qnc.space

Ion-QC

Innovative scalable optical connections for ion-based quantum computing

Steffen Sauer, Technische Universität Braunschweig, steffen.sauer@tu-braunschweig.de
Dr. Vanessa Zamora, Christian Janeczka, Fraunhofer IZM, alethea.vanessa.zamora.gomez@izm.fraunhofer.de
Dr. Stephan Suckow, AMO GmbH Gesellschaft für Angewandte Mikro- und Optoelektronik mbH, suckow@amo.de

1 Motivation

- Quantum computing (QC) applications strongly dependent on the number of qubits
- Qubits demand a large number of laser sources, optical fibers & light conditioning at UV-VIS-NIR

➔ **Scaling** of quantum processor chips

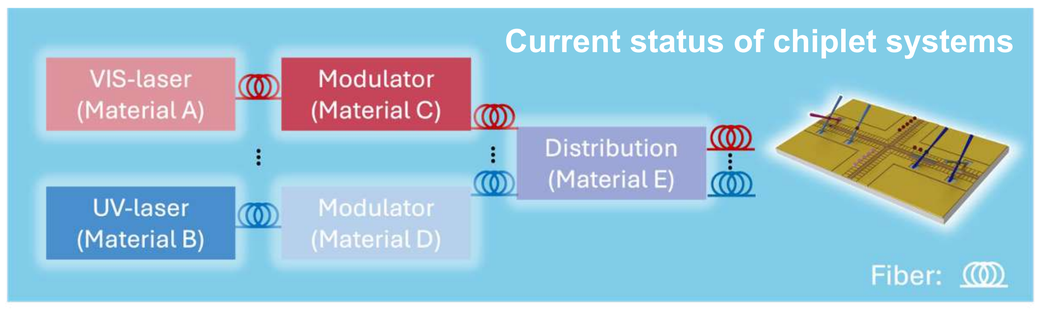
Current limitation:

- Current free beam setups take up a large amount of space
- Integrated photonics require different dimensions and materials depending on the wavelength and application (e.g. light distribution, modulation, laser)
- Chip-based quantum systems connected by fibers (> 30 cm in length & costly)
- Photonic wire bonds (PWBs) have achieved attractive coupling losses of <2 dB, but have so far been limited to the C-band of telecommunications

➔ **Future compact and scalable quantum systems cannot be realised**

Main goal: Develop 3D printed optical interconnects for quantum photonics chiplet systems from the telecom band into the UV-VIS-NIR range

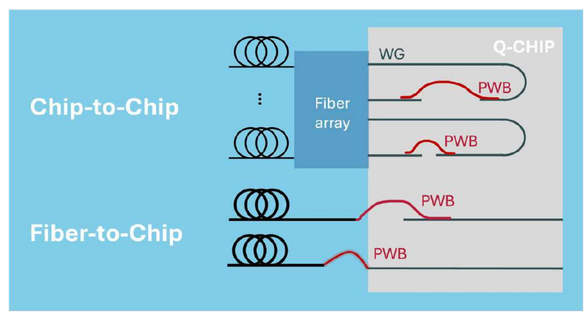
2 Innovation



Targets in Ion-QC:

1. Optimization of the coupling structures in silicon nitride platform for **better coupling loss (0.5 dB) using PWBs** for VIS-NIR range
2. First interconnected **Q-Chip demonstrator** with coupling efficiency of > 70 % for VIS-NIR range
3. Identification and implementation of initial tests to verify **a free-form structure with UV photoresists**

Compact and efficient UV-NIR connections for QC-systems via PWBs

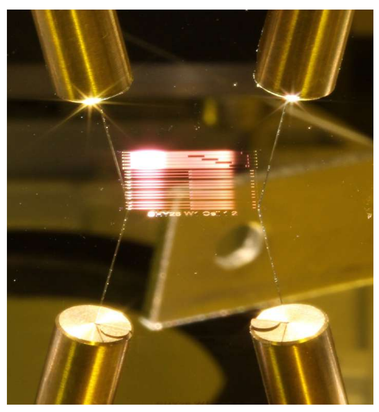


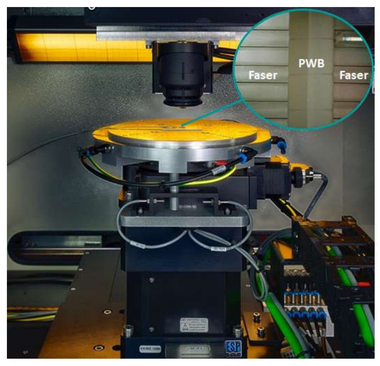
3 Future performance profile & skills of the project partners

AMO GmbH
New process as a building block for contract research via the AMO Services and research projects: efficient fiber-chip coupling is a recurring problem, where an established solution with IZM can help our research and customers

Fraunhofer IZM
Extension of fiber interconnects and photonic packaging know-how to quantum computing and later to other applications, where scalable and compact connections via **two photon polymerization** (2PP) technology, e.g. PWB and micro-optics, can be developed and offered to German and European customers

Technische Universität Braunschweig
Provision of highly efficient optical connections in the UV-NIR range for the **scaling up ion-based quantum computers** and other **quantum technologies**





4 Prospects

When feasibility is demonstrated:

- use of PWB connections for application-orientated **follow-up projects**, e.g. for ion trap QC with industrial partners
- implementation of PWBs for e.g. **biosensor technology, spectroscopy** and **AR glasses in VIS-NIR**, also with integrated photonics: follow-up projects and services offered by Fraunhofer IZM
- Extension to other disciplines of quantum technology:
  - **Quantum Sensing** mit neutral atoms
  - Next-generation ultra-stable & compact cavities: **MightyMirror** *(*ERC-Consolidator Grant of Prof. Kroker @TUBS)

AMO
Fraunhofer IZM
Technische Universität Braunschweig
Nitride Technology Center
LENA Laboratory for Emerging Nanometrology
Institut für Halbleitertechnik
SPONSORED BY THE
Federal Ministry of Education and Research