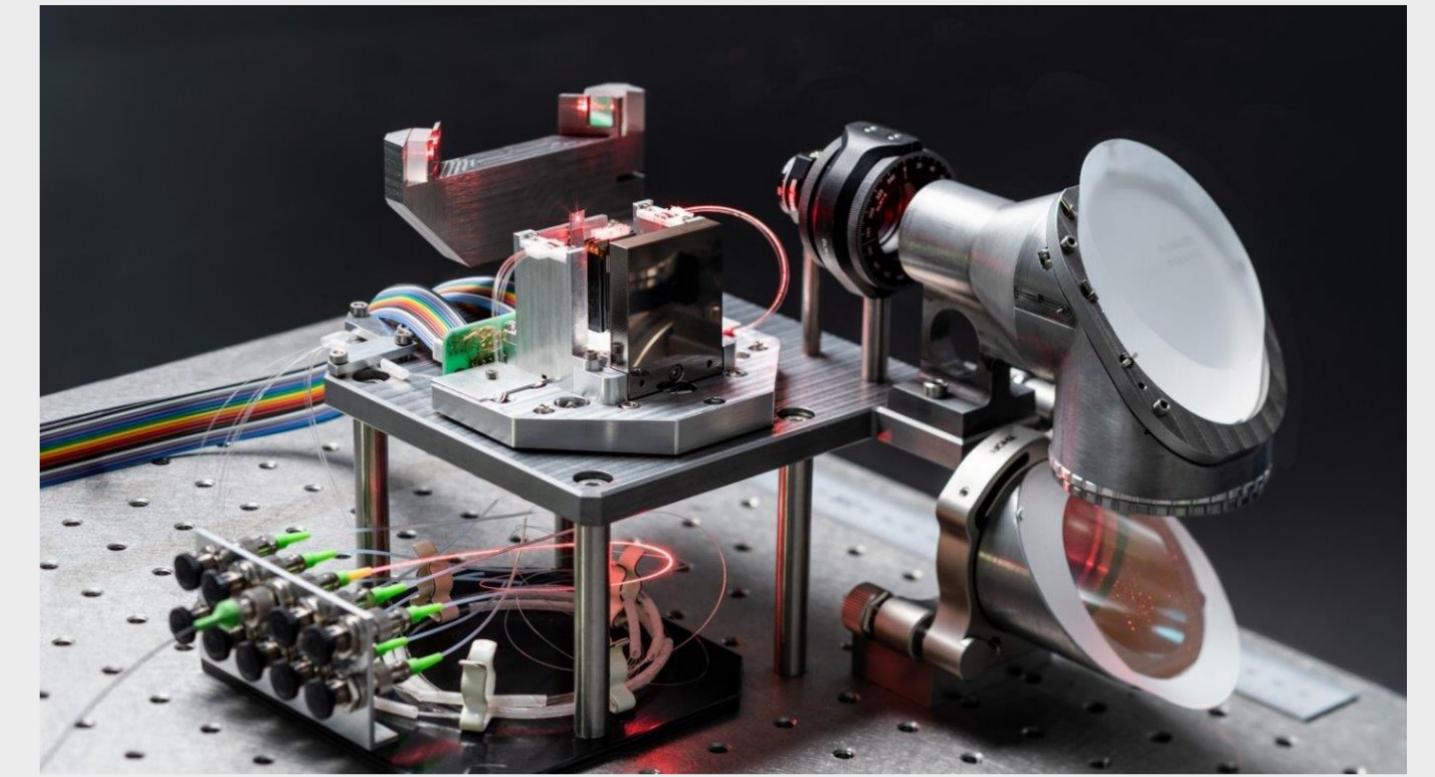**module**qnc
quantum & neuromorphic computing

Optical actuation and control systems

Addressing units for ion- and atom-based quantum computers

1 Application

Application:
- Individual addressing of ions in an ion trap or atoms in an optical lattice
- Spacing of the addressing zones
  - Ions: 5 µm (irregular, linear)
  - Atoms: 1 µm (regular, 2D)

SiO_2 Etched ion trap
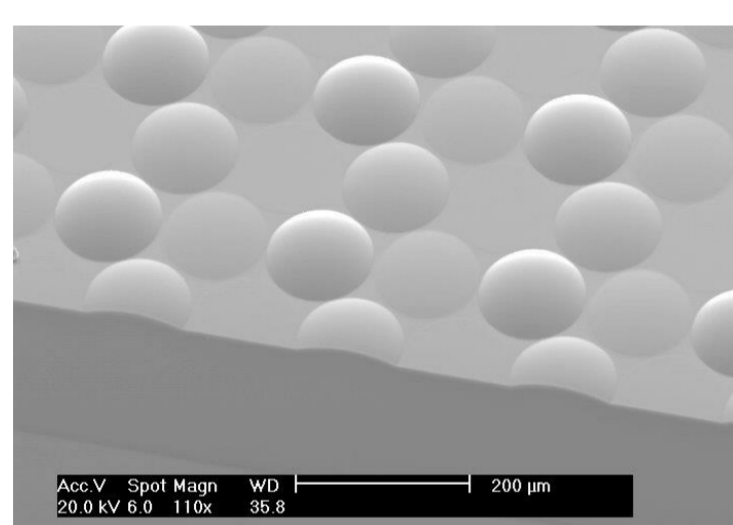
2 Technology

Optical and mechanical design
- Zeemax and Lumerical simulations
- Multi-physics finite-element analysis

Combined mechanical and optical design
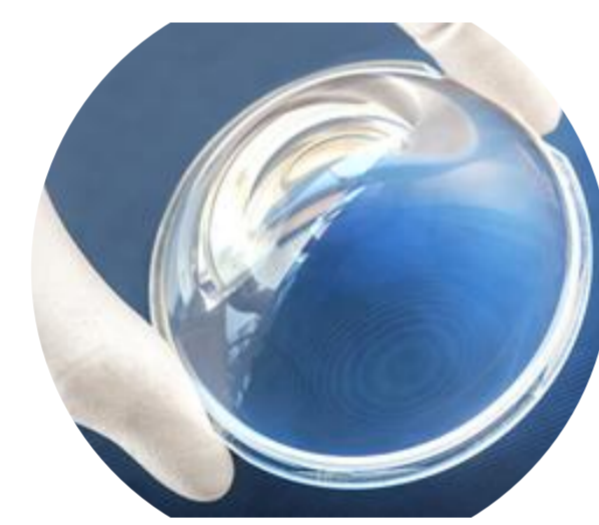
Microlens production
- Reflow microlens array (MLA) production
- Creation of reproduction master by means of lithography
- Polymer apertures and anti-reflective coatings
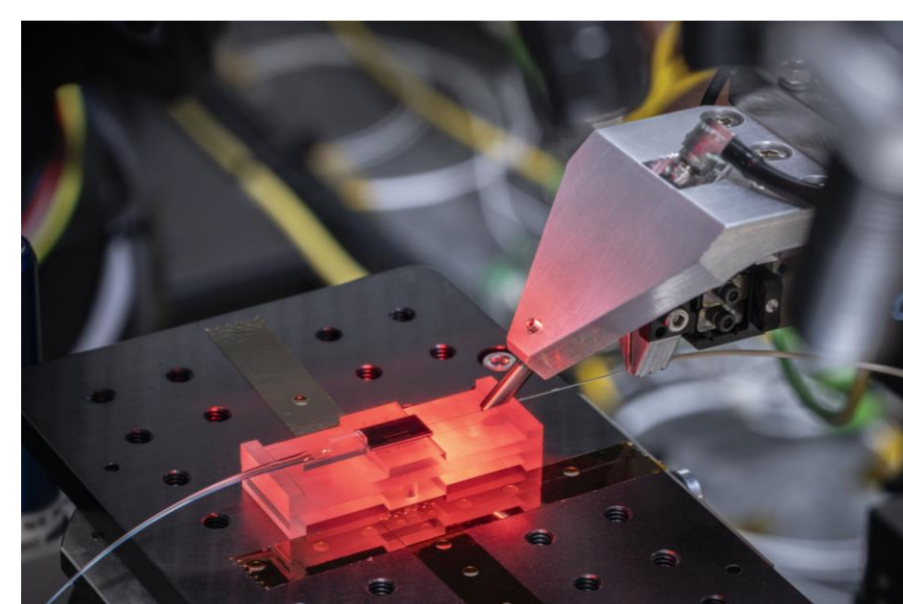

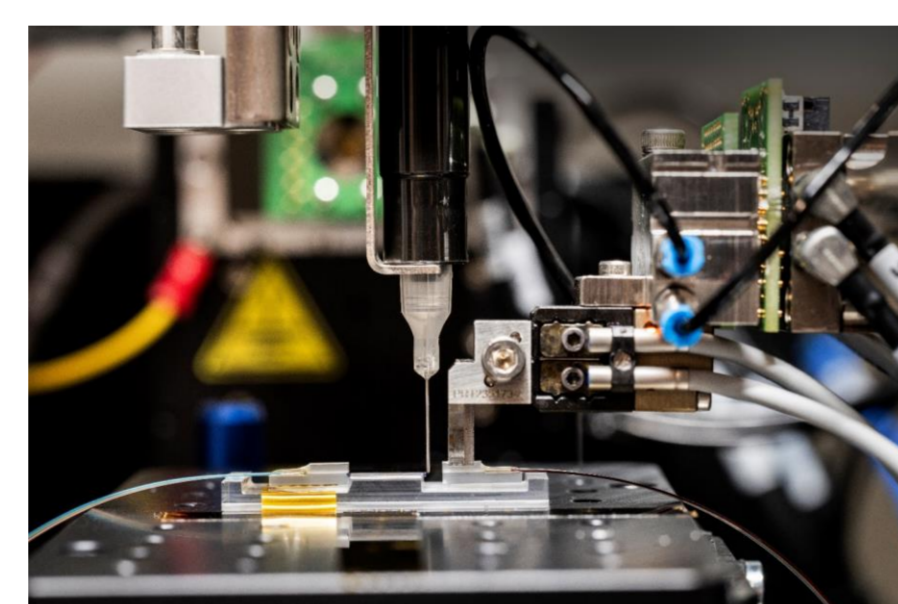*MLA chip of the addressing unit*

MLA with different focal lengths

Anti-reflective coating

Integration
- Active alignment of optical components (fibers, lenses, mirrors)
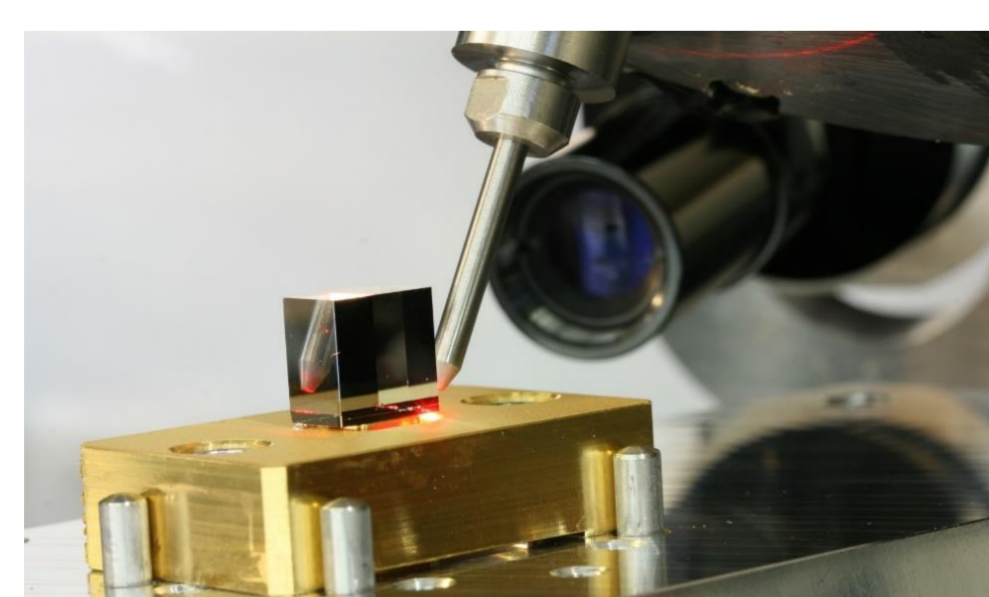- Ultra-low-loss polarization aligned fiber to chip coupling

Single fiber alignment

Fiber array bonding

Ultra-high-vacuum connection technology
- UHV compatible UV-curing adhesives
- Solder jet laser soldering for precession joints of optics
- Inorganic silicate bonding for optical interfaces
- Direct bonding for covalent connections of joining partners

Solderjet bumping

Silicate bonding

3 Ion addressing unit (IQuAn/ ATIQ)

**GEN1: external addressing unit**
- Parallel manipulation of 10 ions lined up next to each other
- Fiber-coupled waveguide as input, collimated with microlens array
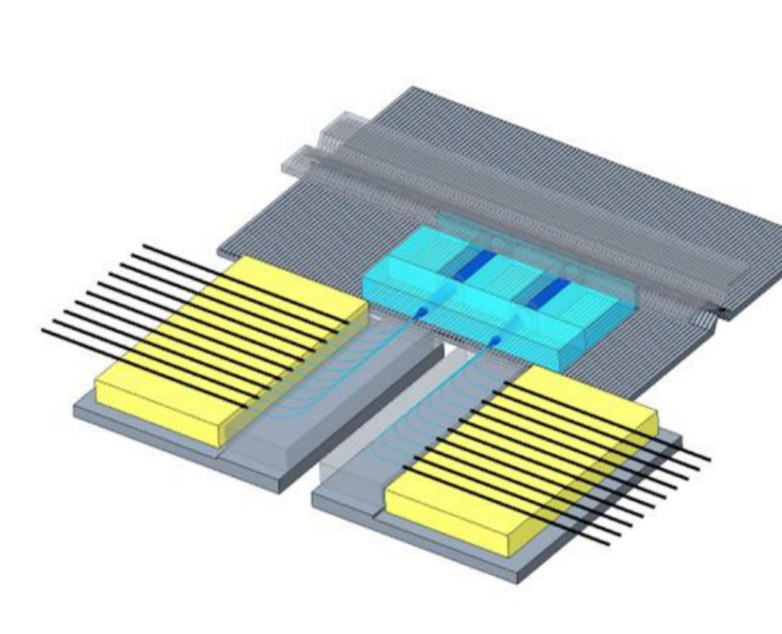
GEN2: integrated addressing unit
- Waveguide and microlenses assembled onto ion trap chip
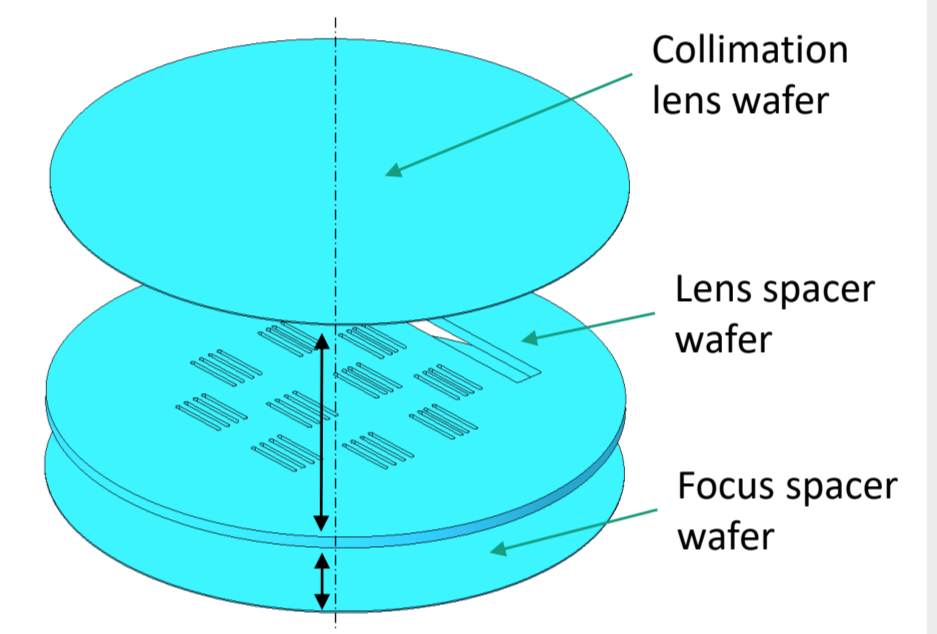- Microlenses pre-assembled using wafer stacking process

Specifications:
- Spot size: 2 µm, spot distance: ~ 5 µm, wavelength: 400 nm
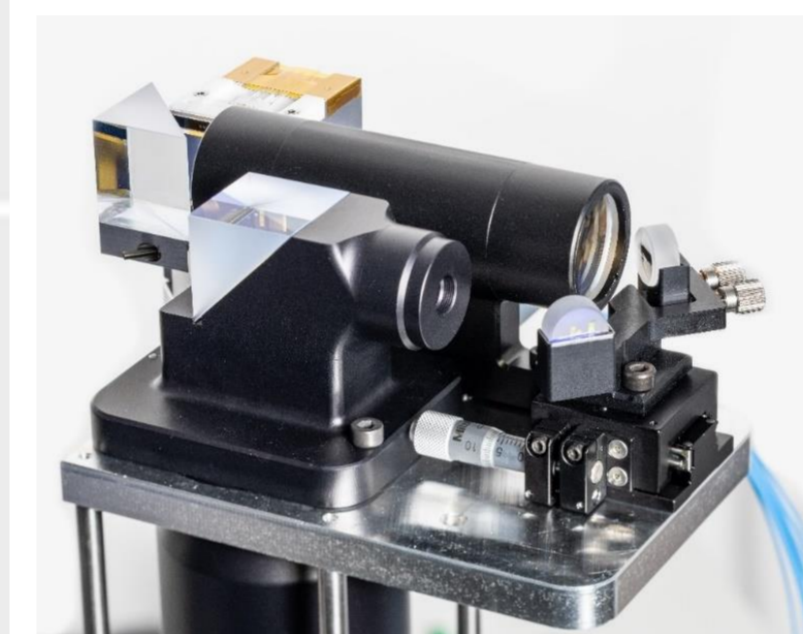
GEN1: Addressing unit

GEN2: Integrated unit

Collimation lens wafer
Lens spacer wafer
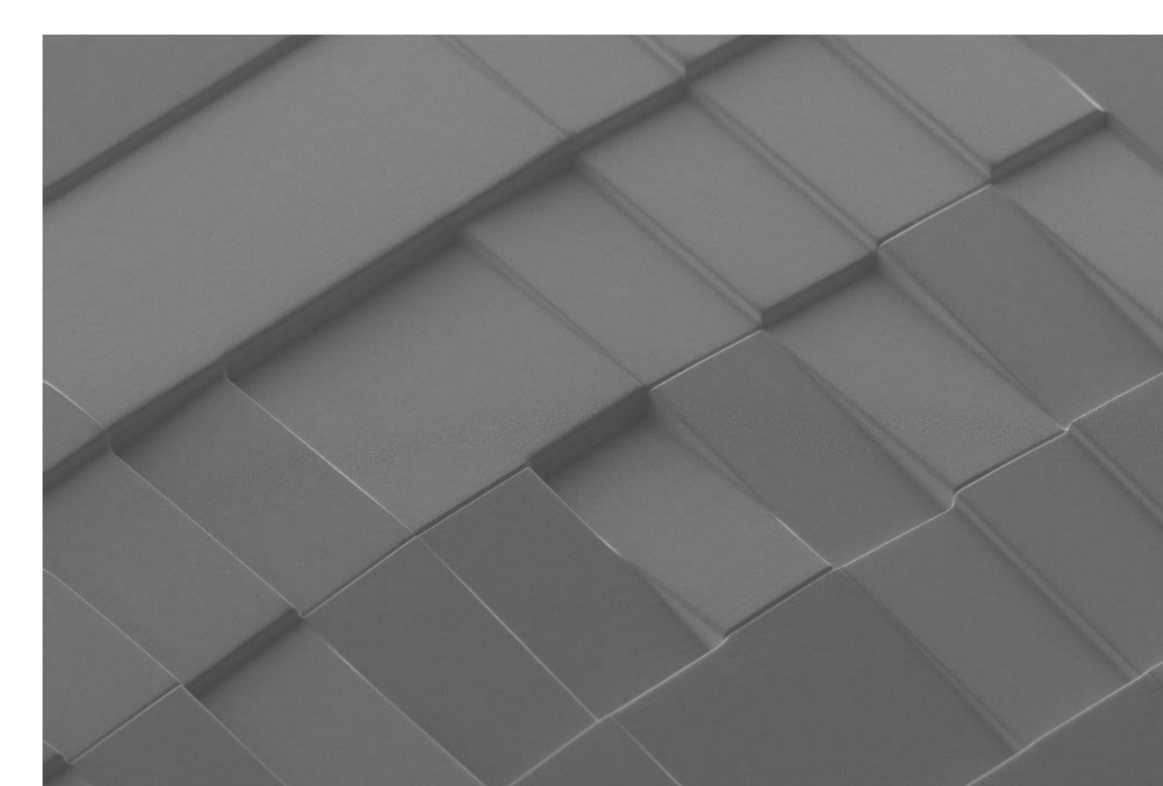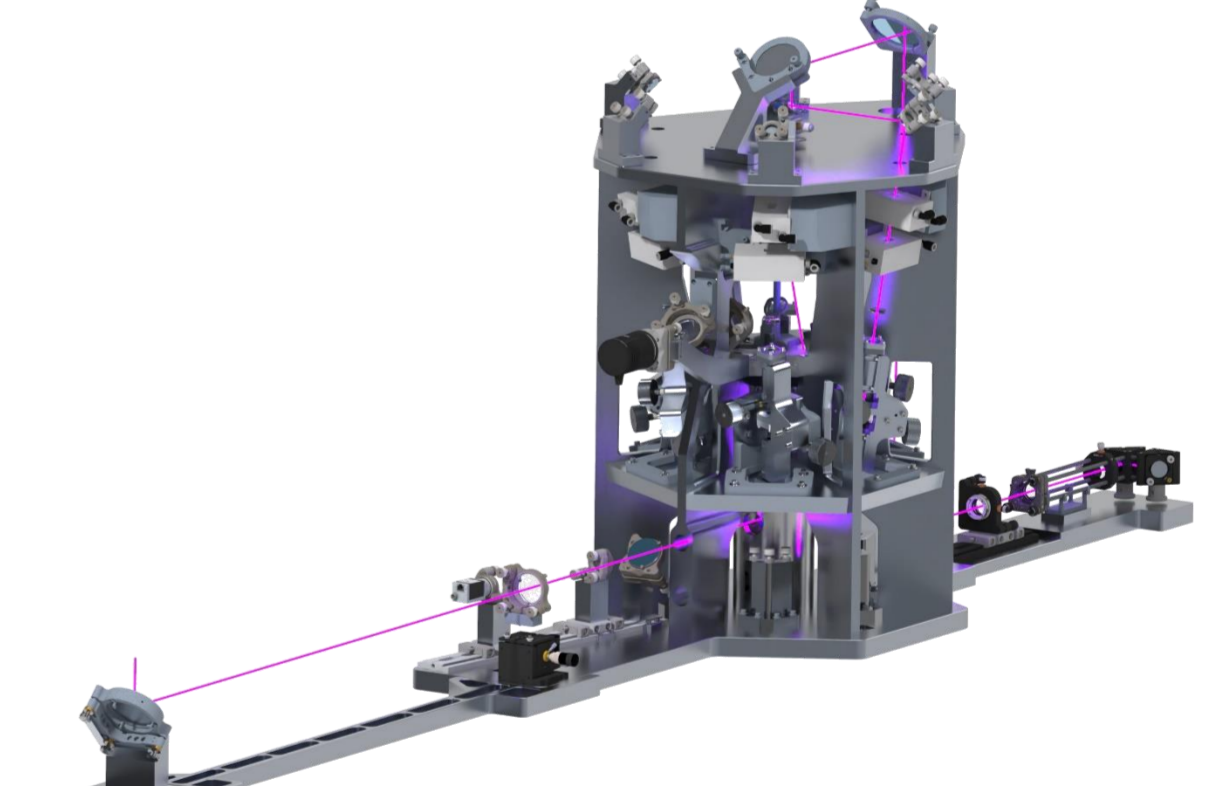Focus spacer wafer
GEN2: microlens stacking

4 Atom addressing unit (FermiQP)

Specifications:
- Addressing for 400 lithium atoms
- Telecentric imaging with analog micromirror array
- Diffractive beam splitter for splitting into 6 sub-beams
- Wavelength: 323 nm, spot size: 0.4 - 1 µm (customizable)

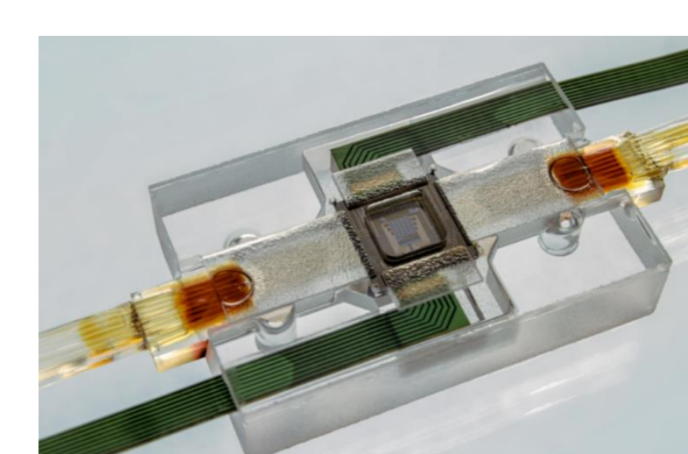*Mirror array with individually tilted 50 x 50 µm² micromirrors*

Design of the FermiQP structure

5 Development of integrated systems

Objective:
- Integrated scalable addressing units using integrated photonics (PICs and micro-optics)

SiN-QPIC for neutral atom manipulation
Integrated in SLE-structured, hermetic glass package, optical fibers and electronics

For inquiries, email us at experts@module-qnc.de