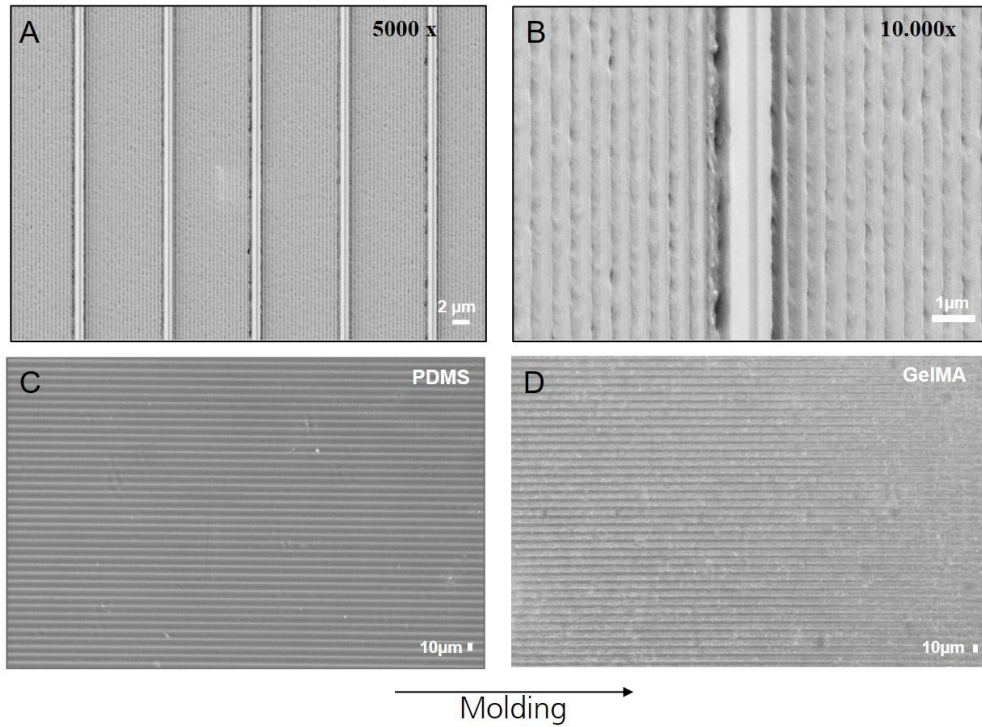
Pattern Transfer



Example: Pattern transfer in Epoxy Resin and 2K-Lacquers

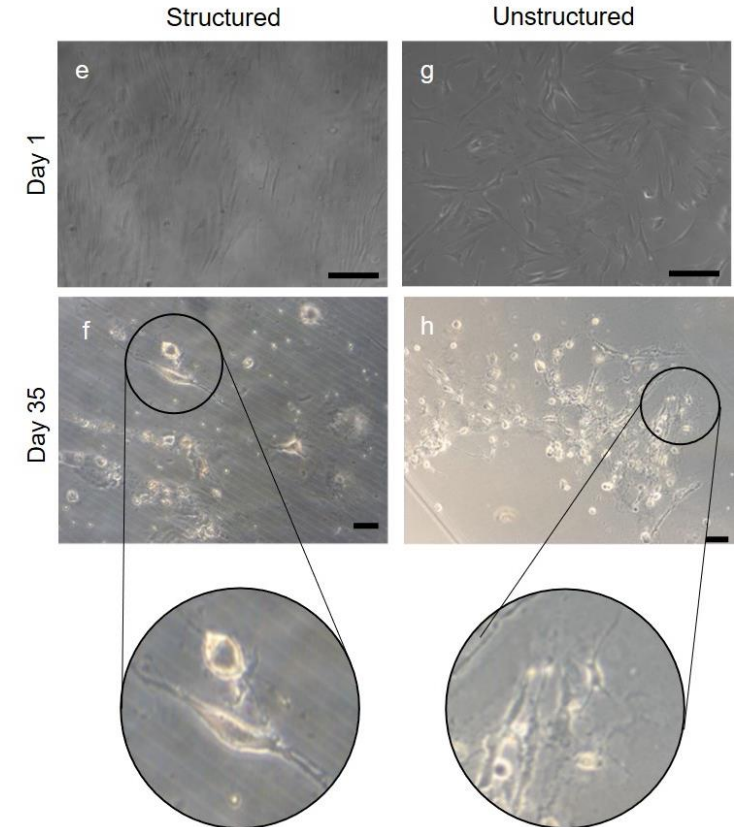


Example: Mechano-transductive cell differentiation



F	Parameter	Indices	Dimensions
Microgroove	Groove size	a	2.4 μm
	Groove depth	b	1.2 μm
	Ridge size	e	8.3 μm
Nanogroove	Groove/ridge size	c	500 nm
	Groove depth	d	32.7 nm

Adherent UC-MSC (aMSC)



Get in contact with us



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