

Glass packaging for ultra-low-loss fibre couplers / NULL Coupler

Low-loss null-couplers for fibre-based quantum information processing

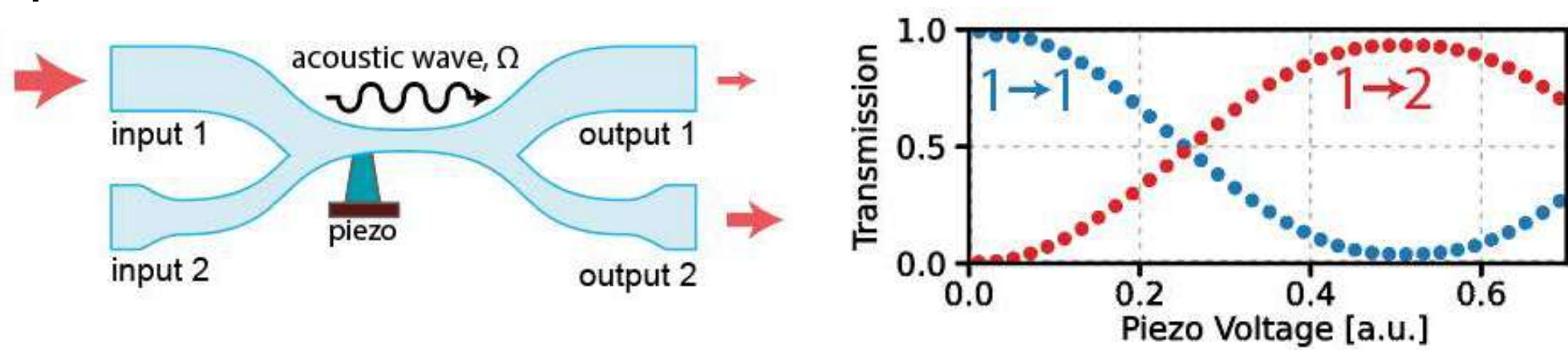
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1 Motivation

Quantum computing (QC) requires more qubits to improve the efficiency of quantum algorithms and for error correction. Since the necessary scaling of quantum processors cannot be achieved by increasing the number of traps for neutral atoms or ions, multiple processors must be interconnected. This will require the realization of:

- **Ultra-low-loss** fibre components such as switches, couplers and filters
- **System integration** and software control of such fibre optic-based interconnect component

So-called **NULL Couplers** offer a solution to this issues by providing packaged low-loss fibre couplers and switches, in which the splitting ratio can be controlled by exciting propagating acoustic waves along the coupler's waist with a integrated piezoelectric actuator.



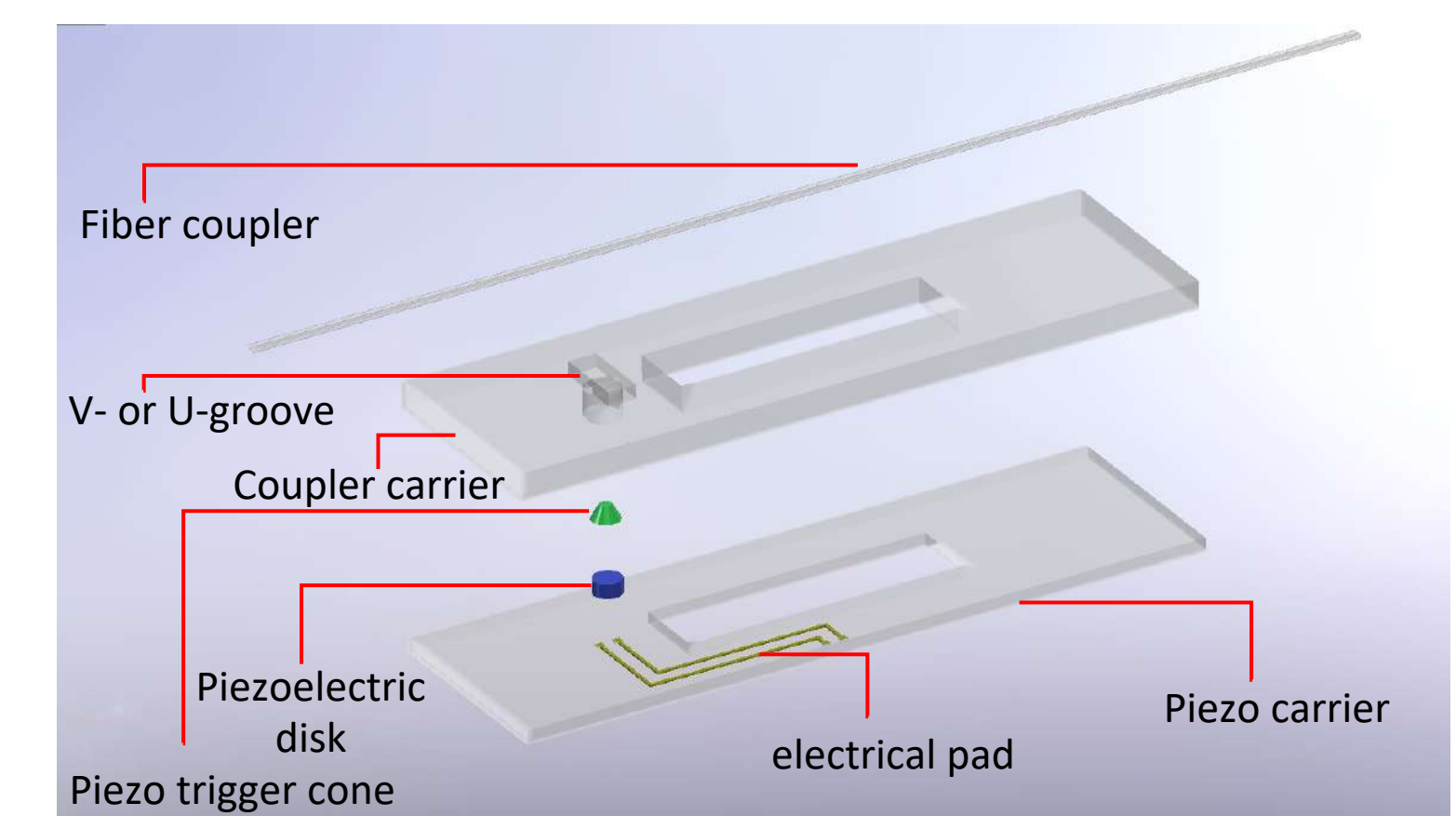
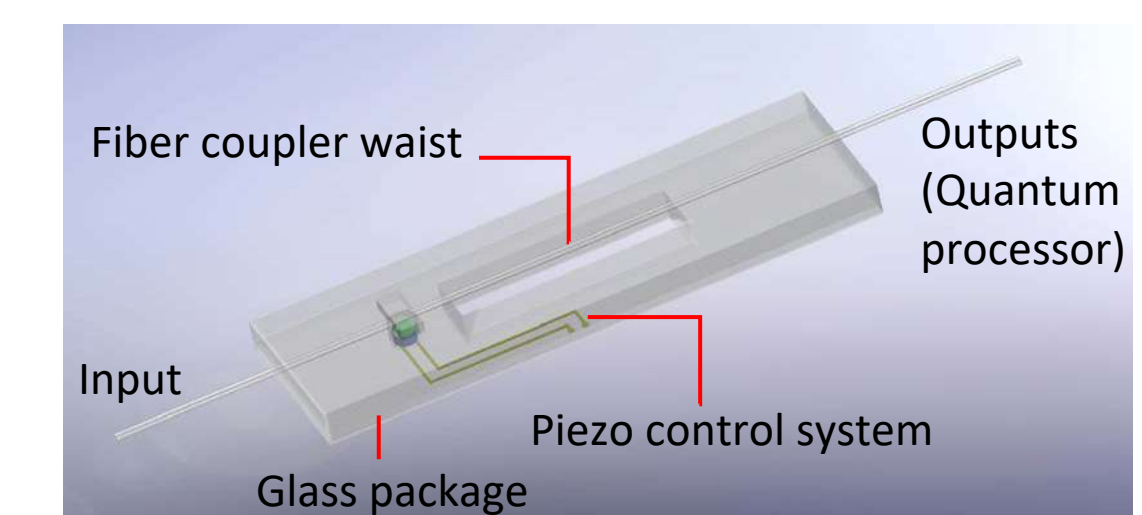
2 Innovation

The optimal functionality and compactness of the proposed coupler will be achieved by the use of:

- **Fusing and tapering** process to produce 2x2 couplers with 2-3 cm in length and 5 μm in diameter
- **Glass platform** to package such couplers via high precision selective laser-induced etching (SLE) & cutting (QNC-05 MDI TGS-650 machine)
- High-performance **piezoelectric integration** on glass

The specifications of **NULL Coupler** are:

- Microcavities with roughness of $< 1 \mu\text{m}$ to ensure stable piezo operation
- Curved cuts with extremely flat facets and an accuracy of $\pm 25 \mu\text{m}$ to increase reliability & manufacturability
- Packaged coupler with insertion loss below 0.05 dB and long working lifetime (> 5 years).



3 Future performance profile & skills of the project partners

Fraunhofer IZM

Skills: Packaging of micro-optic and optoelectronic components in glass based packages with low loss optical fiber interconnects

In NULL Coupler:

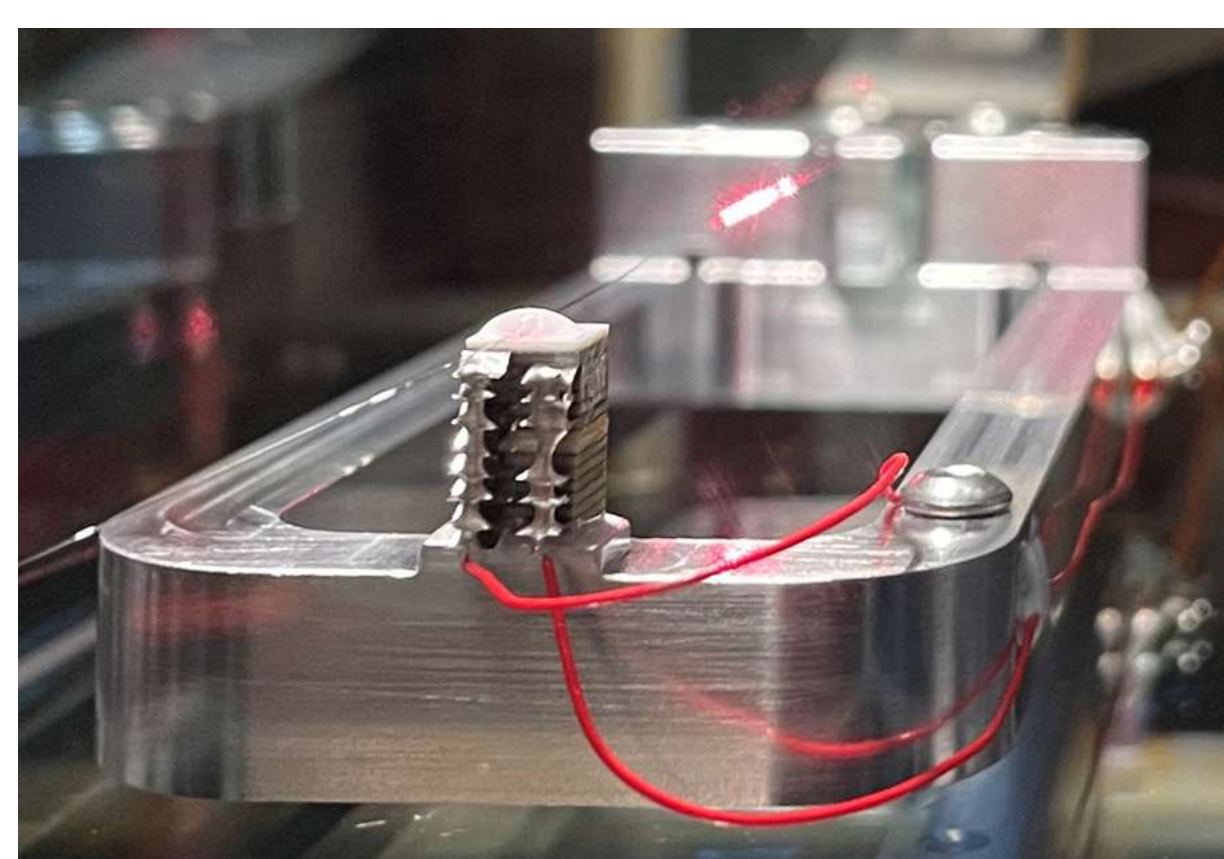
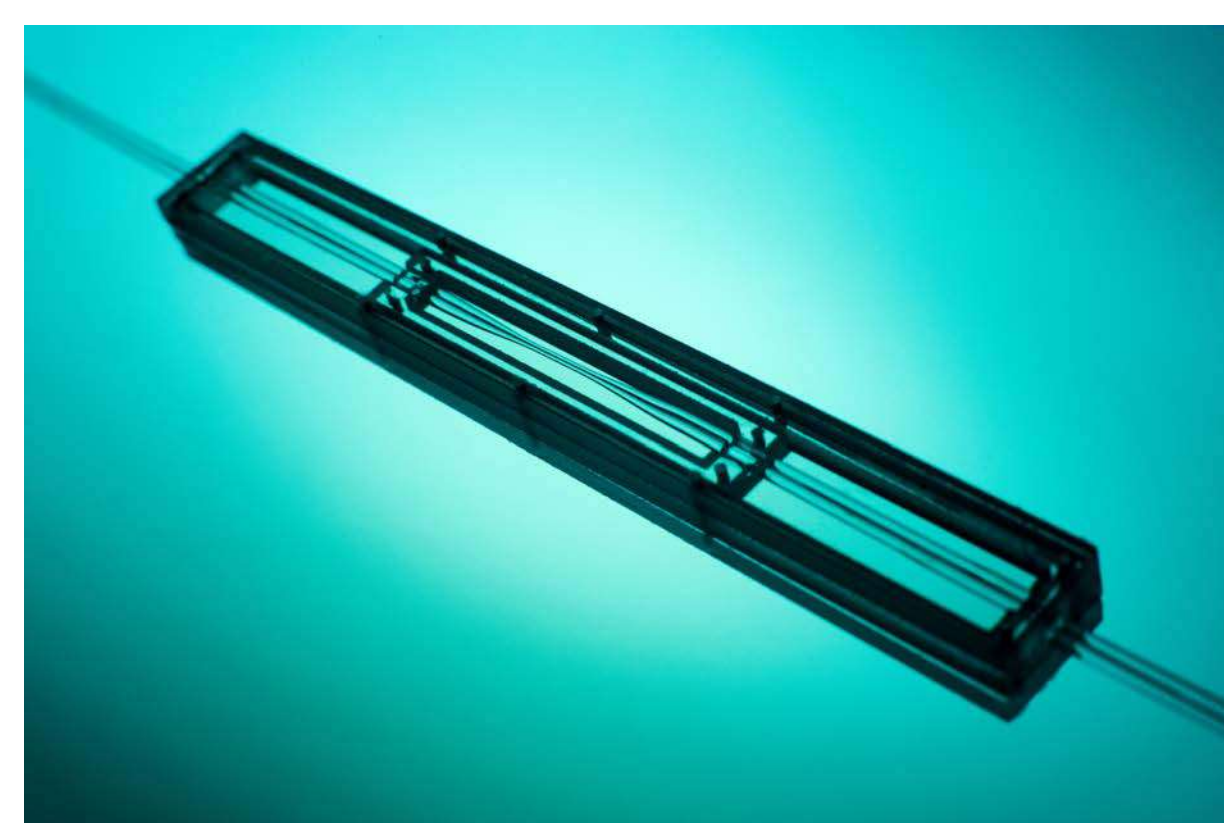
- High-precision structuring and cutting for glass stacking with U- or V-groove structures
- Integration of a piezoelectric actuator and coupler on glass

Humboldt University of Berlin

Skills: Fabrication of fibre couplers in the laboratory for cold atom experiment

In NULL Coupler:

- Production of 2x2 couplers via fusion process
- Acousto-optical characterisation of packaged couplers



4 Prospects

After **NULL Coupler**:

- Packaged couplers will be integrated into an existing cold atom experiment at HUB to demonstrate the generation of non-classical states of light by the Rauschenbeutel group
- Establish collaborations with industrial partners interested in low-photon-loss QC applications for testing
- Development and transfer of a unique production process to reduce the cost of QC infrastructure
- German suppliers of fibre-optic components to benefit from volume production of state-of-the-art optical communication over glass platform