

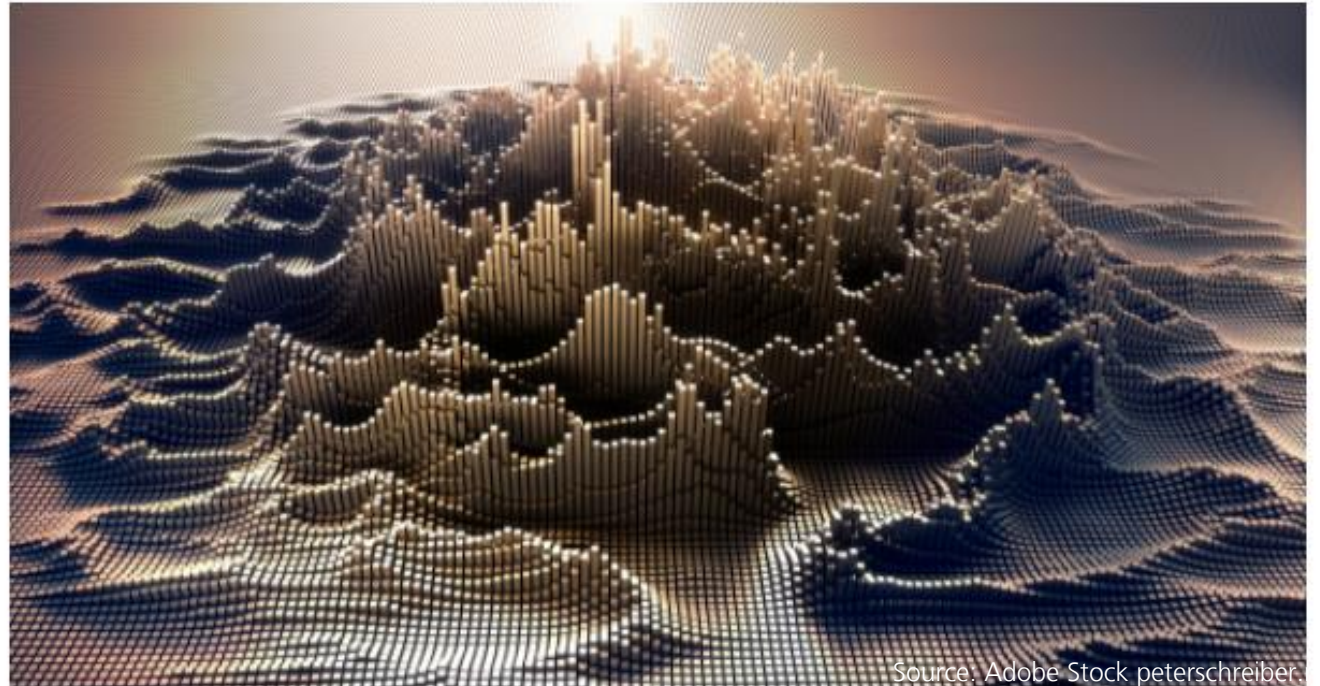


Smart Light Management via optical microstructures created by SLM-based interference lithography

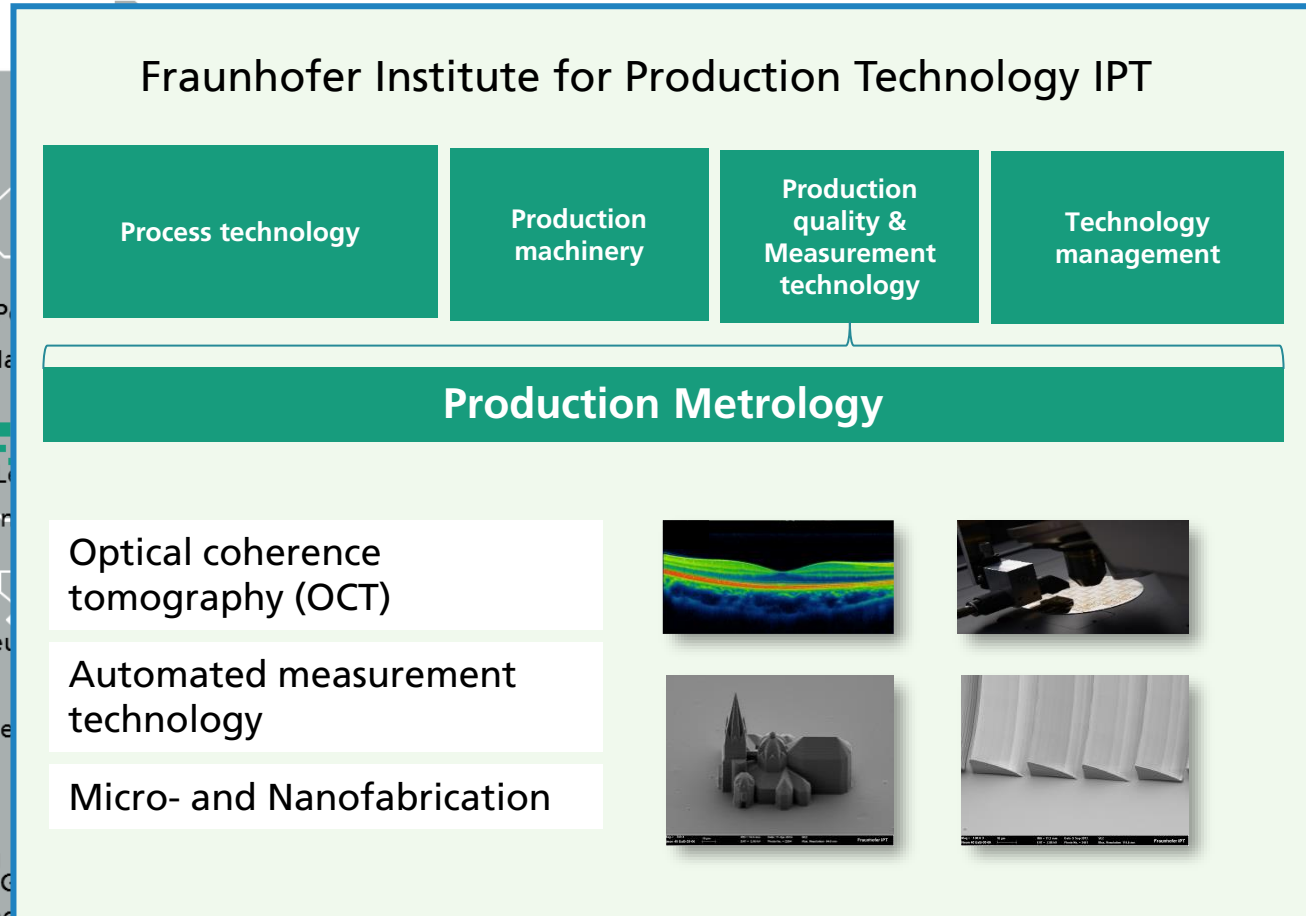
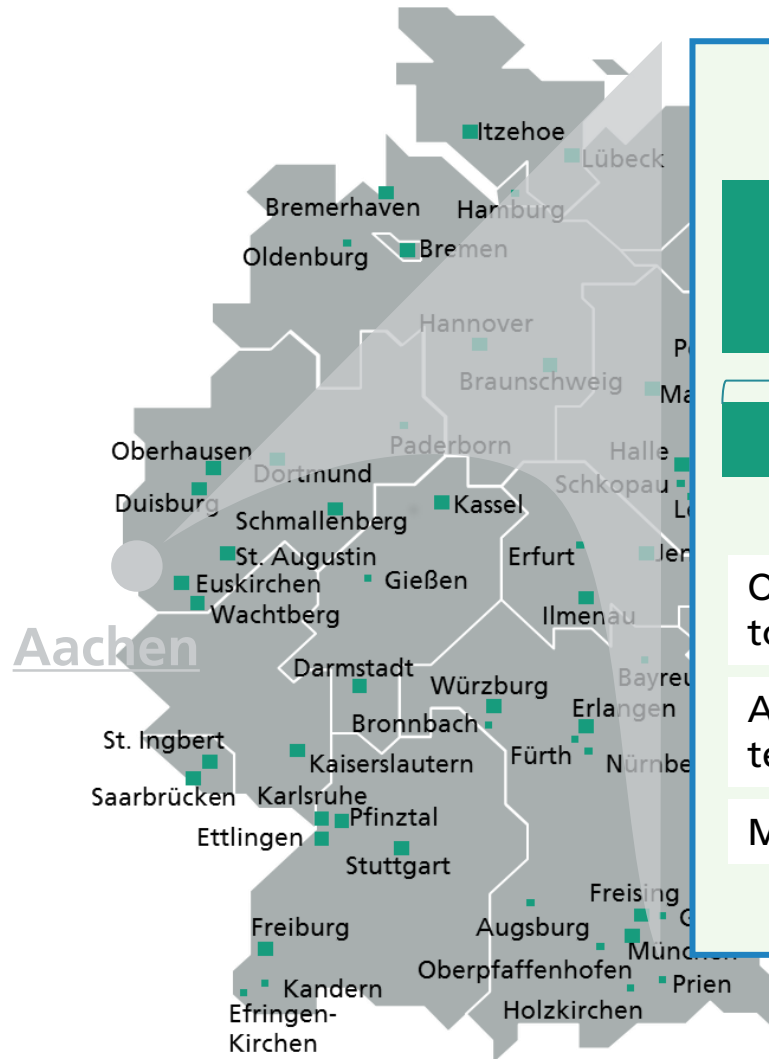
Wetzlarer Herbsttagung – Fraunhofer IPT
Andreas Ulm, 28.09.2021

Agenda

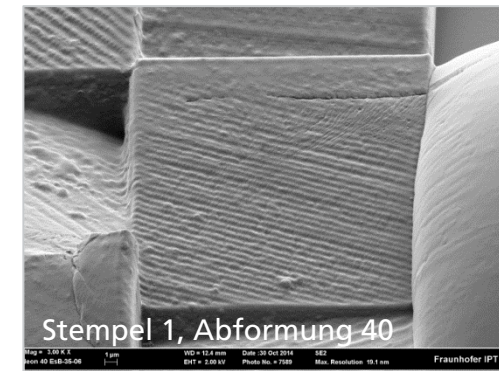
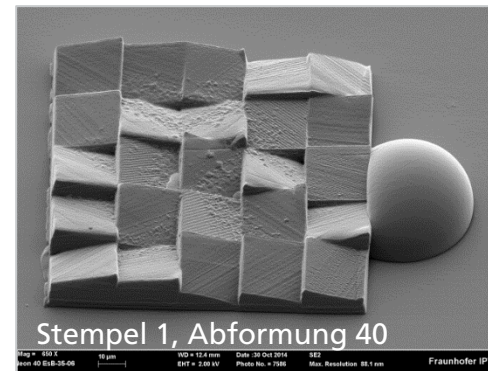
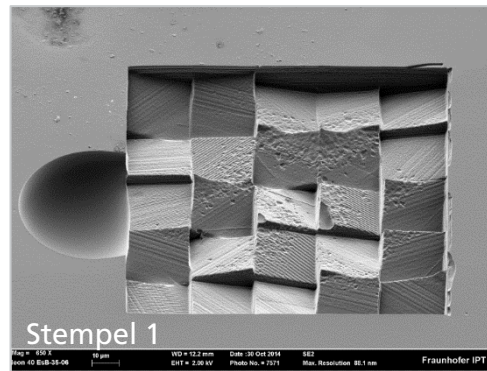
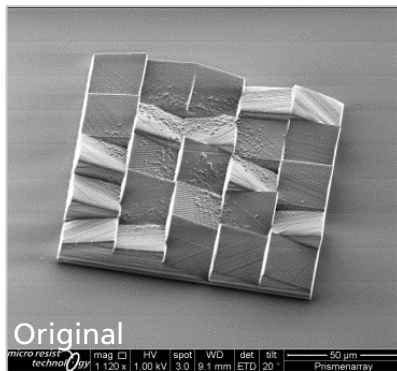
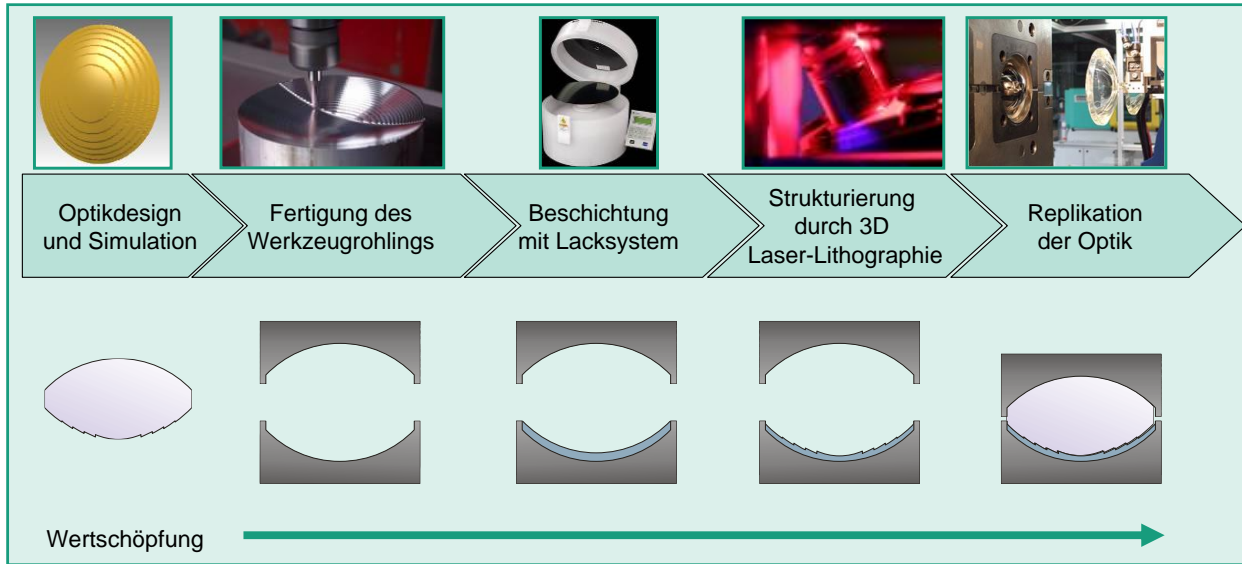
1. Introduction
2. Smart light management
3. Interference lithography
4. Spatial light modulator lithography



Production Technology from Aachen

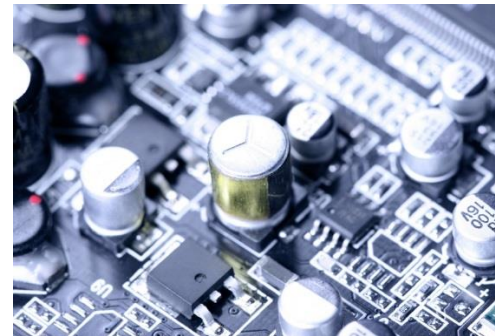


1. Introduction LithOStrukt - Replication of lithographical (sub-) microstructures via injection molding



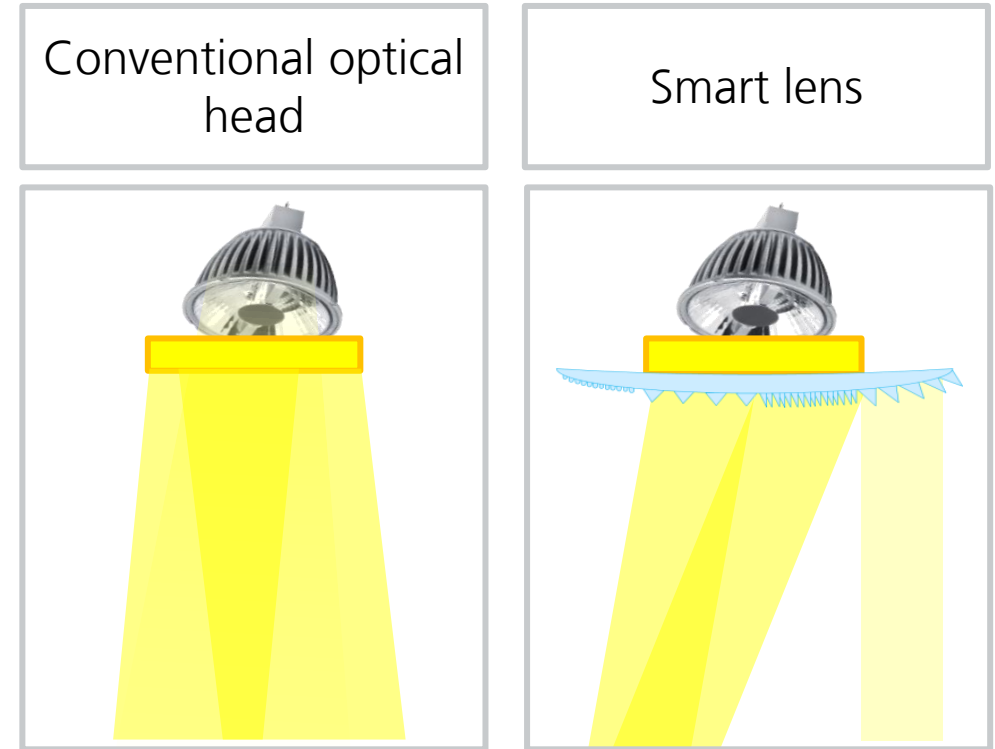
2. Smart light management

- Light source are more and more replaced by energy efficient LEDs
 - Efficient light management for LEDs needed
- Components of smart lighting
 - Light Sources
 - Computer hardware - Chips
 - Software
 - Light guiding components

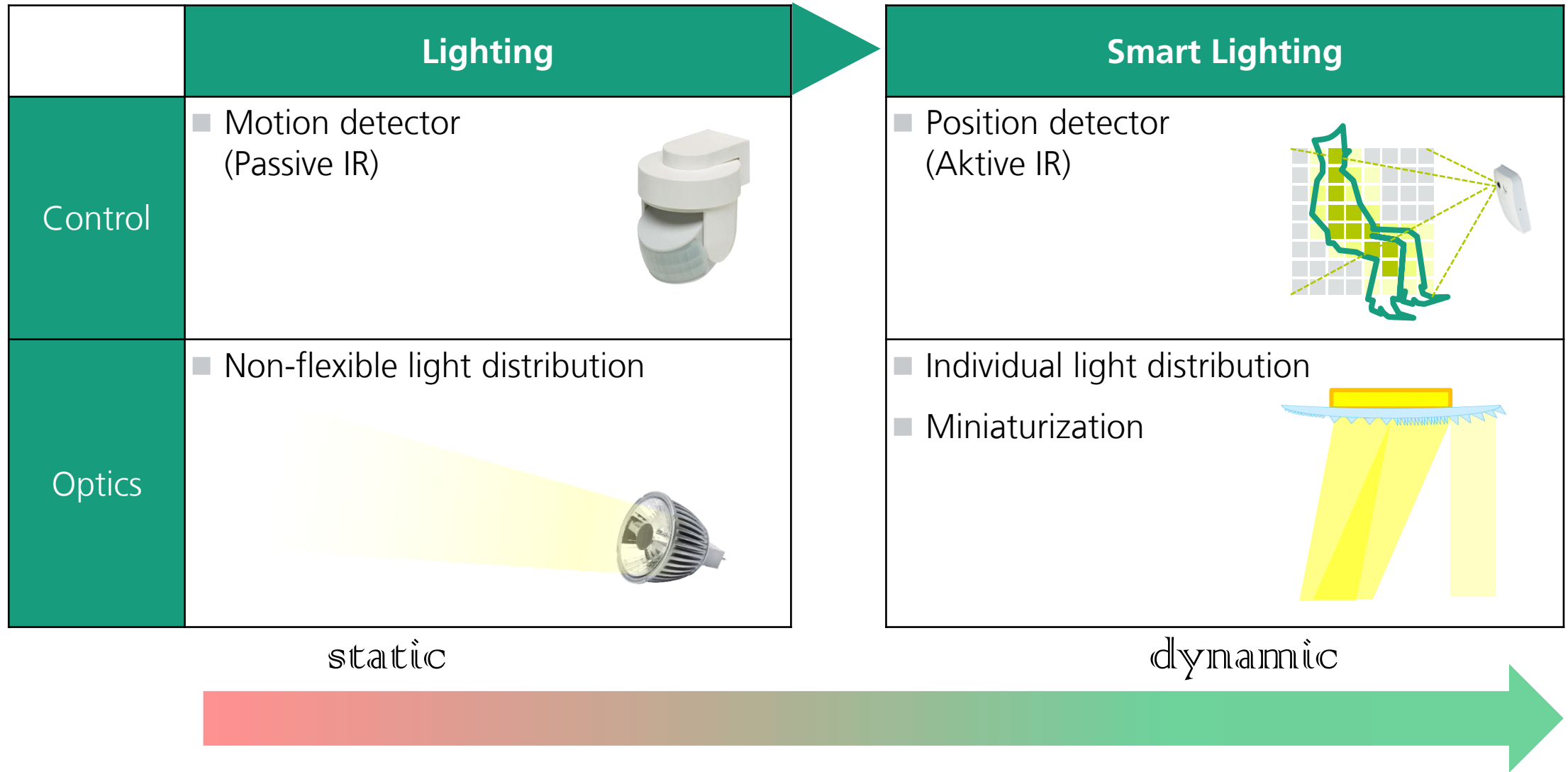


Smart components for efficient energy management

- Optical components for LEDs to achieve an individual light distribution
- Structures combine various features
 - Refractive or diffractive lens
 - Diffusor
 - IR-optical components
 - Anti-reflex structures

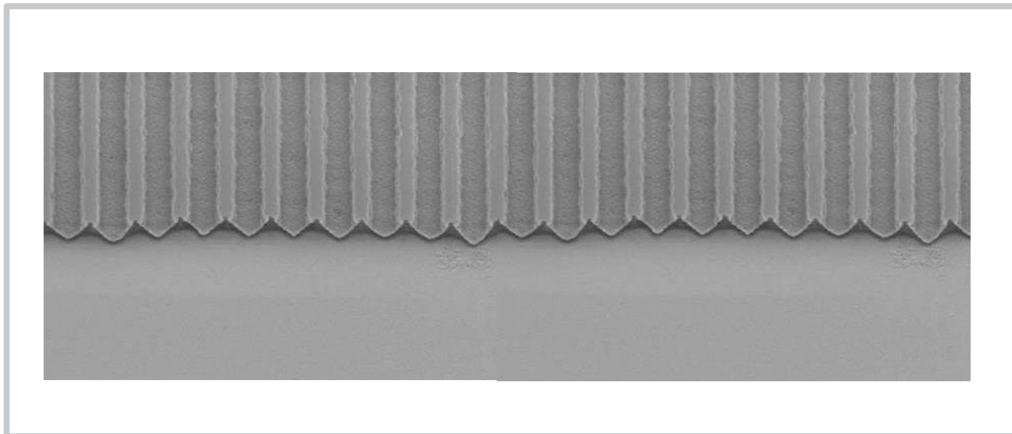


Smart light management

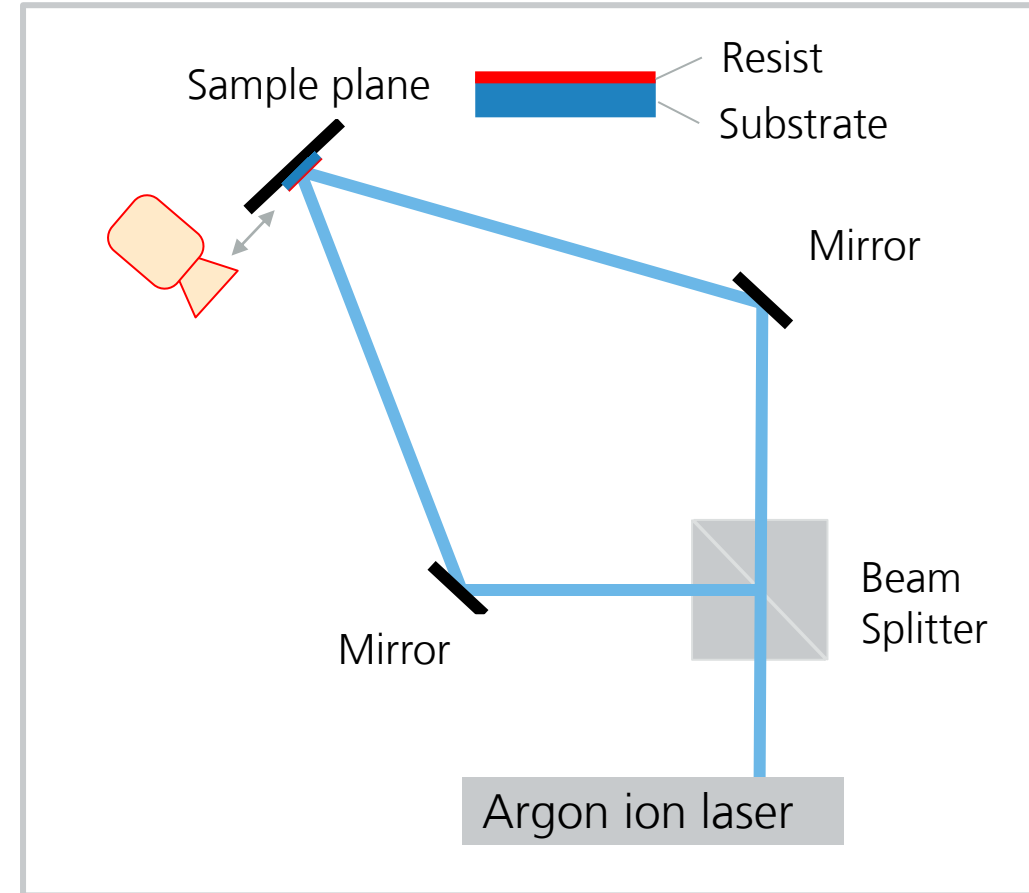


3. Interference lithography

- Classical interference lithography (IL):
 - Sample preparation
 - Two beams
 - Periodic gratings (180 nm to few μm)
 - Honeycomb structure, 2D gratings



Periodic structure created with IL



Setup for two beam interference

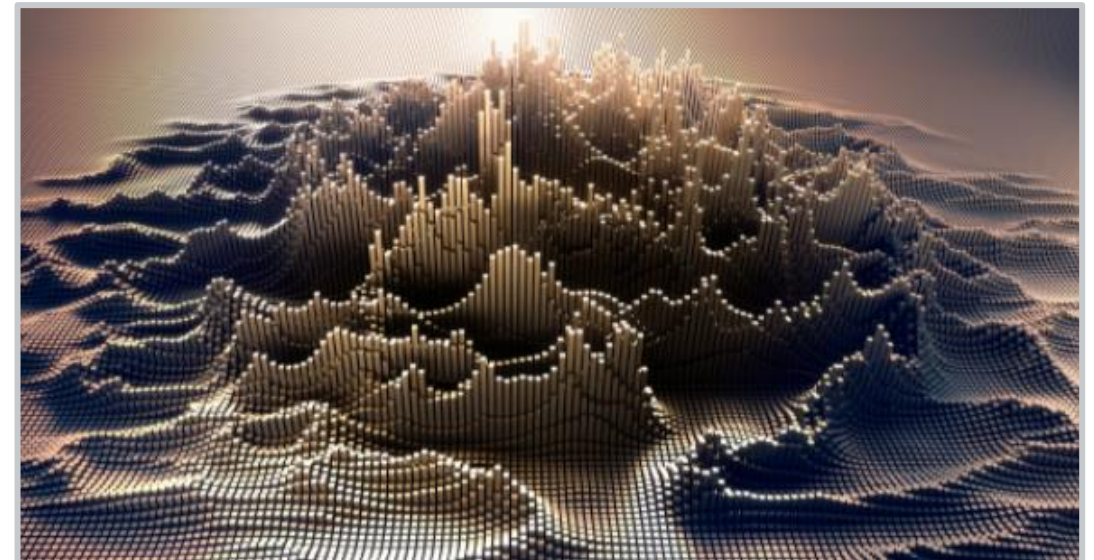
Spatial light modulator (SLM)

- Microdisplay with liquid crystals
- 1 Mio. pixels = subbeams
- Complex interference pattern



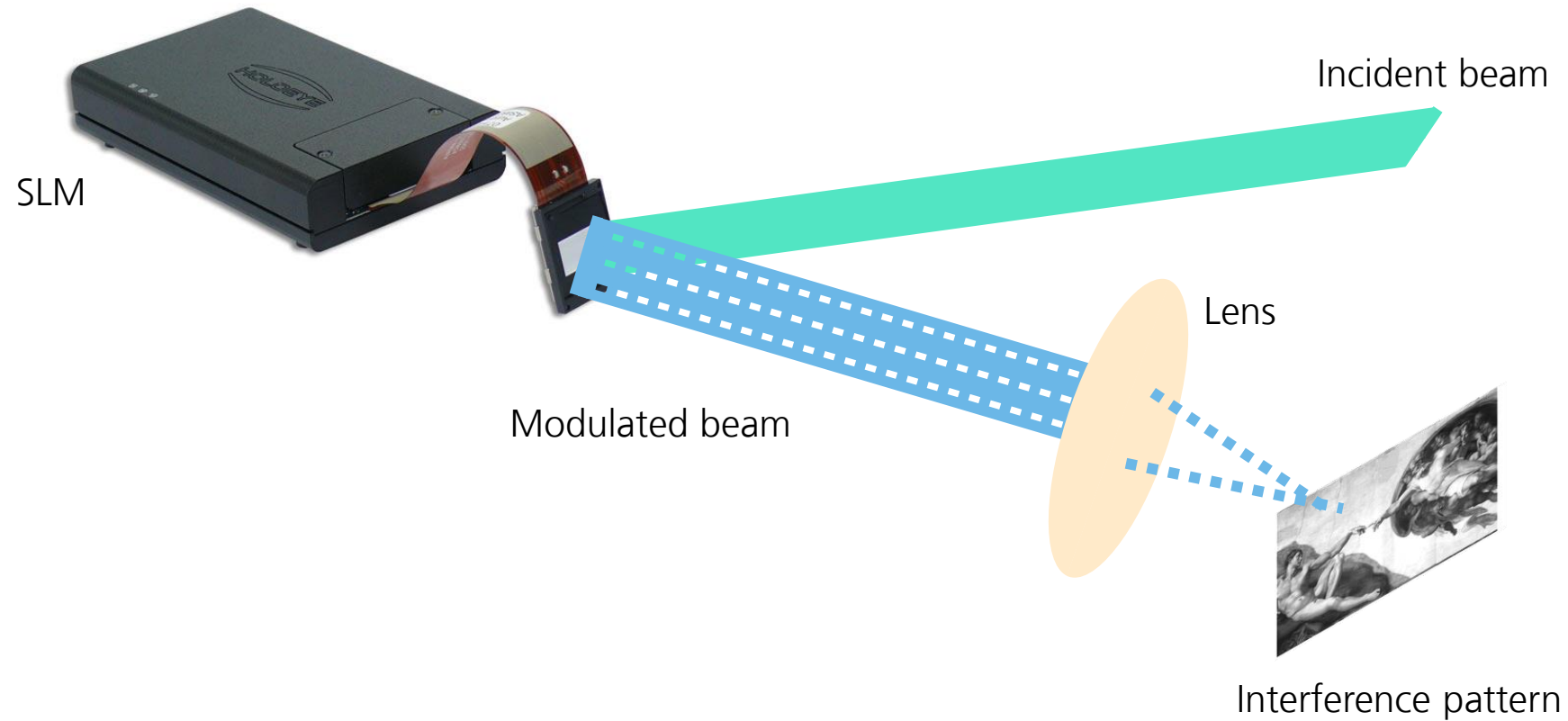
Source: Holoeye Photonics AG

Spatial light modulator Holoeye Pluto 2

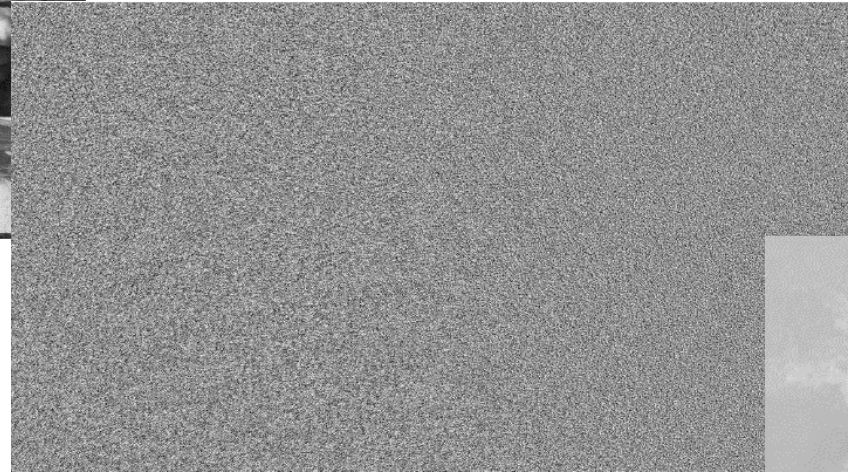
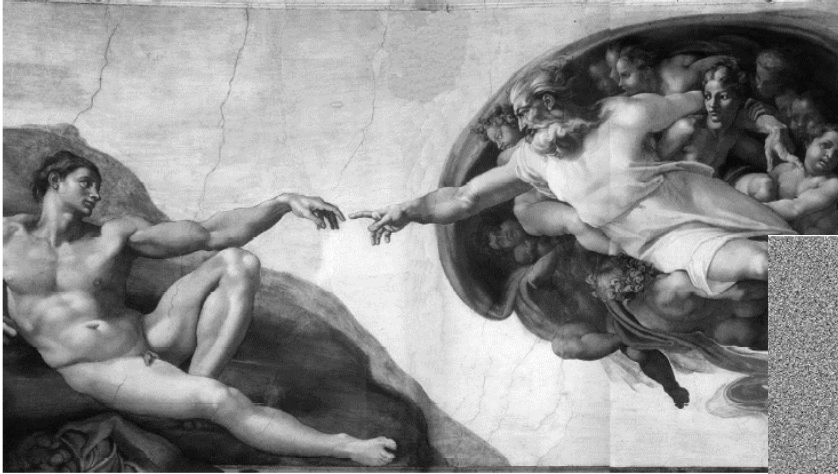


Modulated phasefront

SLM - Setup on the optical table



SLM – Software development



→ Different holograms possible



Calculate hologram



Interference pattern in sample plane



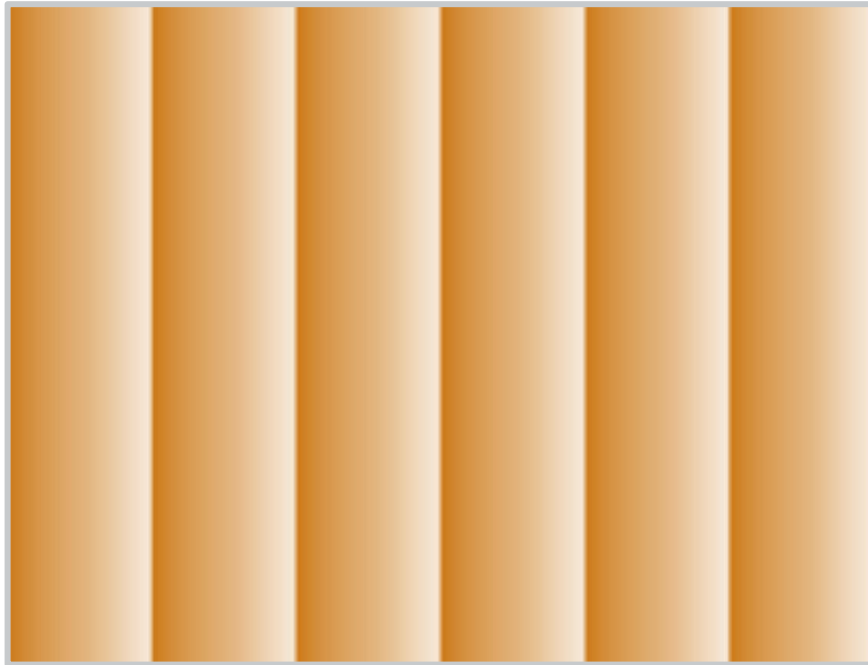
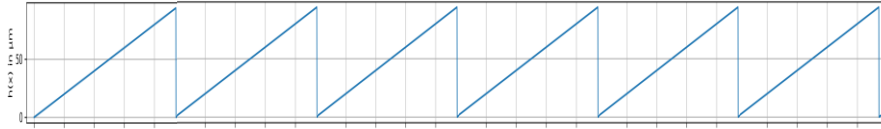
Challenges

- Reflection artefacts
 - 1st order
 - Border reflections
- Intensity correction
- Speckle

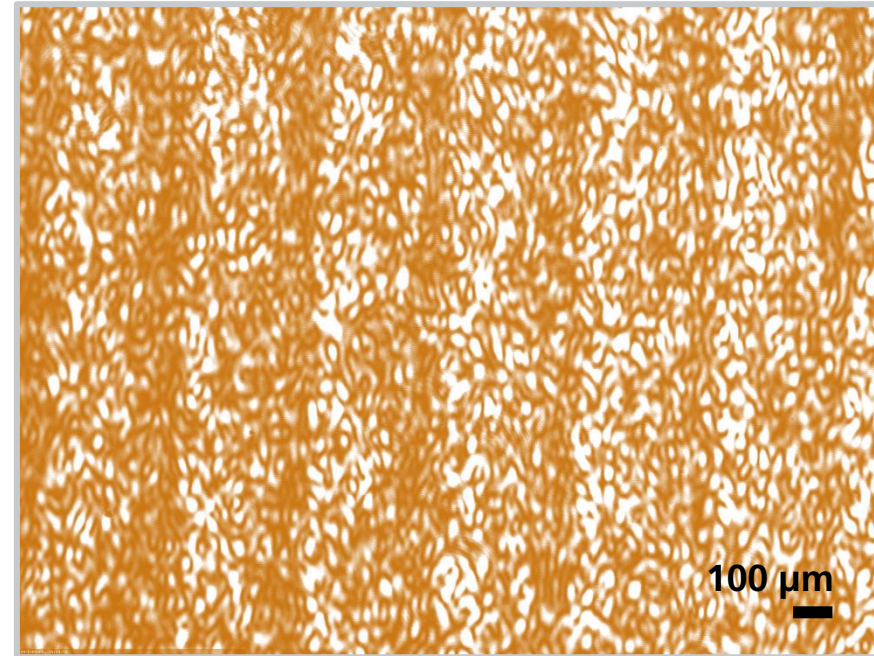


Image showing 1st order artefact

Speckle – interference effect



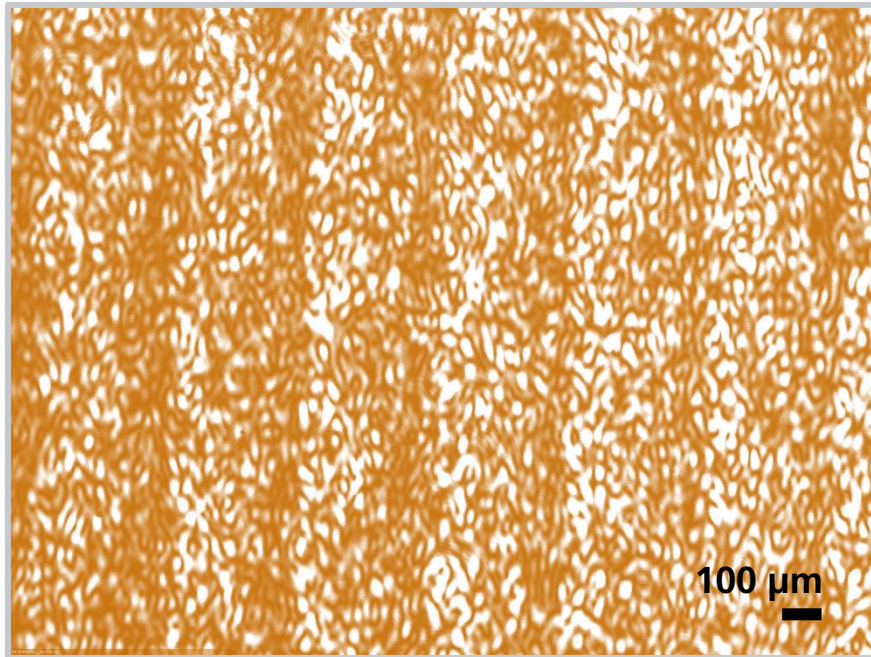
Blaze signal



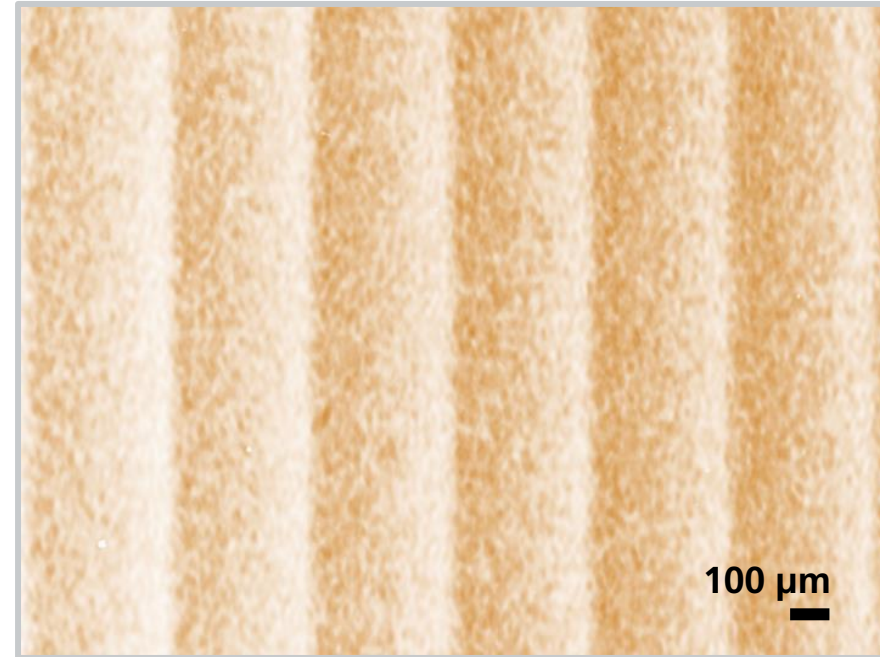
Camera image of blaze signal with speckles

Speckle reduction (1/3)

- Temporal averaging

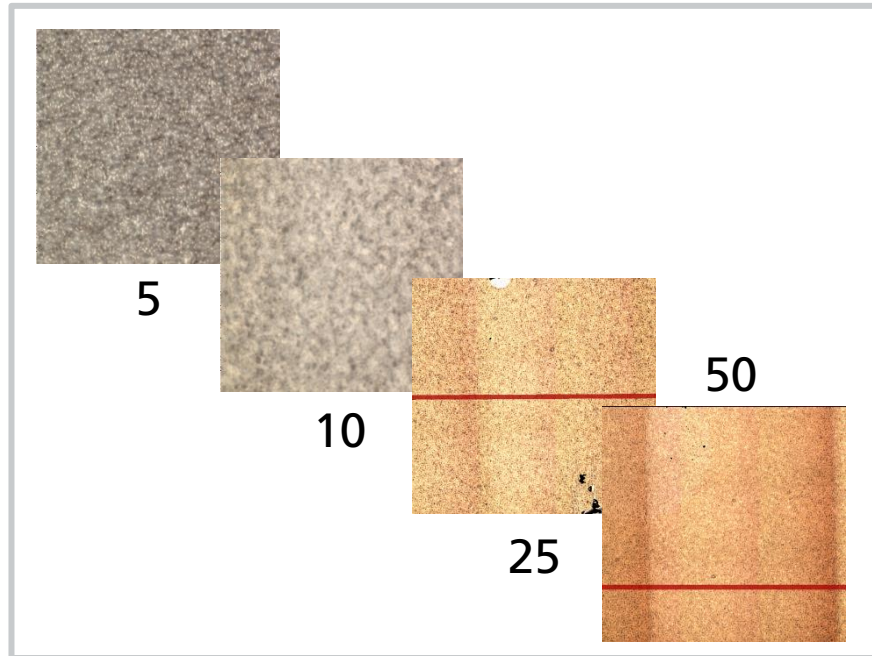


Interference pattern for Blaze image

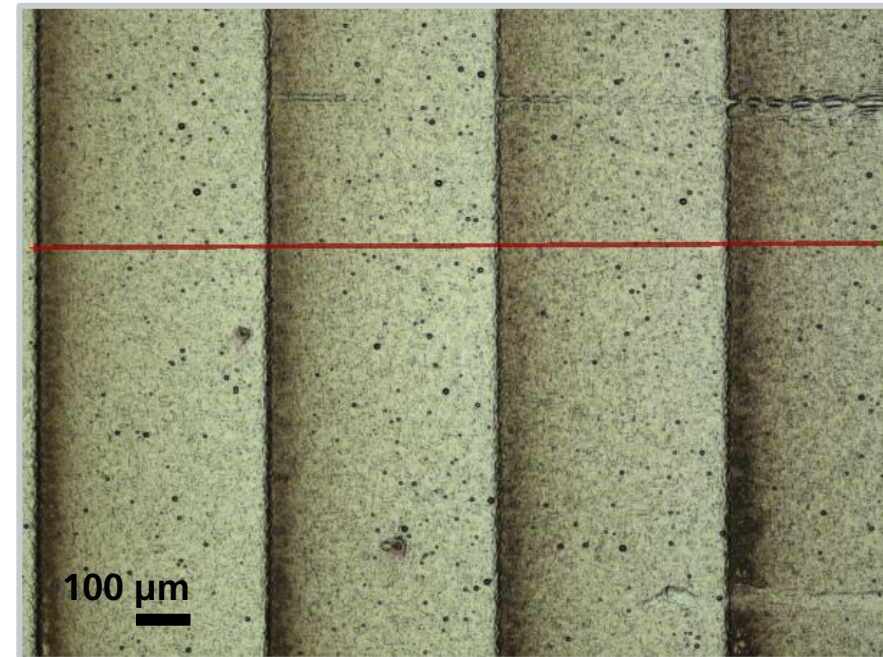


50-average interference pattern

Speckle reduction (2/3) – temporal averaging



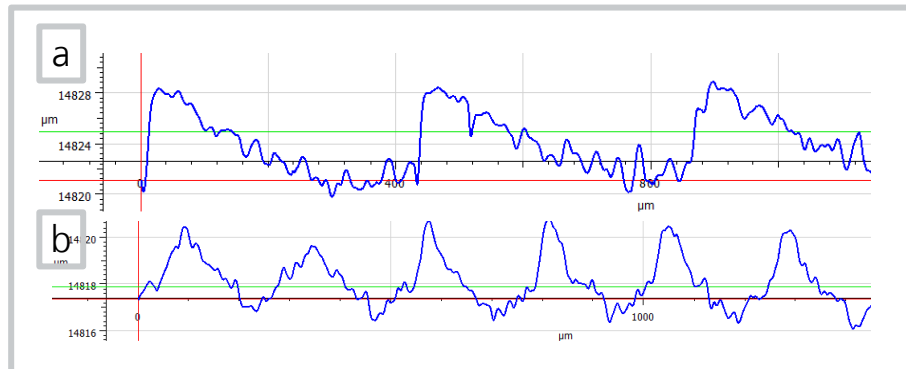
5,10,25,50-average blaze pattern (period 400 μm)



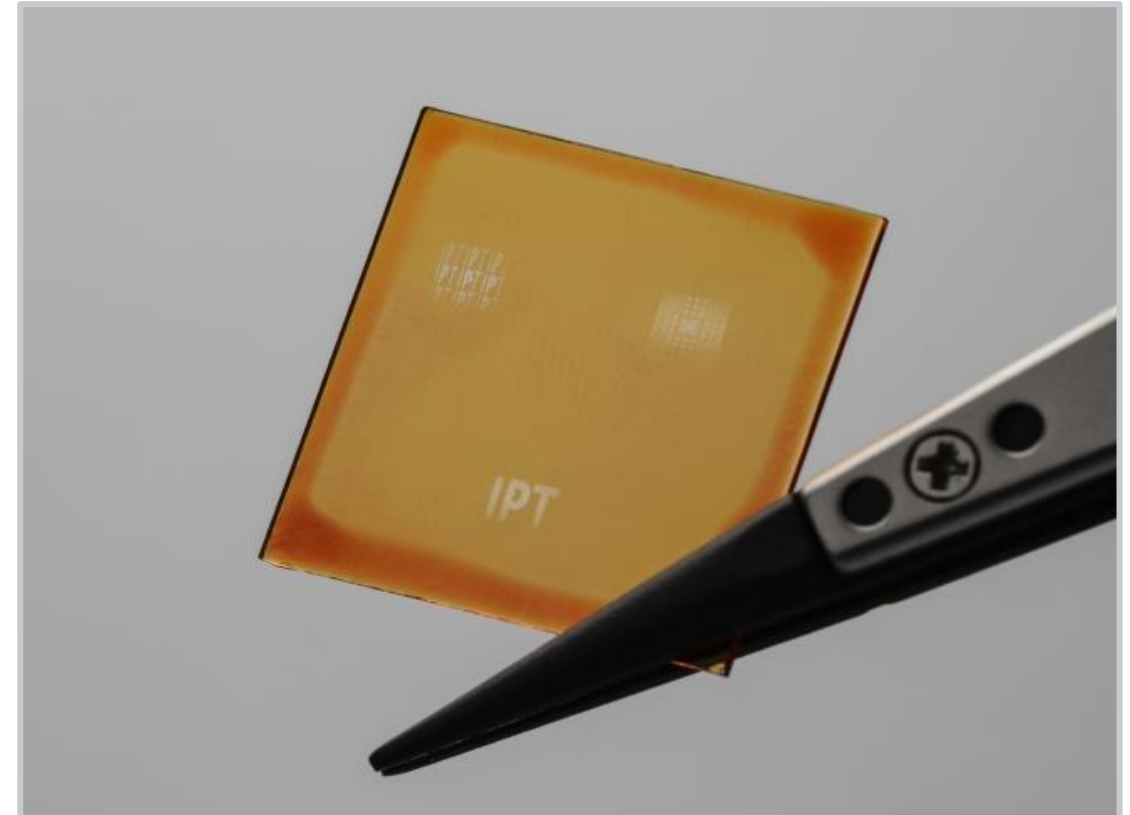
100-average blaze pattern

Speckle reduction (3/3)

- Increase of Signal-to-Noise ratio
- Structures with no speckles visible to the eye, minimal structural periods:
 - Blaze pattern, 400 μm
 - Triangular pattern, 250 μm



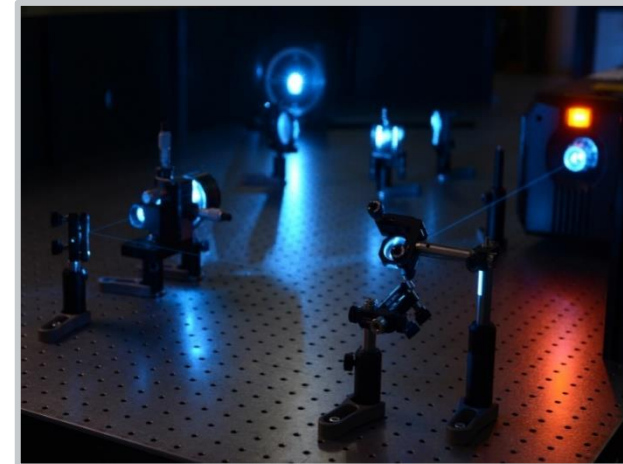
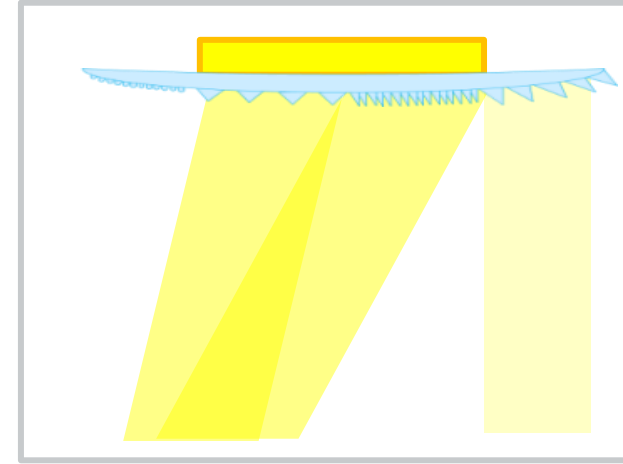
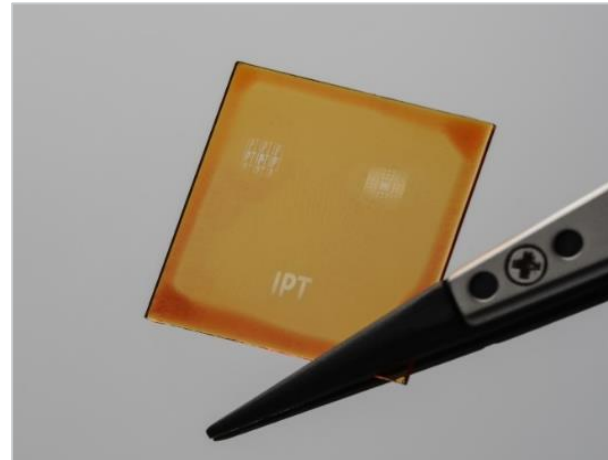
Profiles showing blaze (a) and triangular (b) shapes



Sample with various structures

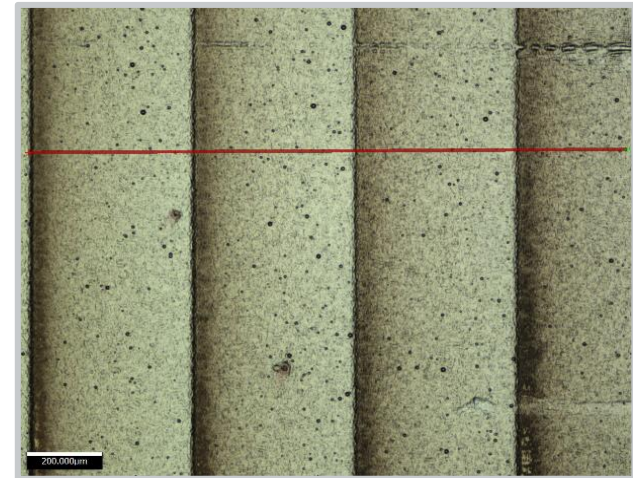
SLM lithography – future work and applications

- Setup with:
 - Positioning systems
 - Various lenses
- Optimization of hologram using AI support
- **Applications:**
 - Smart light management
 - Easy to replicate microoptics
 - Diffusor structures
 - Freeform optics
 - Anti-reflex structures
 - Combinations



Summary

- Spatial light modulator lithography
 - Feasibility studies for periodic and individual structural geometries for smart light management systems
 - Sizes up to several cm²
- Speckle noise could be significantly reduced
 - Increased resolution



Ihr Kontakt zu uns



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