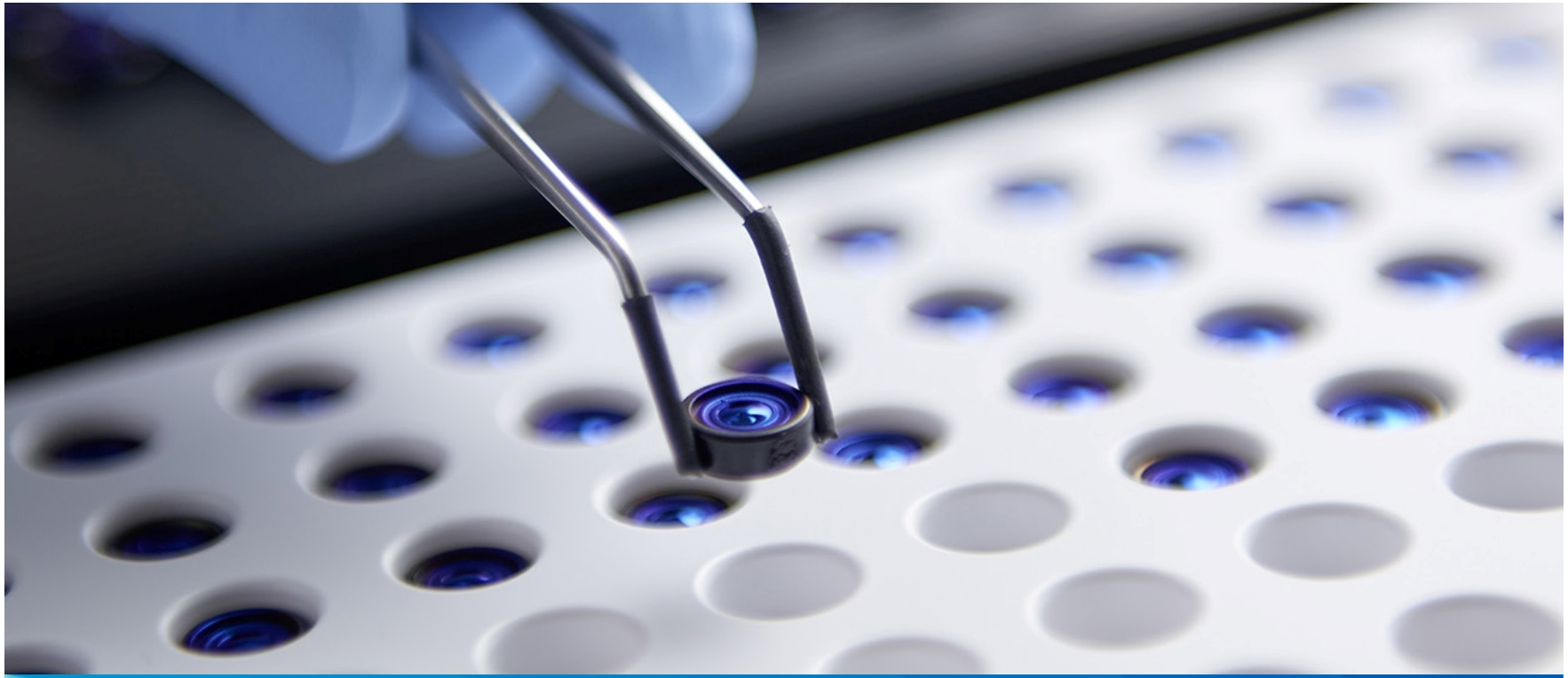


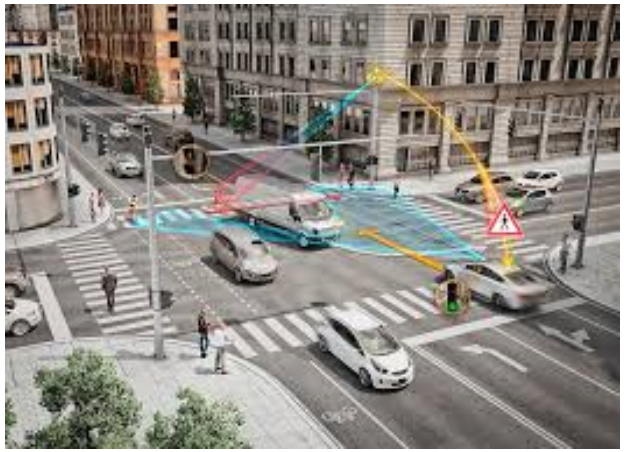
JENOPTIK

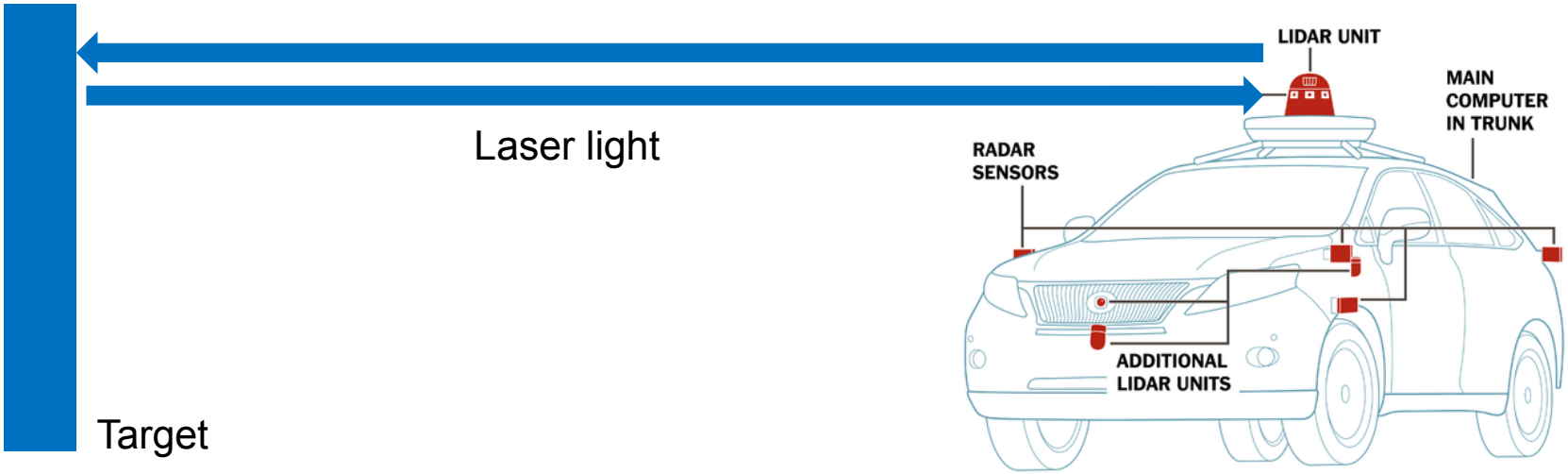
MORE LIGHT

Freeform Optical Technologies for Lidar Applications

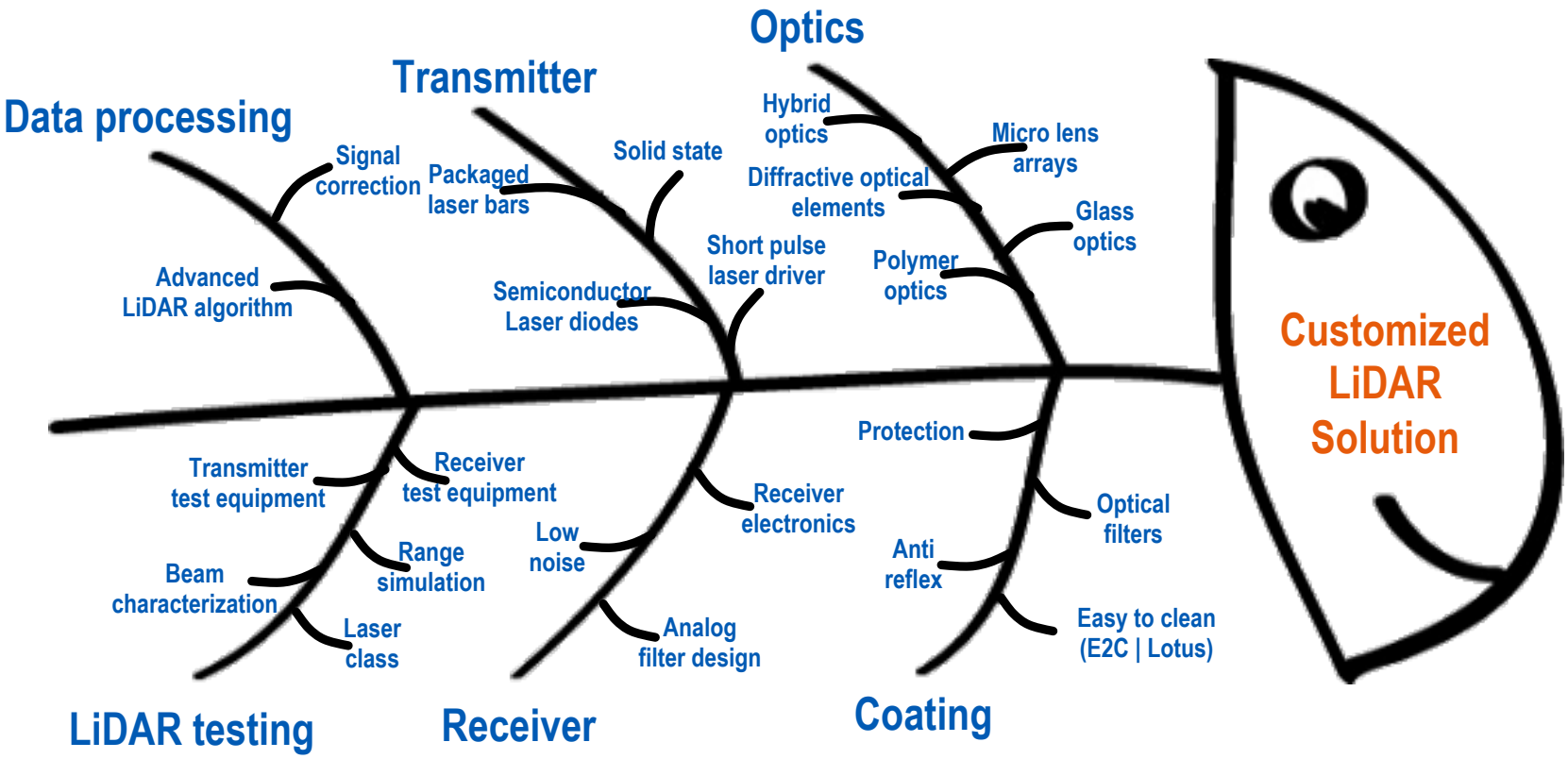
Dr. Hagen Schweitzer | 03.12.2019

Introduction

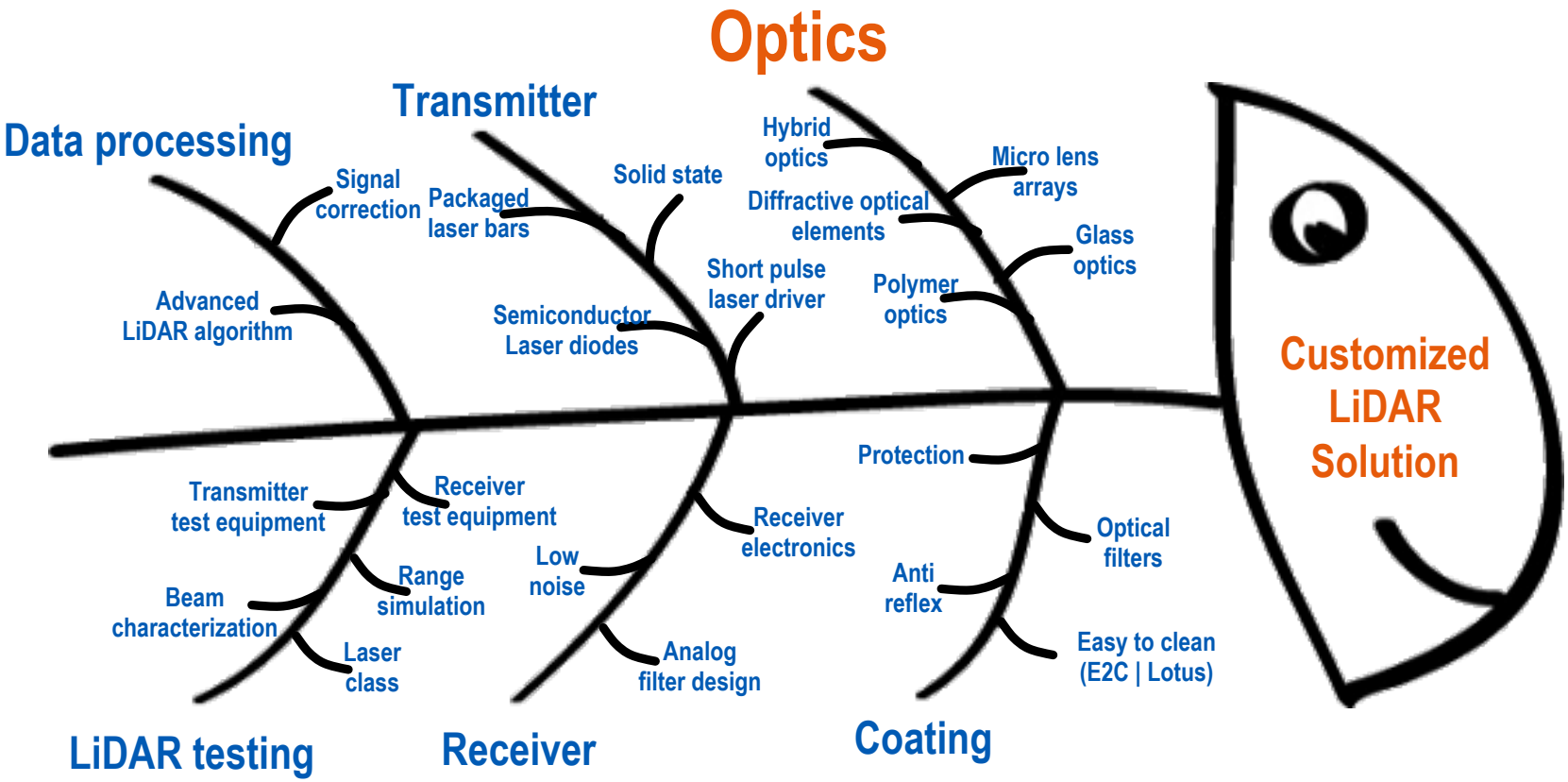




Photonic Technologies for LiDAR
Jenoptik LiDAR Competencies in all areas

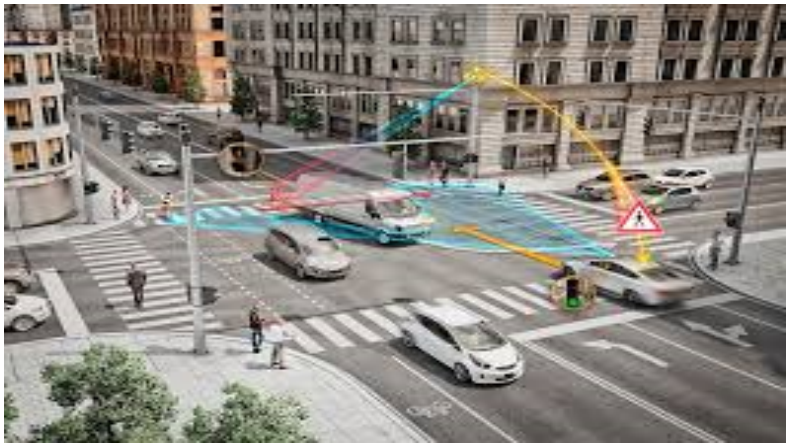


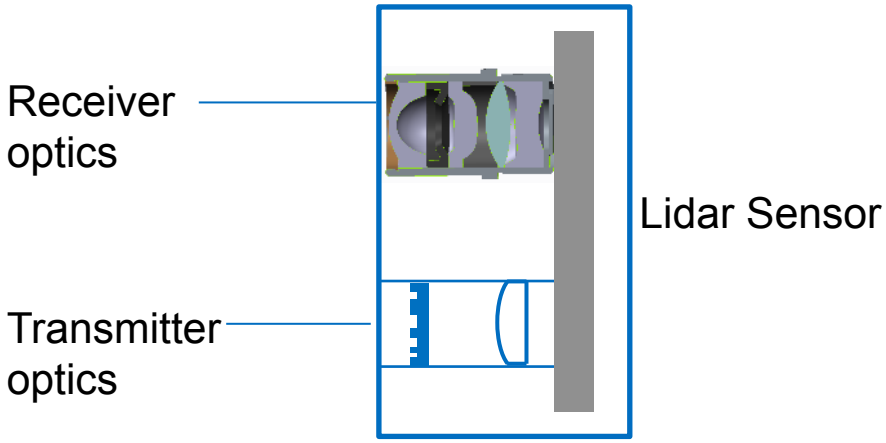
Photonic Technologies for LoLiDAR
Jenoptik LiDAR Competencies in all areas

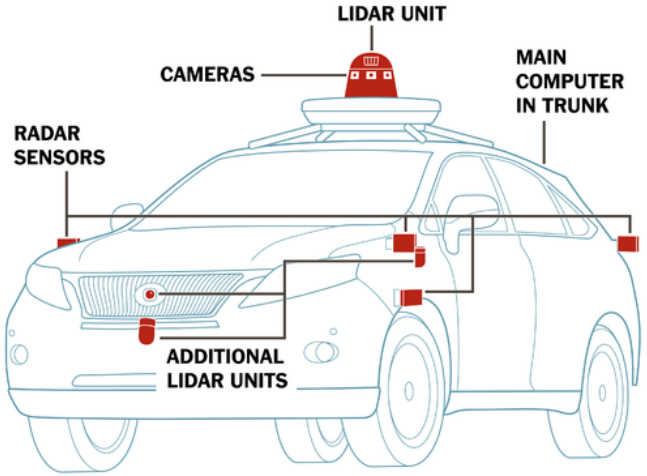


Introduction

Receiver and transmitter optics may contain freeform components

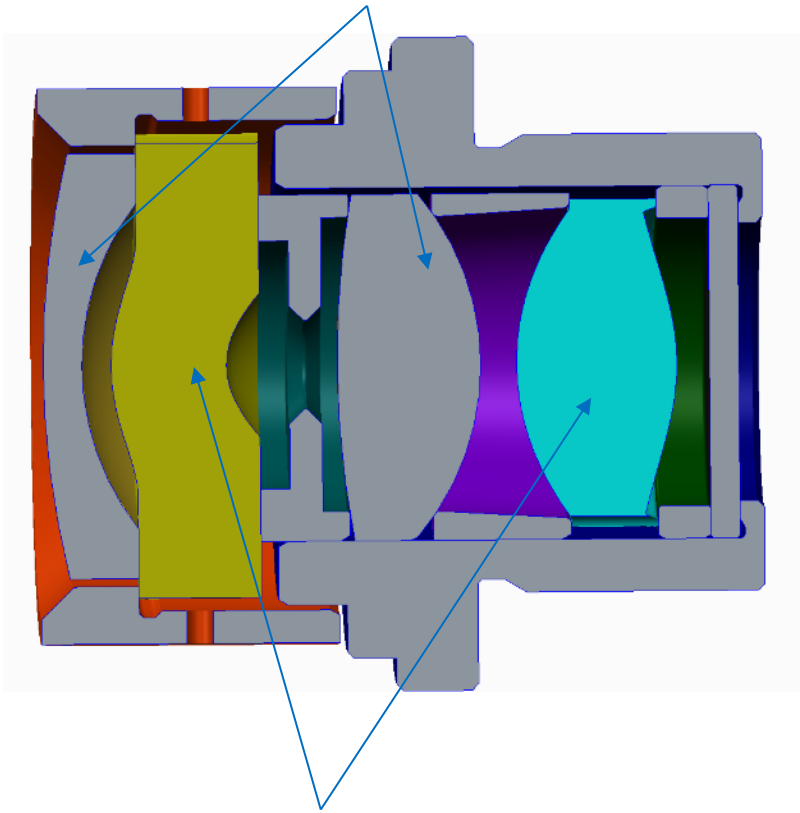






Applications of Freeforms in LIDAR Systems: Receiver
Anamorphic Receiver Lens

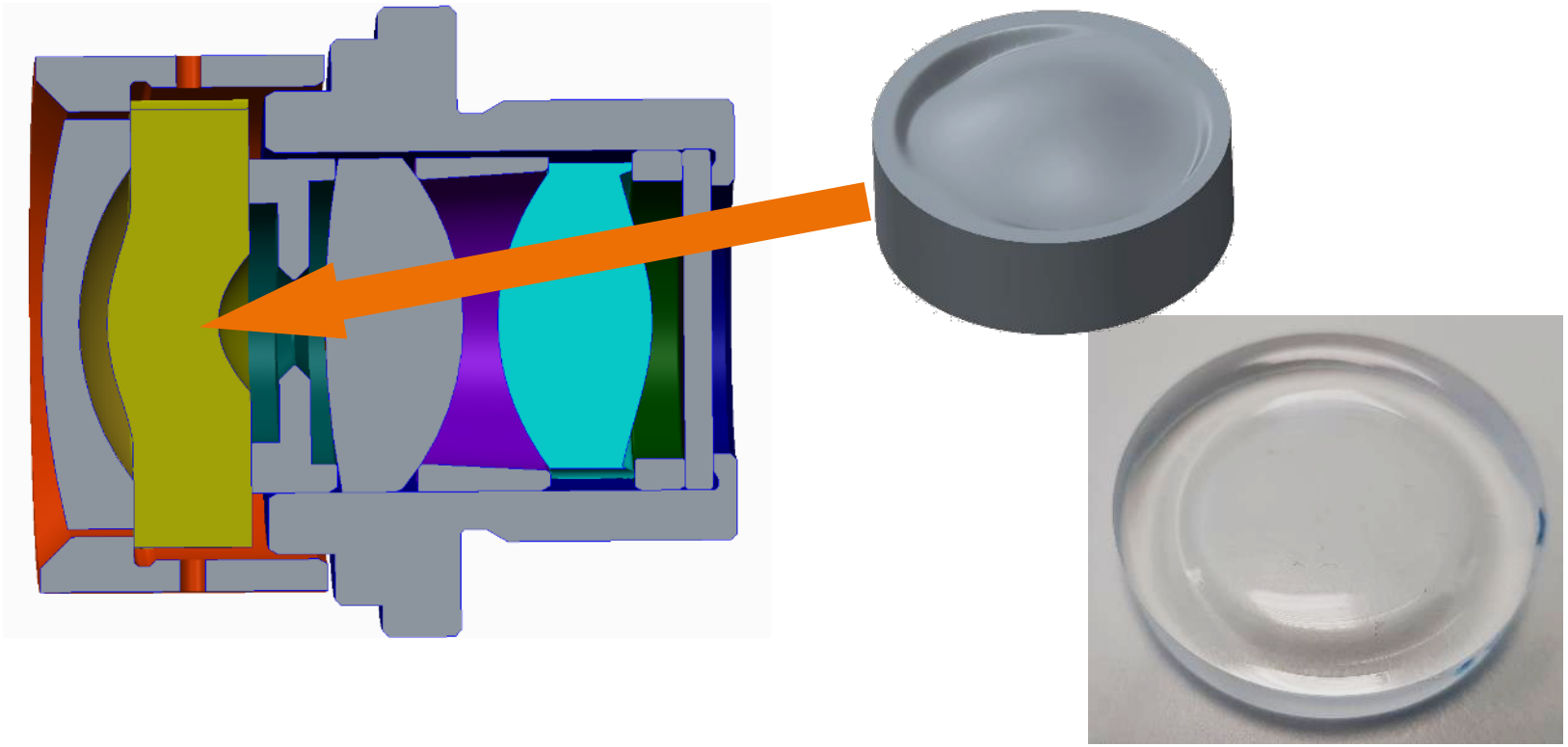
Glass lenses



Freeform polymer lenses

- Hybrid objective lens containing two polymer freeform lenses and two spherical glass lenses.
- Athermal between -40°C and 110°C.
- Anamorphic lens for changing aspect ratio between FOV and image.

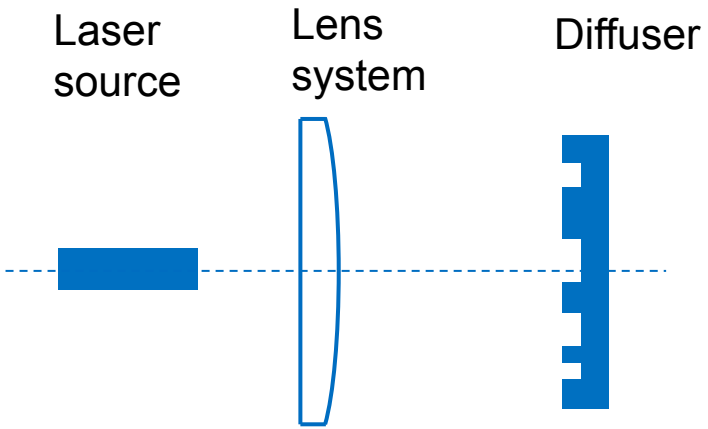
Applications of Freeforms in LIDAR Systems: Receiver
Anamorphic Receiver Lens

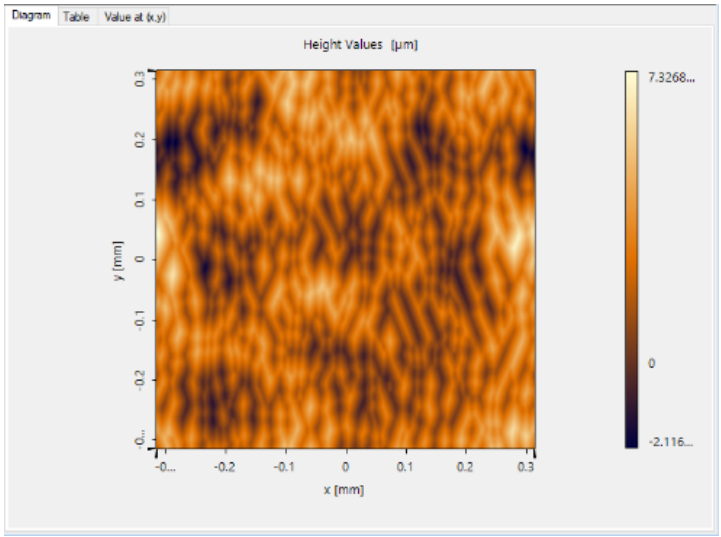


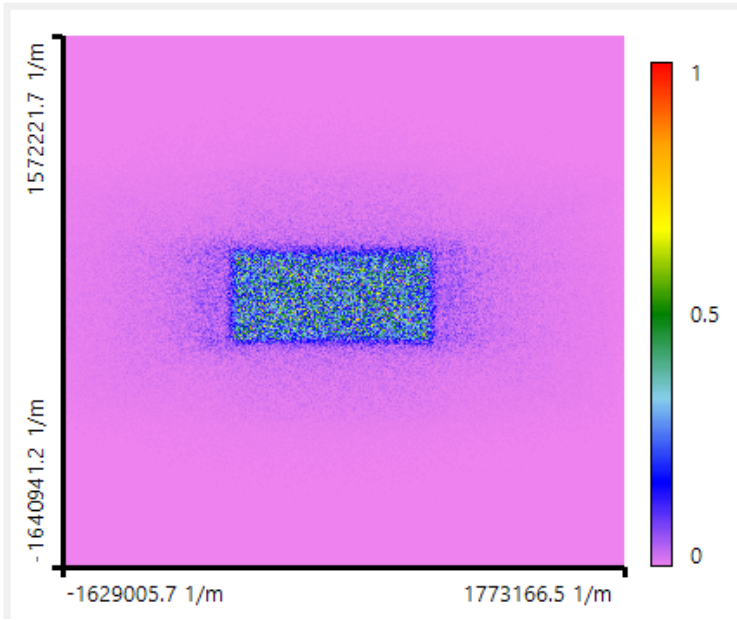
Polymer (Zeonex) lens with freeform surface

Applications of Freeforms in LIDAR Systems: Transmitter
Diffusor for FOV Illumination

- Refractive diffusers for illumination of field of view
- Left lower figure: diffuser surface
- Right lower figure: angular scattering distribution



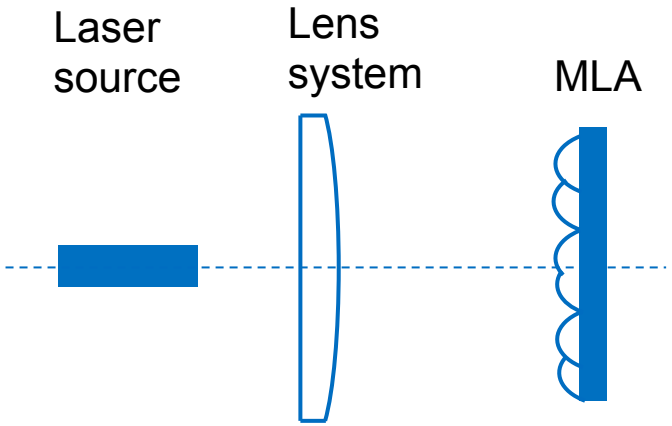


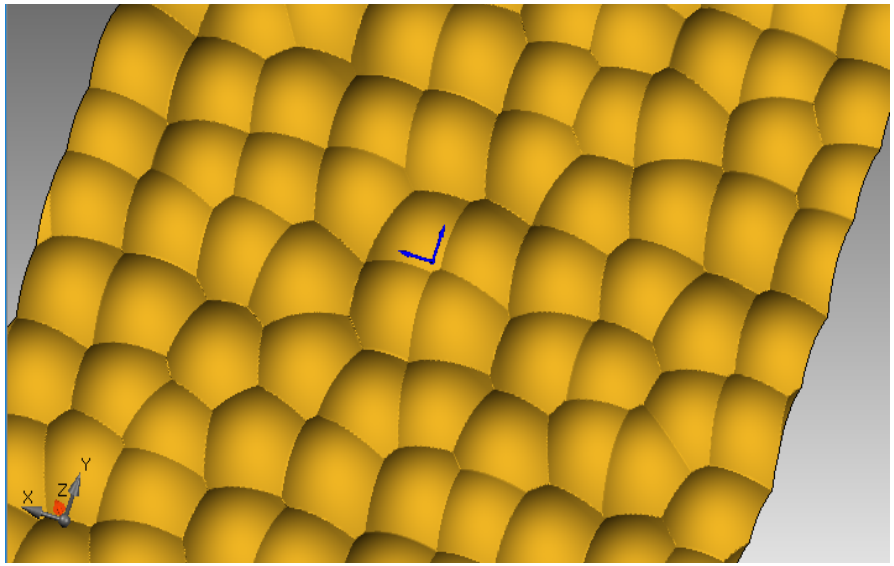


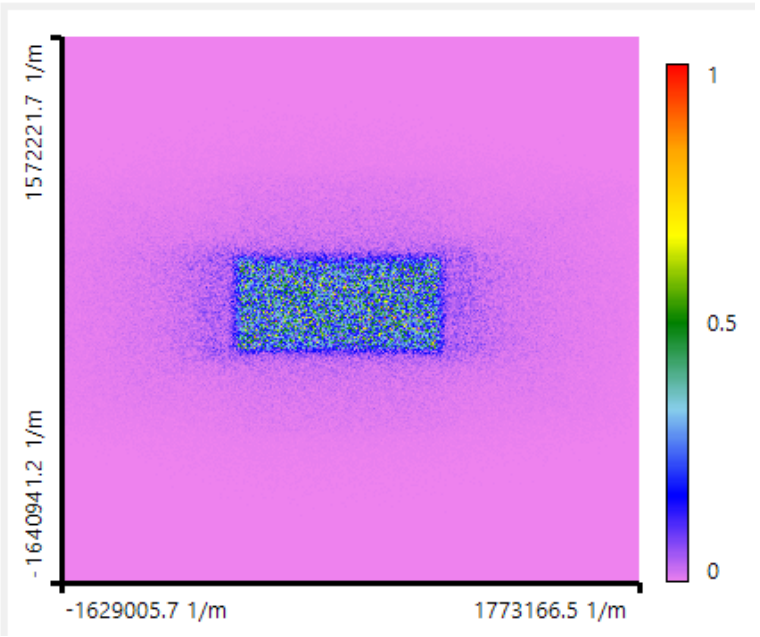
Applications of Freeforms in LIDAR Systems: Transmitter
MLA for FOV Illumination

JENOPTIK
MORE LIGHT

- Random micro lens array
  for illumination of field of view
- Left lower figure: micro lens surface
- Right lower figure: angular scattering
  distribution

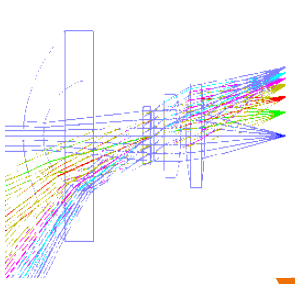






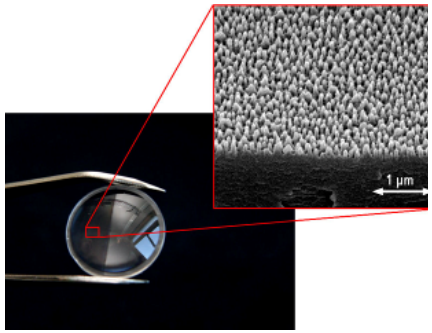
Optical Technology
From design to automotive-quality series production

JENOPTIK
MORE LIGHT






Optics & System Design | Tooling | Optical Components | Optical Coating | Assembly | Quality Assurance

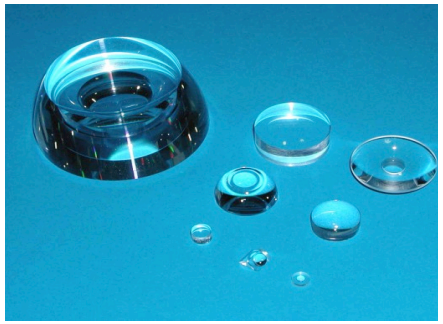




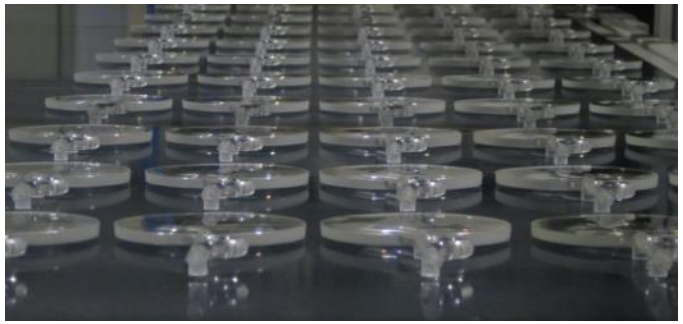
Precision manufacturing competencies
Ultra Precision Turning, Milling, Ruling

JENOPTIK
MORE LIGHT

→ Metals and polymers prototype elements

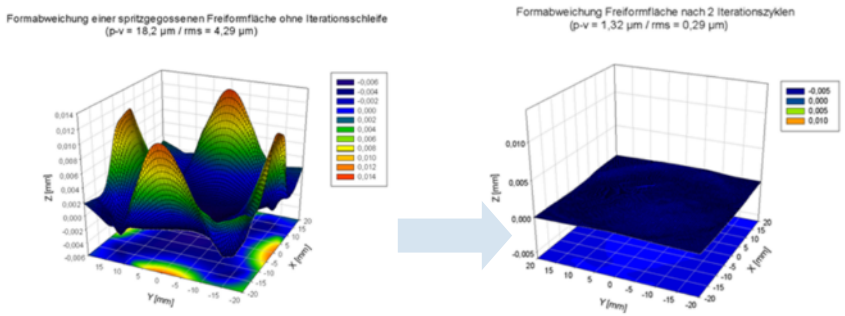


→ Small Series



→ Inserts for injection molding

→ Compensation of shrinking of polymer elements



Slow Tool Servo Technology (3 CNC Axis)

JENOPTIK
MORE LIGHT

Features

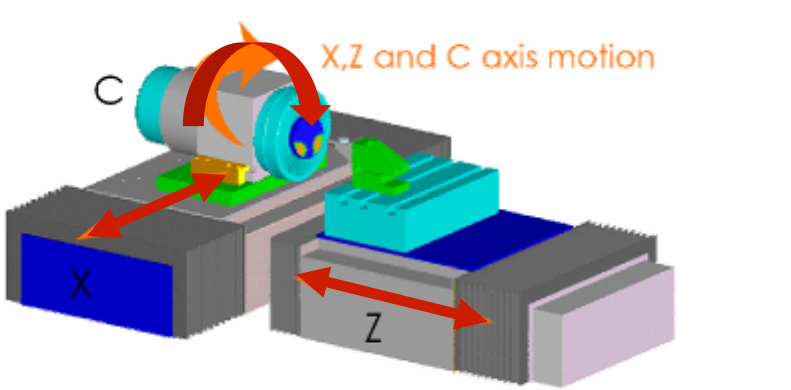
- XZC mode: Z = f (X, C)
- Angle dependent feed of diamond tool.
- Oscillation of z-axis depending on surface profile

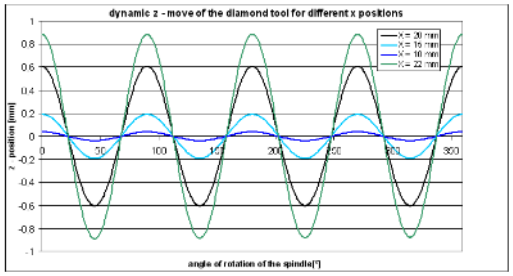
Surface types

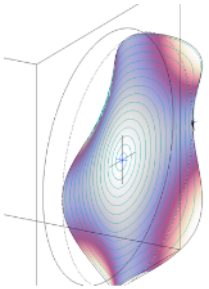
- Symmetric and asymmetric free form surfaces
- Continuous surfaces

Limitations

- Dynamic (modulation) of surface in angular direction
- Surface angle







Extension of STS Technology
Ruling with virtual y-axis

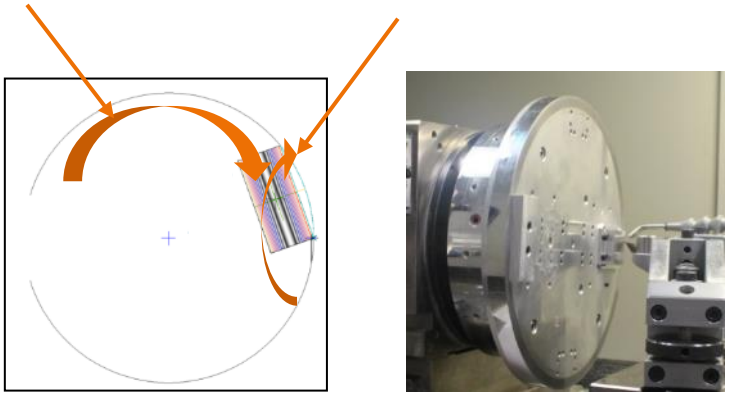
JENOPTIK
MORE LIGHT

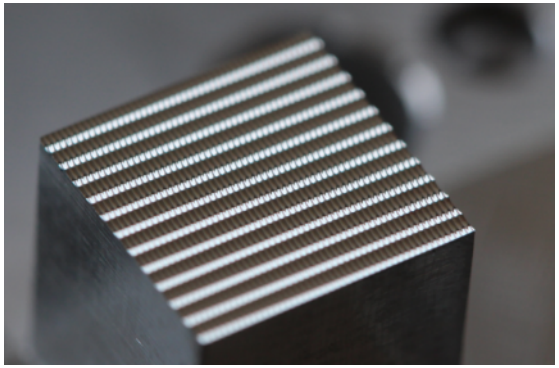
Ruling => German “Hobeln”

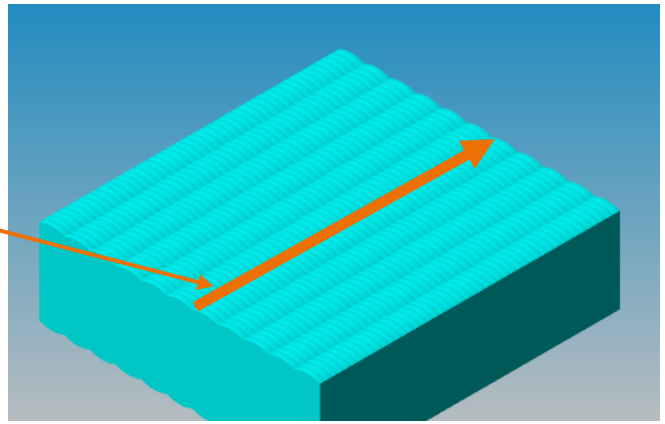
By “special software controlled“ tool path.

Features

- Cylindrical lens arrays
- Flexible surface structures perpendicular to cutting axis.
- Surface angle perpendicular to cutting axis >30°.





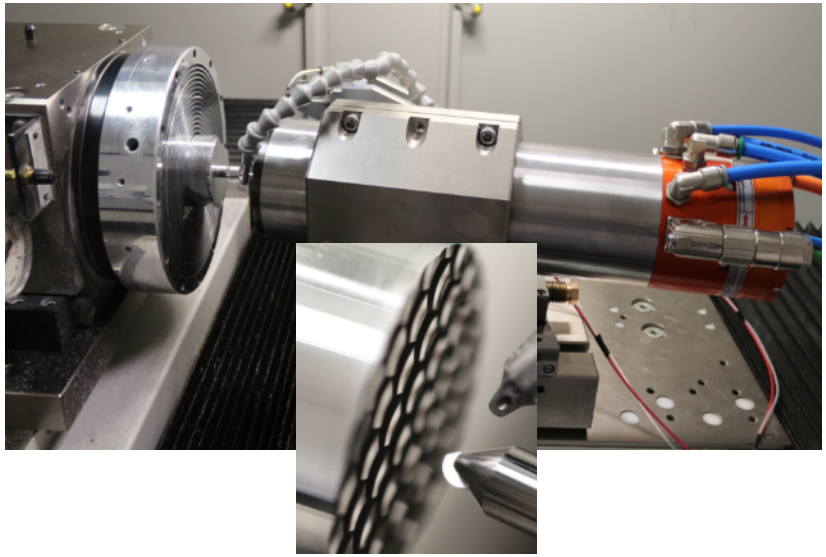


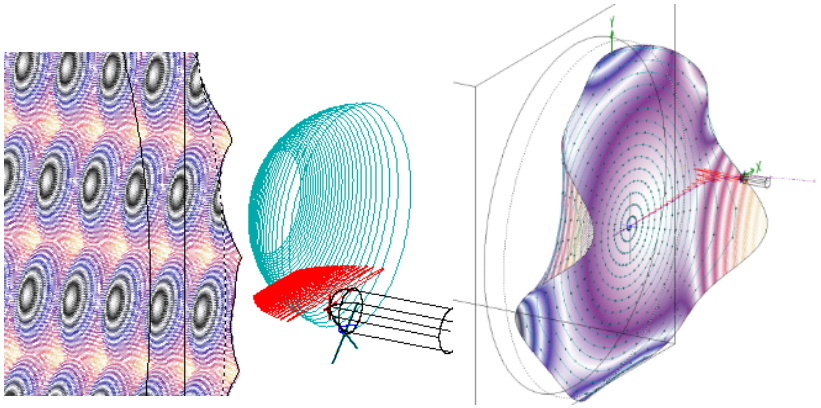
Precision production technologies
Ultra Precision Milling

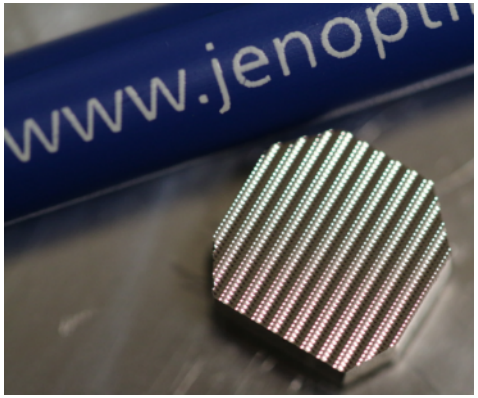
JENOPTIK
MORE LIGHT

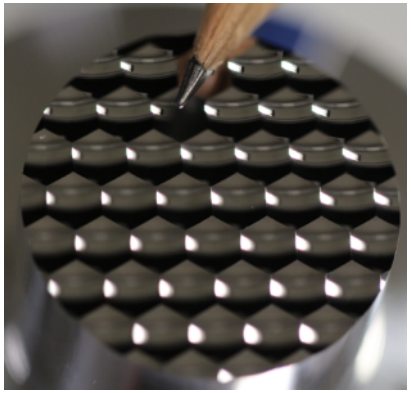
Surface types

- 2D Micro lens arrays
- Freeform surface with large surface angles
- Reference/ alignment marks







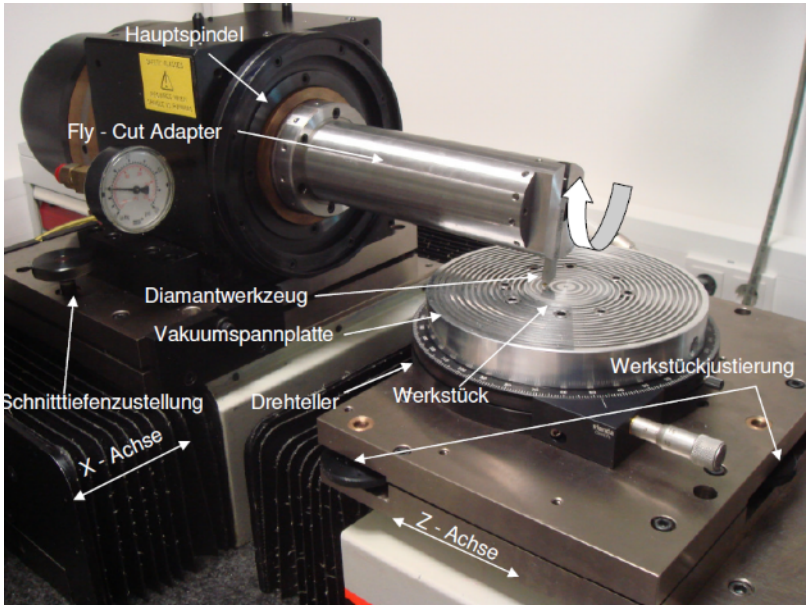


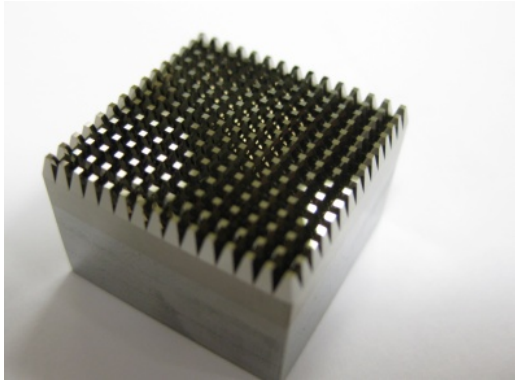
Precision production technologies
Fly Cutting

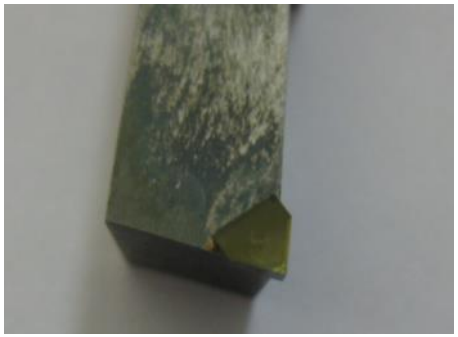
JENOPTIK
MORE LIGHT

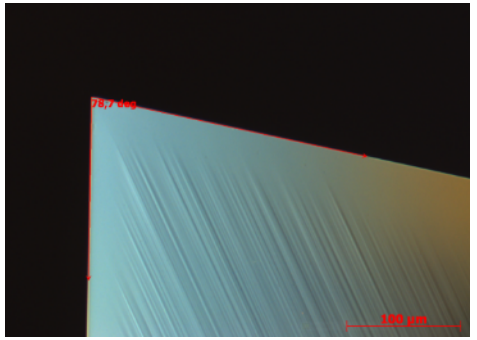
Features

- Cutting with special shapes diamond tools
- Precise cutting along a linear axis
- Cutting along two or more axis possible by turning of substrate.









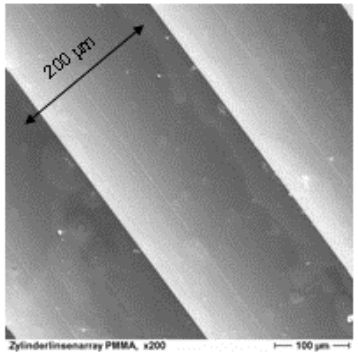
Precision production technologies
Fly Cutting – Surface Types

JENOPTIK
MORE LIGHT

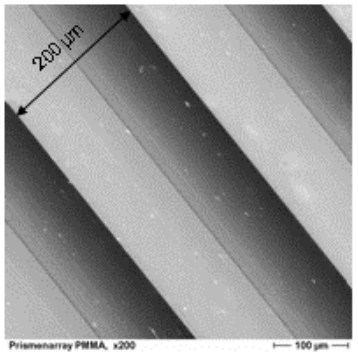
Options

- Cylindrical lens arrays
- Prism arrays
- Pyramid arrays
- Retro reflector arrays
- Gratings:
  - Periods typical: 50 µm – 1mm
  - Periods best resolution: 2 µm

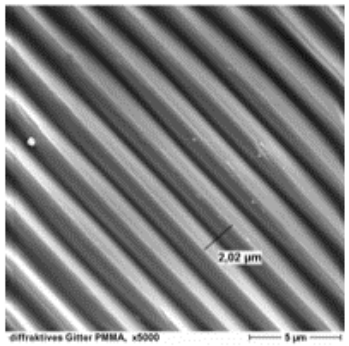
cylindrical lens array



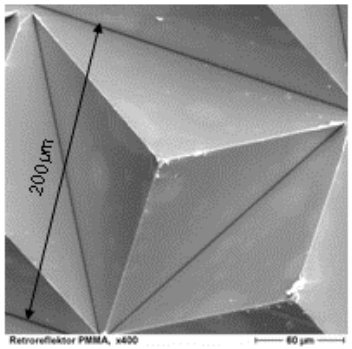
prism array



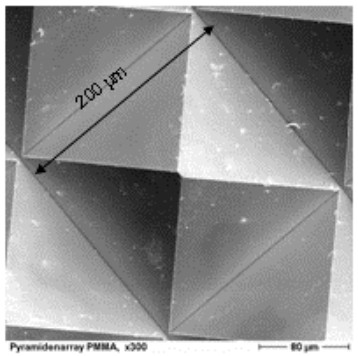
diffractive grating



retro reflector array



pyramid array



Precision series production technologies
Polymer Optics – Injection Molding

JENOPTIK
MORE LIGHT

Injection Molding Technologies

- Electrical & hydraulic injection molding machines, clamp forces 50 … 3250 kN
- Micro injection molding
- 2-component injection molding
- Variothermic injection molding
- Automated handling

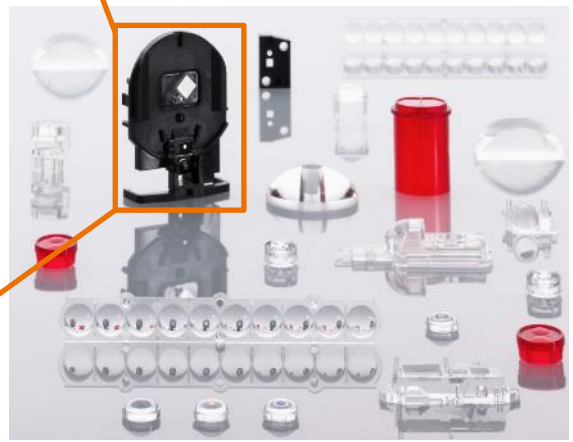
Products & Services

- Spheric, aspheric, diffractive & free form components
- Fresnel lenses, prisms, micro arrays, mirrors
- High-volume production certified for medical & automotive products
- Customer-specific production processes

Precision series production technologies
Polymer Optics – Injection Molding

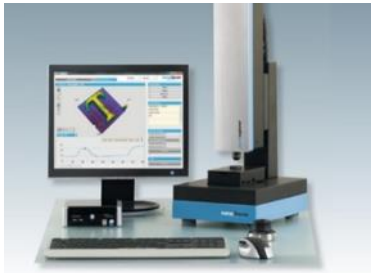
JENOPTIK
MORE LIGHT

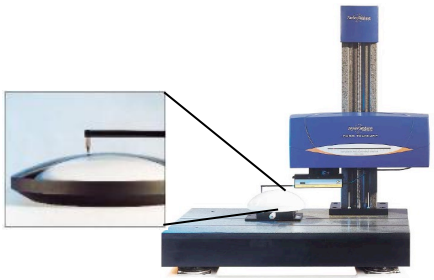
2- component injection molding mechanical mount with window and 3 lenses.



Measurement of Optical Surfaces

- Interferometer (Computer Generated Holograms can be used)
- Stylus instrument Taylor Hobson Form Talysurf PGI 1240
- 3d Coordinate measuring machine Zeiss O – Inspect / Contura*
- 2 ½ D Profilometer Panasonic UA3P*
- Confocal microscope Nanofocus
- Multiwavelength / white light interferometer (Luphos)





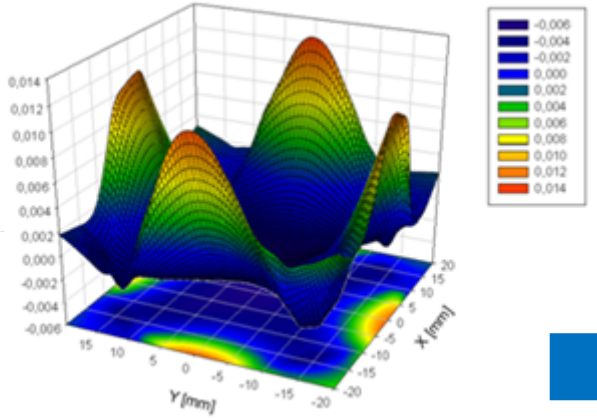
Quellen: Taylor Hobson, Panasonic, Luphos, Zeiss, Nanofocus

*- in Kooperation mit anderen JENOPTIK Standorten

Compensation of Skrinking of Polymer Components

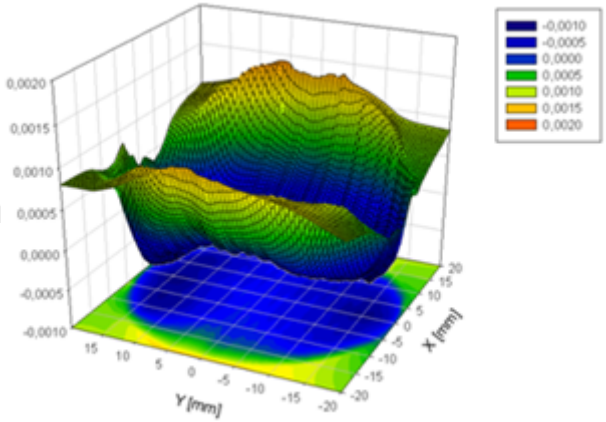
Surface deviation caused by shrinking

PV 18 µm



Reduction surface deviations by compensation process

PV 1.8 µm



Reduction of surface form deviations of molded optical components to values of < 2 µm PV.

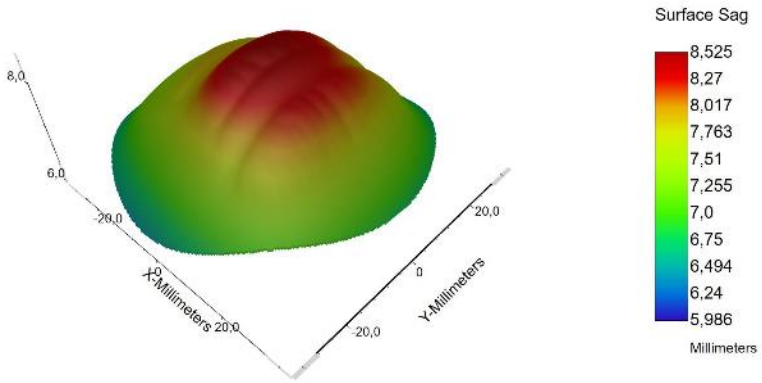
Freeform Component Example
Jenoptik Logo

JENOPTIK
MORE LIGHT

Freeform component for light shaping

Image Simulation

Freeform Surface



Real Image

Summary

- ✓ Jenoptik offers electronics, light source, optical components and optical systems for LIDAR sensors.
- ✓ Optical components with freeform surfaces can be used in transmitter and receiver optics of LIDAR sensor.
- ✓ Fabrication of polymer and metal optical freeform elements and mold inserts by ultra precision turning, ruling and milling.
- ✓ Injection molding of freeform components and assembly of optical systems.

JENOPTIK
MORE LIGHT

Thank you for your Attention

Dr. Hagen Schweitzer

Optics Design & Development, JENOPTIK | Light & Optics division

Tel. +49 36482 45-151
Fax +49 36482 45-222
E-Mail hagen.schweitzer@jenoptik.com

http://www.jenoptik.de

Image Source

JENOPTIK
MORE LIGHT

- Slide 2 and 7:
  - Upper left image: https://www.next-mobility.news/autonomes-fahren-die-rolle-der-radarsensoren-und-wie-sie-sich-testen-lassen-a-728831/, 30.08.2018
  - Upper right image: https://www.pressebox.de/pressemitteilung/continental-reifen-deutschland-gmbh-hannover/CES-2018-Technologien-von-Continental-fuer-intelligente-Kreuzungen-machen-Strassen-in-Smart-Cities-sicherer/boxid/886794, 30.09.2018
  - Lower right image: https://www.nytimes.com/2017/05/25/automobiles/wheels/lidar-self-driving-cars.html, 30.08.2018