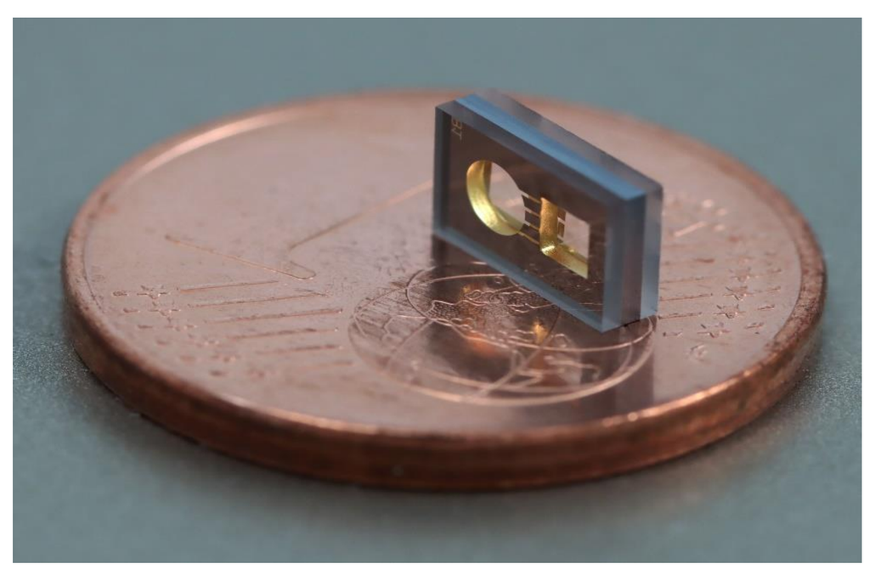
Packaging of macro- to micro-optical superstructures

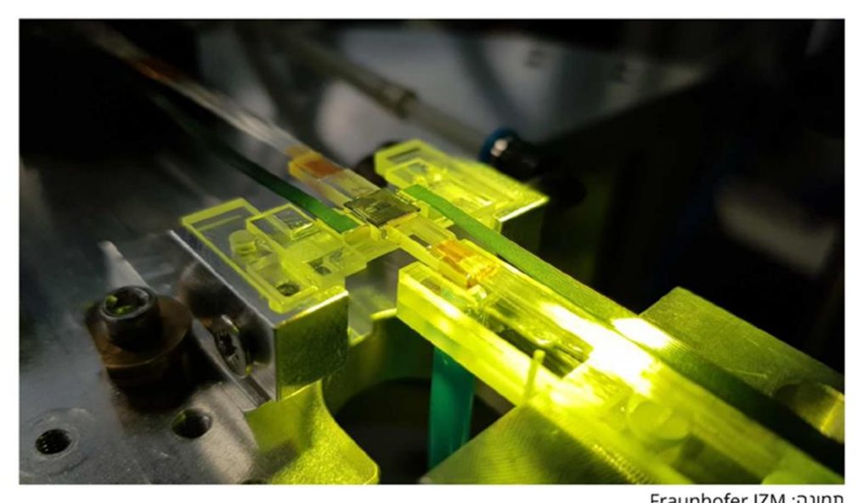
1 Application

- Production of "chip-size" and hybrid integrated physics packages
- Vacuum-sealed macroscopic cells for quantum sensors in glass
- Substrate materials for quantum Computing Applications (LNOI)
  → stable assembly of heterogeneous material systems
- Miniaturized and robust light sources and light control units for optical quantum technologies



2 Packaging and integration technology

- Bonding methods for different material classes & coatings
  - Anodic bonding
  - Plasma-activated bonding
  - Silicate bonding
  - Hermetic Glass – Glass bonding
- Structuring methods
  - Deep reaction ion etching (DRIE)
  - Laser drilling of Si wafers
  - 3D printing of ceramics and metals
  - Lithography (e-beam, gray tone)
  - Selective laser assisted etching (SLE)



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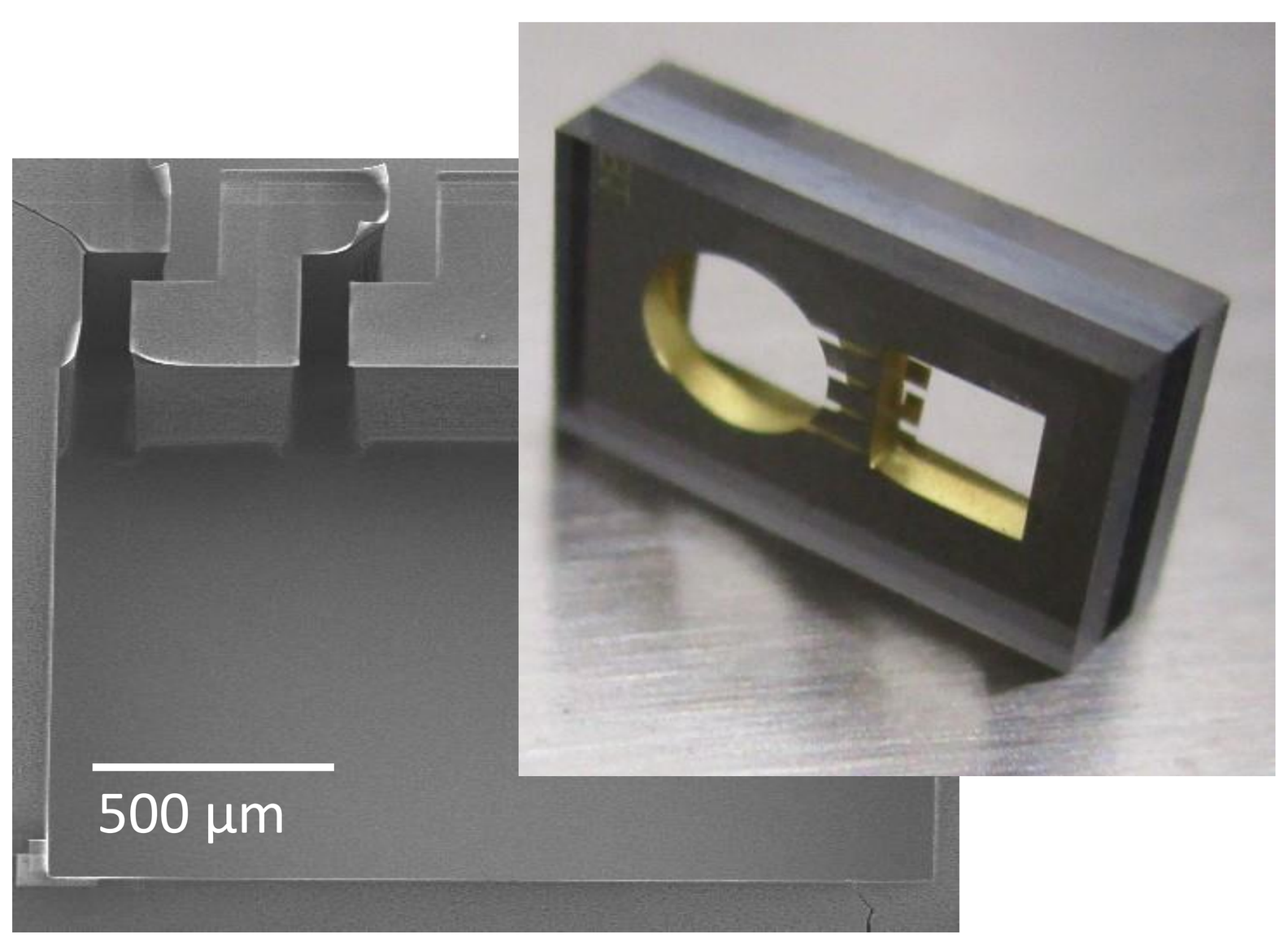
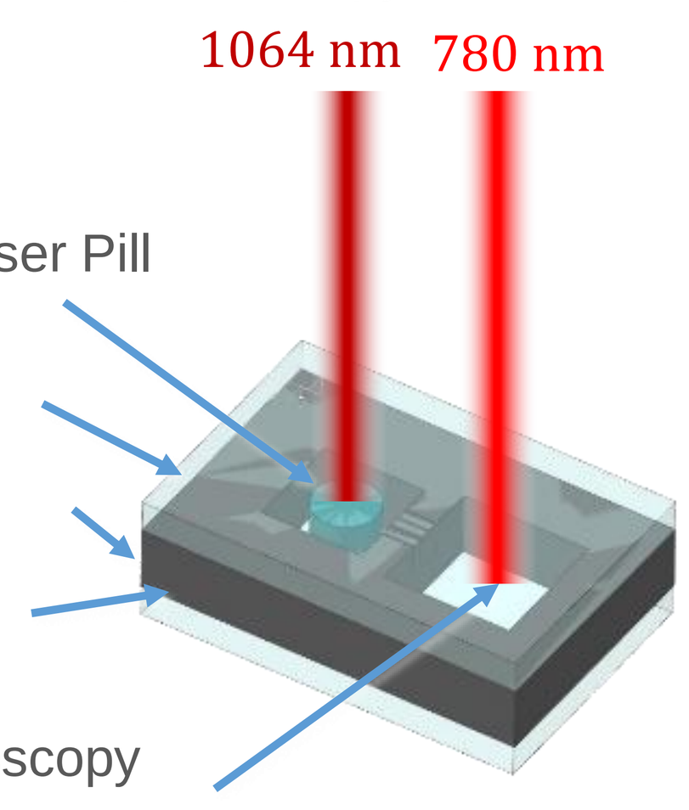
3 Example: MEMS-based micro gas cells

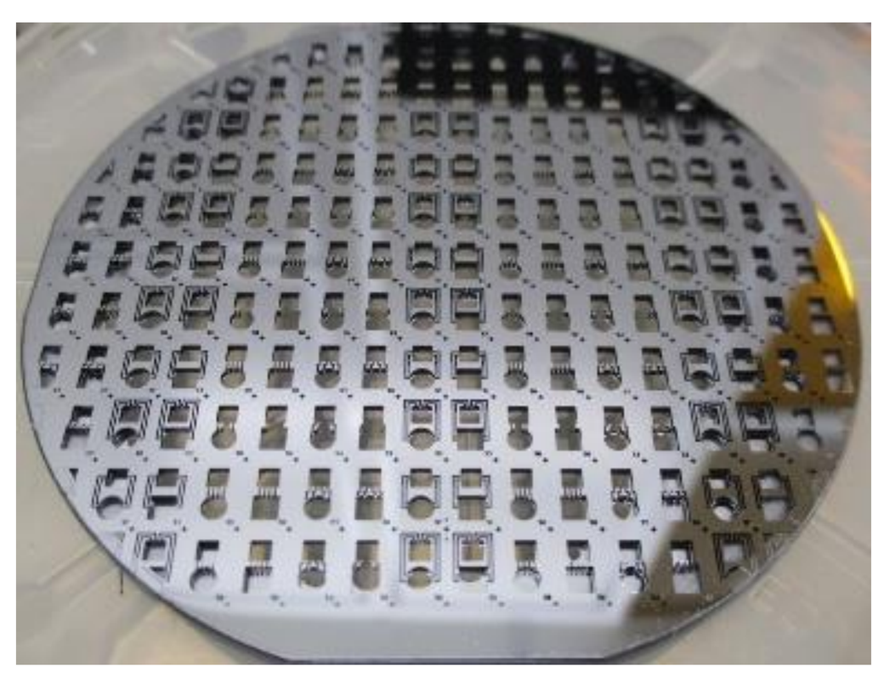
- Etching of cavities and microchannels in Si wafers.
- Bonding of glass wafers onto Si wafers under vacuum.
- Insertion of alkali atoms (dispenser pills).
- Wafer bonding and integration of macroscopic components: coated and uncoated, as well as structured and unstructured substrates

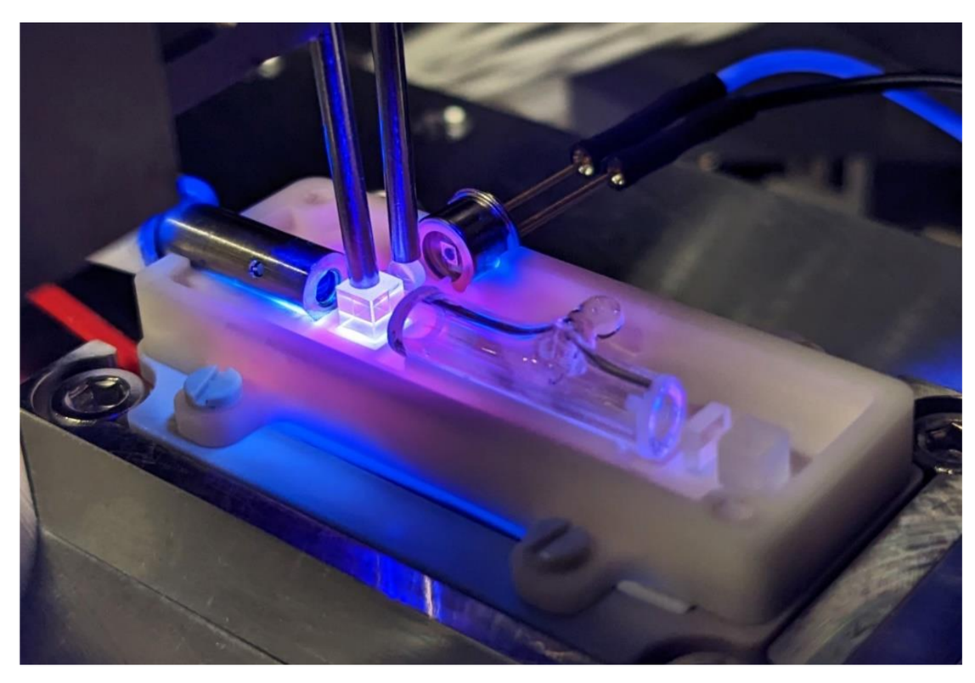




4 Specifications

- Geometry: Wafer up to 12" diameter; thickness up to 70 mm
- Bonding materials: Glass (silica glass, borofloat), silicon, GaAs, lithium niobate, etc.
- Ceramic 3D printing: Lithography-based printing process with 40 µm lateral resolution and 10 µm layer thickness, installation space 102 x 64 x 320 mm (Al_2O_3, ZrO, AlN)
- Powder bed based laser melting of metals (SS 316L, $AlSi_{10}Mg$, Ti_6Al_4V)
- Micro-positioning systems with 6 degrees of freedom (1 µrad, 1 nm) for hybrid integration of micro-optical systems





5 Summary and outlook

- Combination of different processes from MEMS and semiconductor technology as well as additive manufacturing
- Hybrid microintegration of complex photonic modules (lasers and light control units)
- Automation of manufacturing processes for scalable production of photonic modules for quantum computing with neutral atoms and ions

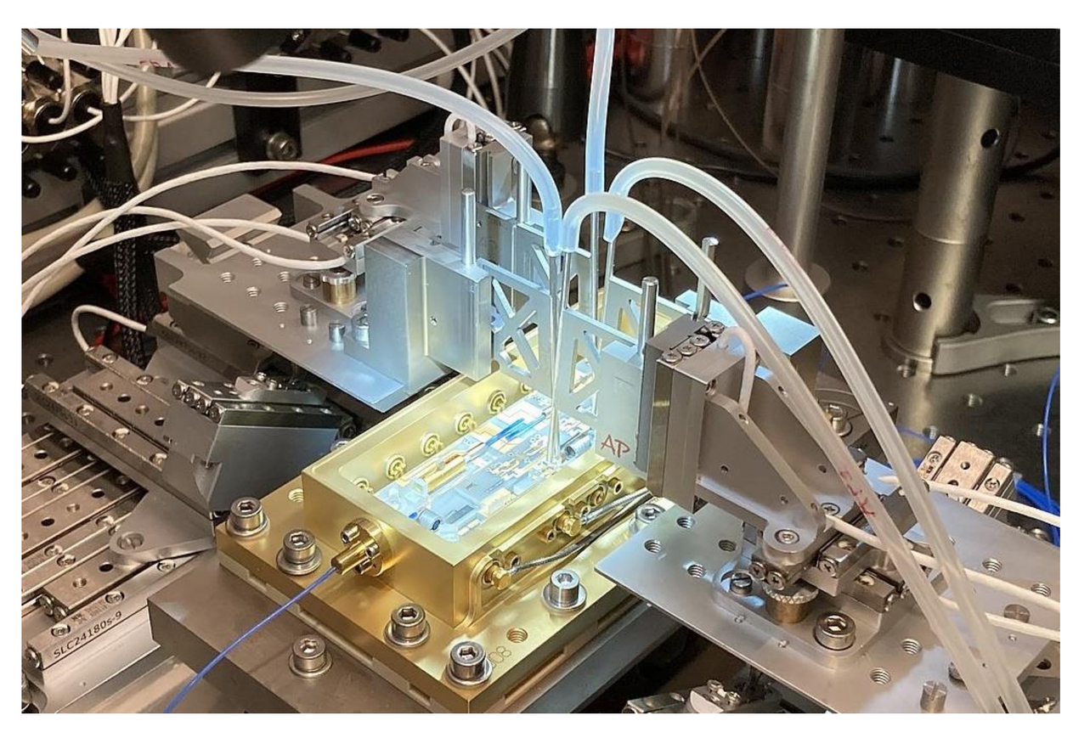


Photo: J. Baumann, FBH

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