Highly integrated low-noise quantum frequency converters

Quantum internet

Quantum computers promise a revolution in information processing. The entanglement of such computers in a quantum network increases their computing power in a superlinear fashion and allows users inherently secure access to such a network with comparatively simple end devices and over long distances. As part of scientific research projects, leading development teams around the world are competing to build the first network demonstrators. Quantum information is exchanged by means of single photons via optical fibers. Quantum frequency converters (QFC) convert the wavelength of the photons into the telecom band and are required to transmit these with low loss in optical fibers. The decisive factor here is the best possible signal-to-noise ratio (SNR). For the entanglement exchange between nitrogen vacancies in diamond, so-called NV center qubits, Fraunhofer ILT has already improved the state of the art in SNR by two orders of magnitude with the so-called NORA QFC. The Fraunhofer ILT technology is currently also being used by QuTech for the entanglement exchange between Delft and The Hague.

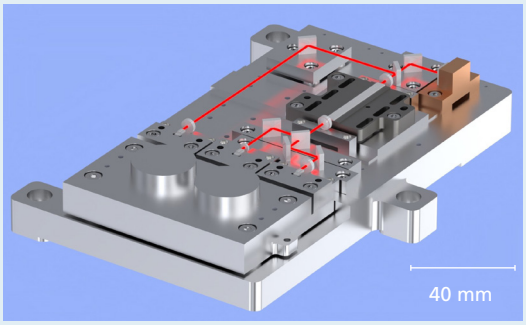
Next generation quantum frequency converter

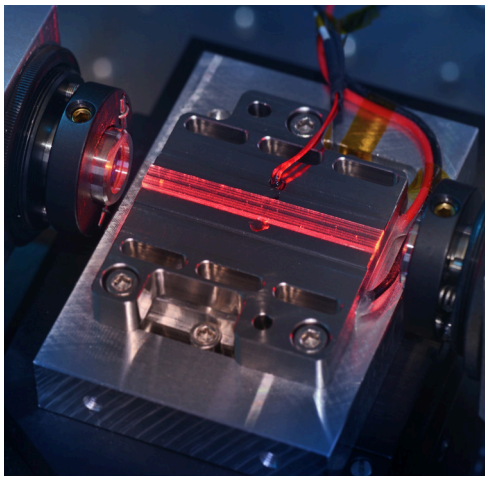
In the BMBF project HIFI (FC 13N15925), Fraunhofer ILT is now working with partners from industry and research to develop an alternative QFC concept that can be implemented in large quantities in the future in a less costly and highly integrated manner. The converter is based on non-linear optical difference frequency generation in periodically poled lithium niobate waveguides. What is new is that the conversion from 637 nm to 1587 nm with a laser wavelength of 2128 nm is implemented as a two-stage process within a single non-linear device. This innovation makes it possible to reach good efficiency (26 percent) and very low noise (2.2 Hz/pm) in a very small installation space. The performance thus approximately reaches the level of the NORA QFC and shows further potential for optimization.

Closing in on commercial use

By combining a compact design and very low noise, the partners have developed new QFC technology that is an exciting prospect and approaching market implementation. To this end, Fraunhofer ILT is now establishing the system technology as part of the HIFI project to develop the necessary manufacturing processes on site in Aachen together with the partners..

Author: Hans Huber M. Sc., hans.huber@ilt.fraunhofer.de





1 CAD model for integrated implementation.
2 Laboratory setup.