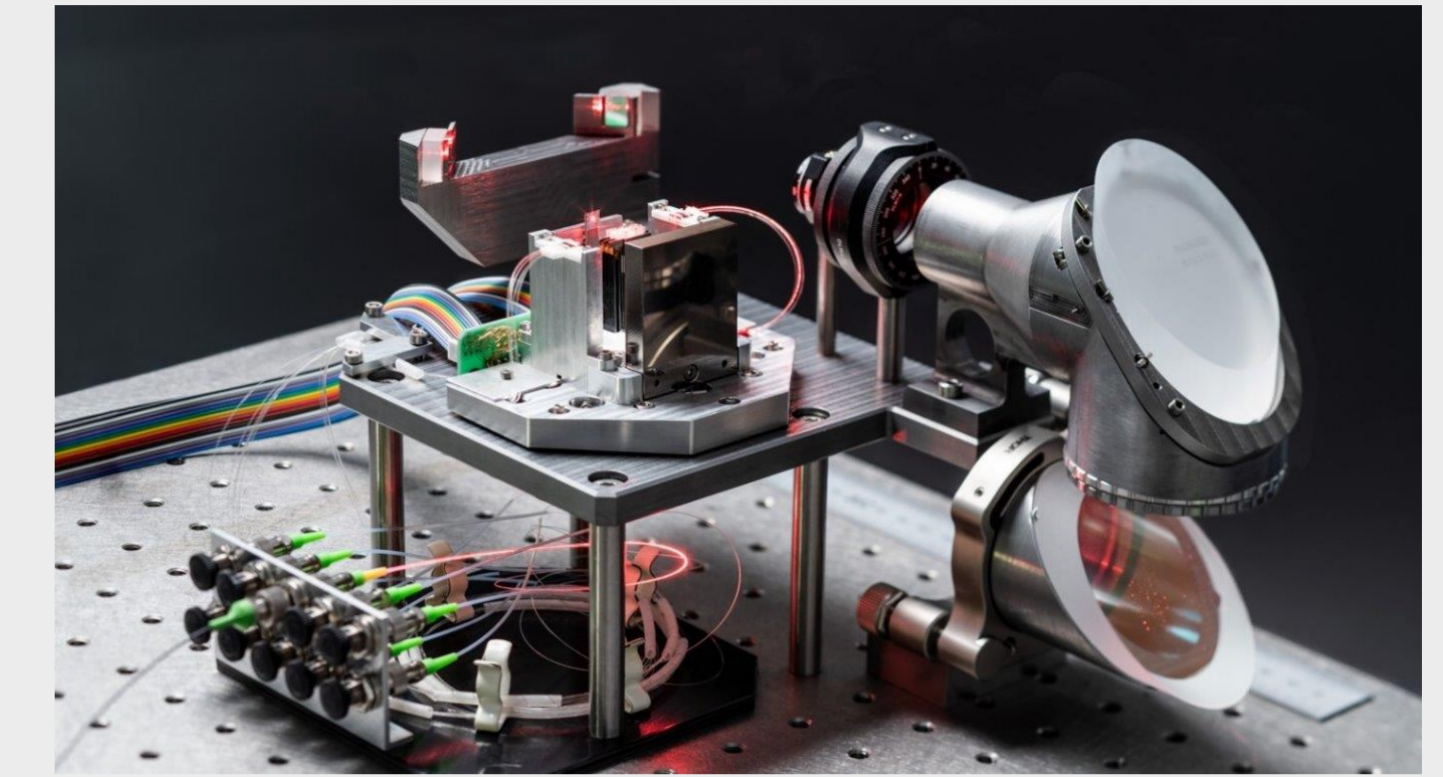


Optical actuation and control systems

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)



SiO₂ Etched ion trap

2 Technology

Optical and mechanical design

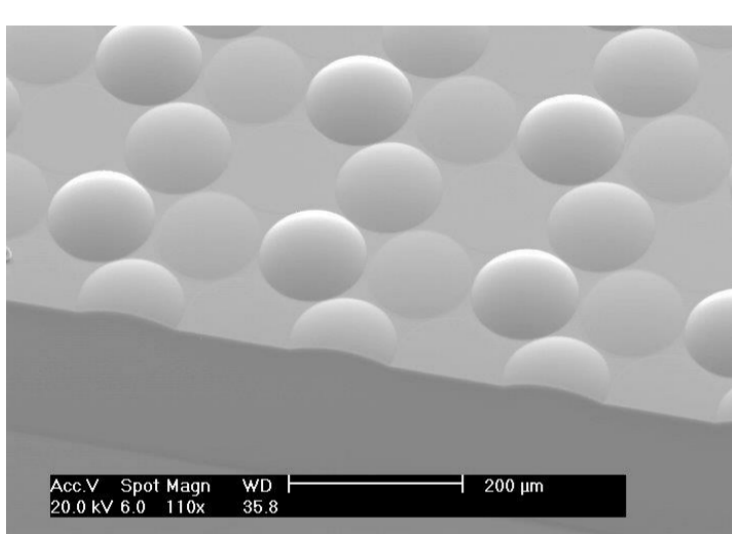
- Zeemax and Lumerical simulations
- Multi-physics finite-element analysis



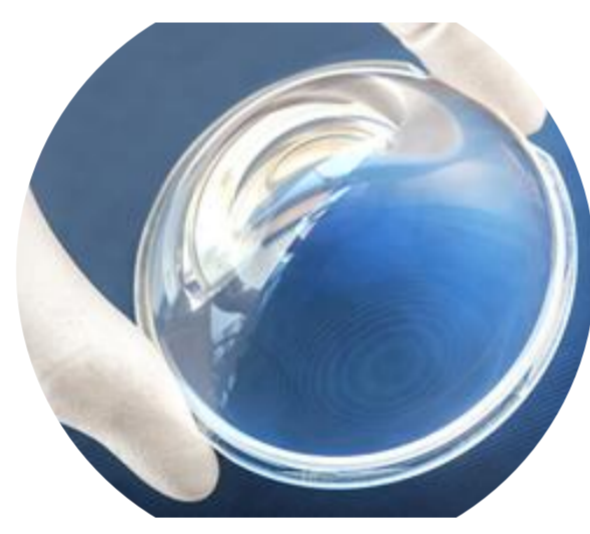
Combined mechanical and optical design

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

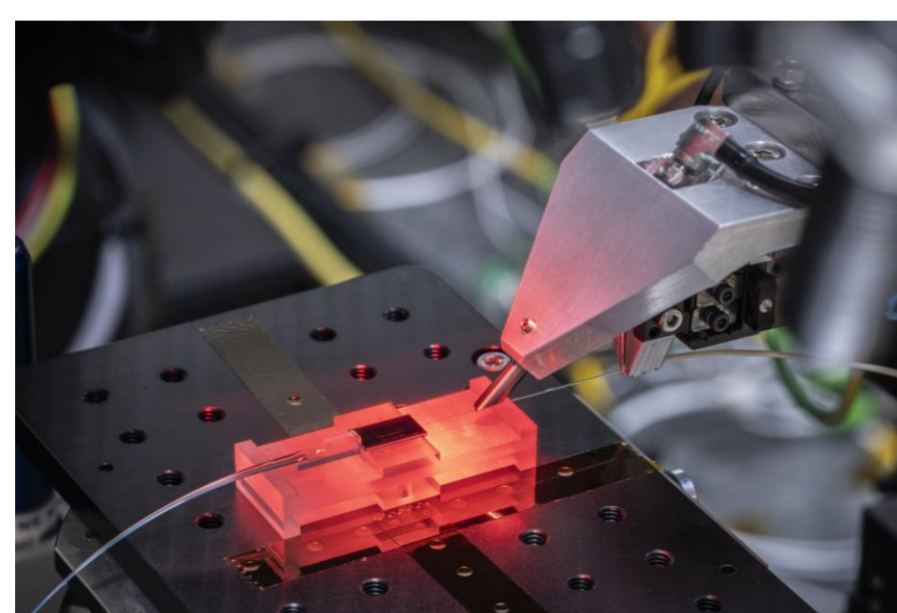


Anti-reflective coating

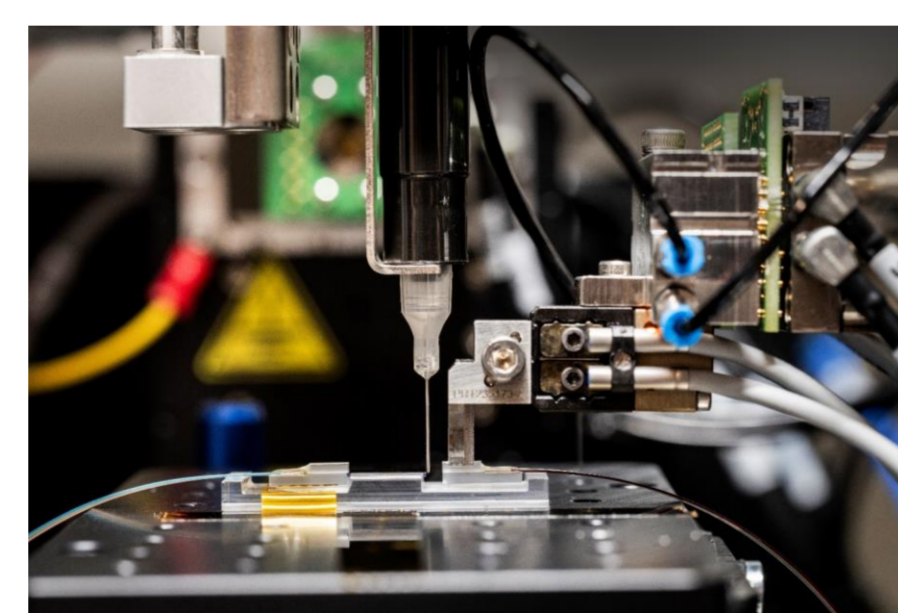
MLA with different focal lengths

Integration

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



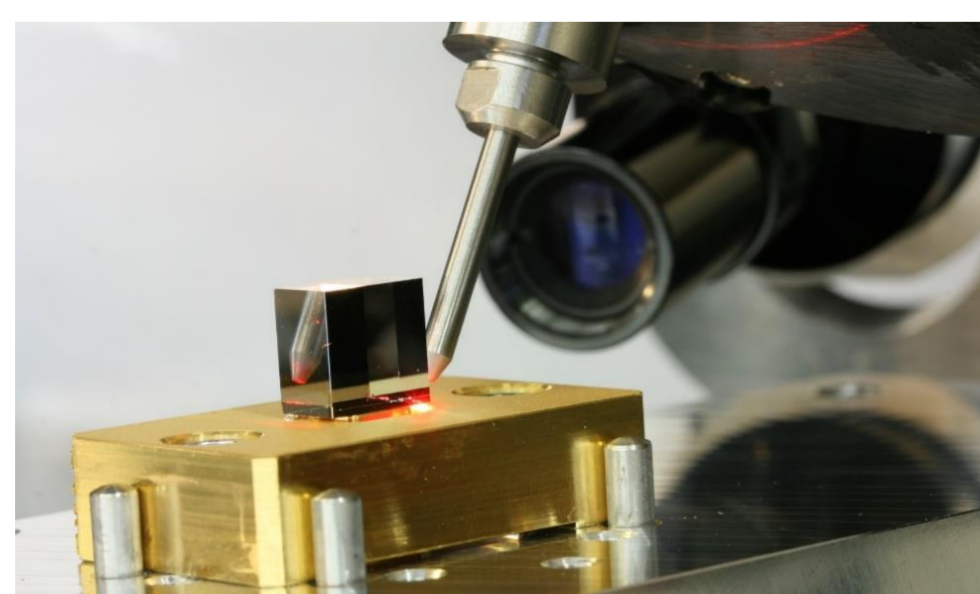
Single fiber alignment



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

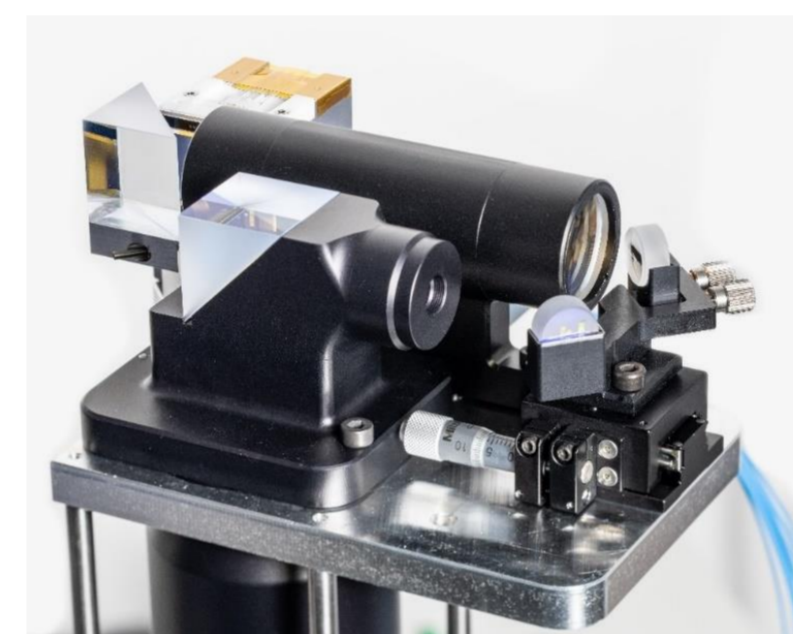
- Parallel manipulation of 10 ions lined up next to each other
- Fiber-coupled waveguide as input, collimated with microlens array

GEN2: integrated addressing unit

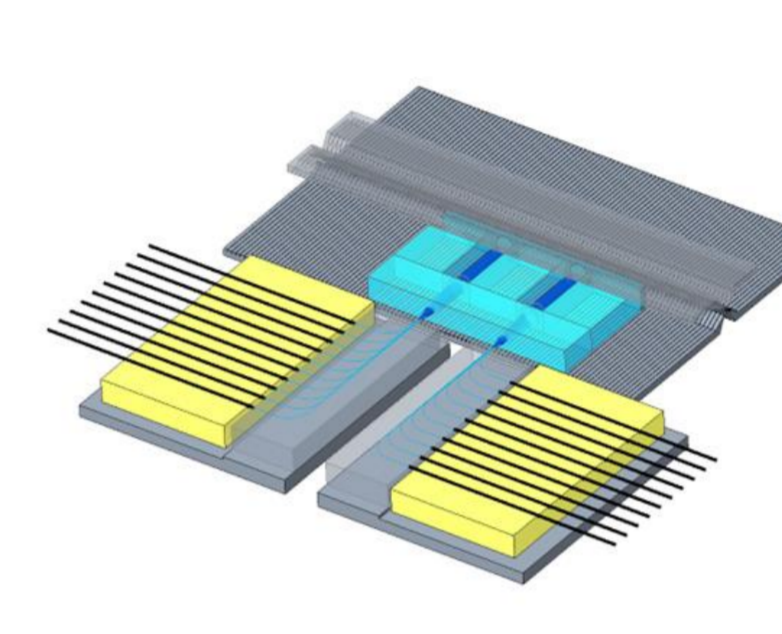
- Waveguide and microlenses assembled onto ion trap chip
- Microlenses pre-assembled using wafer stacking process

Specifications:

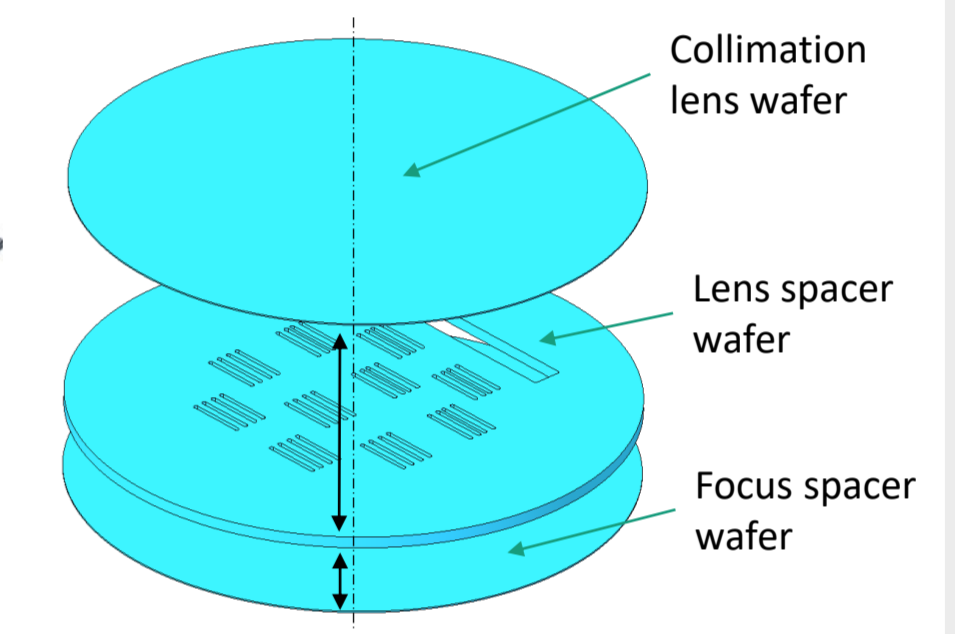
- Spot size: 2 μm , spot distance: \sim 5 μm , wavelength: 400 nm



GEN1: Addressing unit



GEN2: Integrated unit

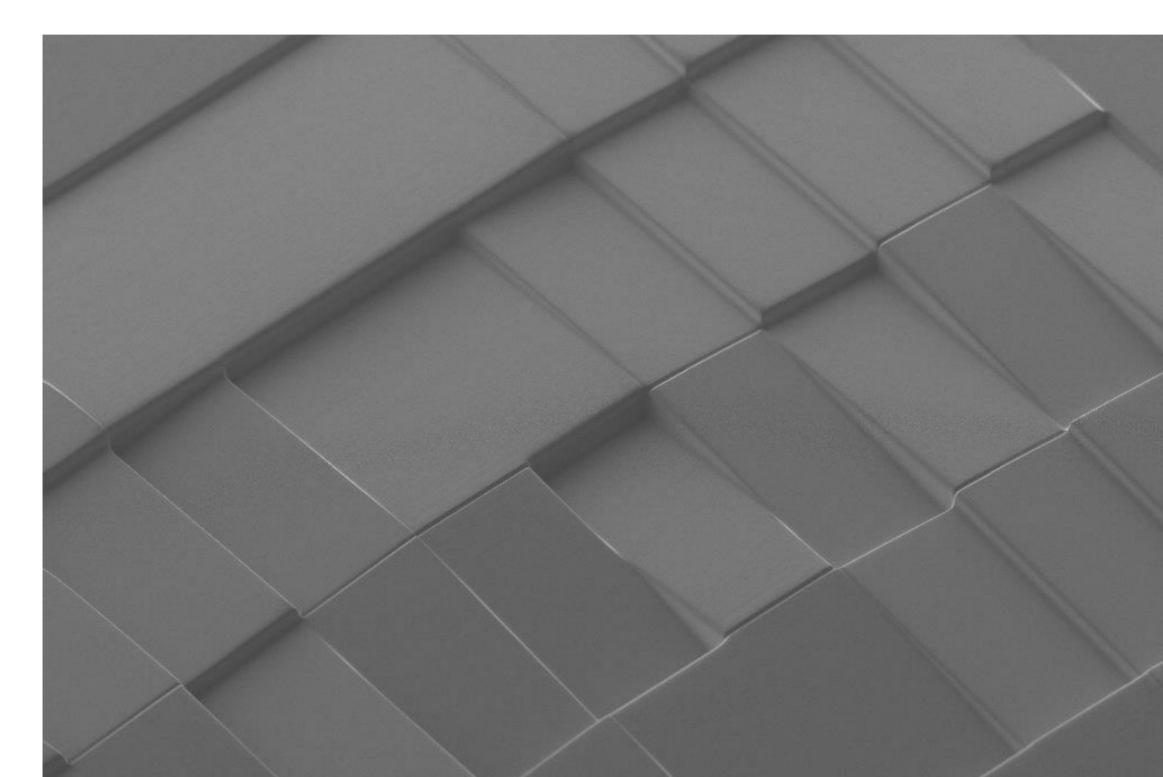


GEN2: microlens stacking

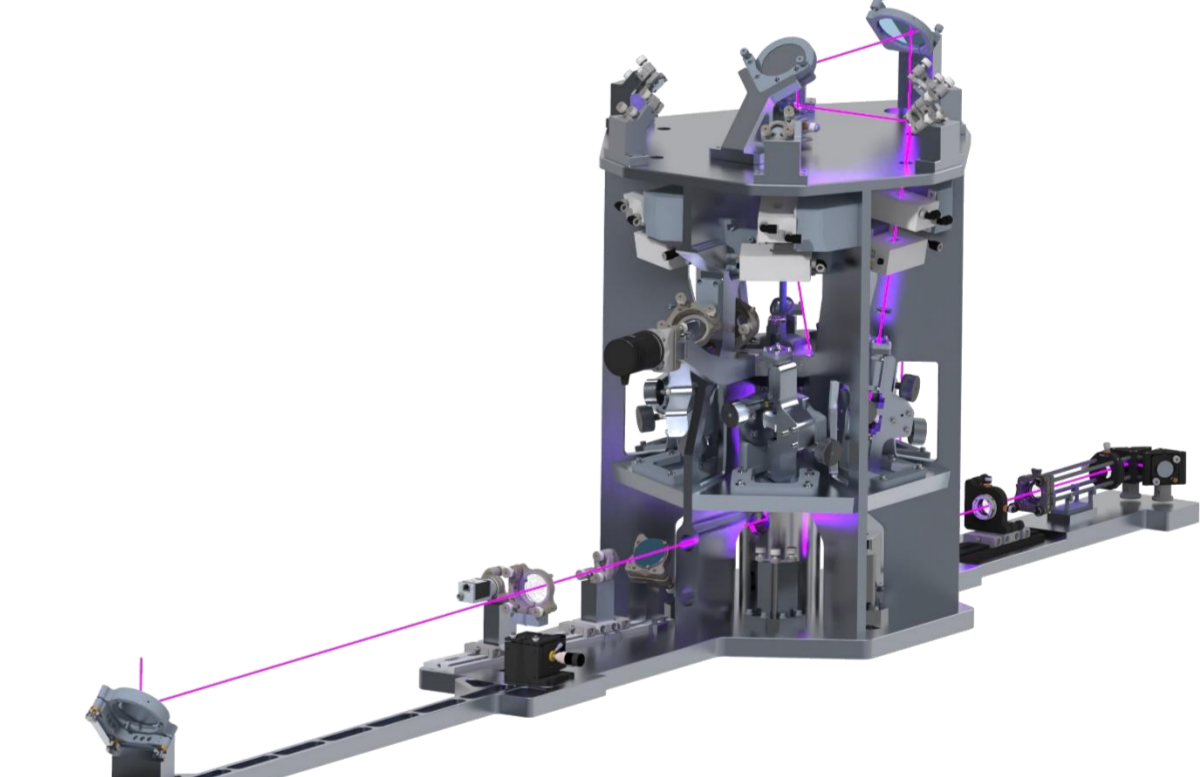
4 Atom addressing unit (FermiQP)

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 μm^2 micromirrors

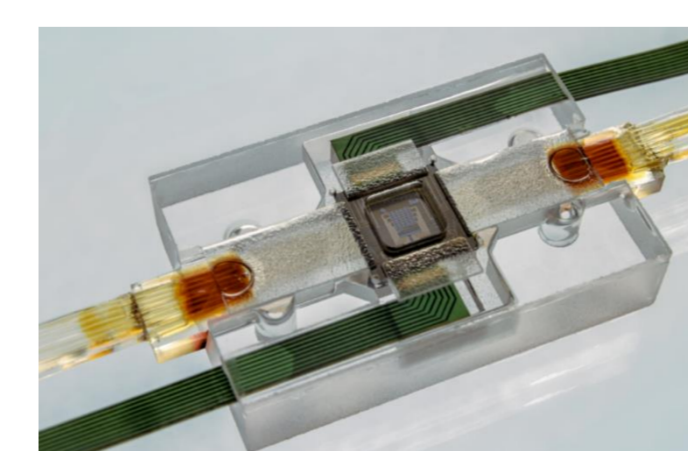


Design of the FermiQP structure

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



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