

Energy-efficient quantum communication eye transducer



Overview

High-efficiency microwave-optical quantum transduction based on a. In this paper, we propose a high-efficiency, low-pump-power quantum transducer based o.

Key Takeaways

Recent advances in quantum transducers enable energy-efficient conversion of microwave photons to optical photons, crucial for scalable quantum communication networks. Overview of Quantum Transducers

Quantum transducers are devices that convert quantum information between different physical carriers, such as microwave photons used in superconducting qubits and optical photons suitable for long-distance fiber-optic transmission. This conversion is essential for building distributed quantum networks, allowing quantum computers in different locations to communicate efficiently.

Mechanisms for Energy-Efficient Transduction

- **Electro-Optic Transduction:** Devices exploit the Pockels effect in non-centrosymmetric materials to directly convert microwave signals into optical photons. Recent traveling-wave electro-optic modulators (EOMs) achieve broadband conversion with near-unity efficiency while maintaining tunable frequencies, overcoming bandwidth limitations of cavity-based designs.



- **Mechanical Resonator Intermediates:** Some transducers use micromechanical resonators as intermediaries, coupling microwave and optical modes via piezoelectric or optomechanical effects. These systems benefit from long coherence times, small footprints, and strong coupling rates, enabling low-noise, energy-efficient operation .
- **Material Innovations:**
 - Pure crystalline silicon transducers reduce energy loss and noise compared to piezoelectric-based devices, achieving continuous microwave-to-optical conversion at rates 100 times faster than previous technologies .
 - Rare-earth ion-doped crystals (e.g., ytterbium-171 in YVO₄) provide on-chip, low-noise transduction suitable for integration into quantum networks .
 - Lithium niobate and silicon-organic hybrid platforms enhance electro-optic coefficients, improving efficiency and scalability .

Advantages for Quantum Communication

- **Low Energy Loss:** Minimizes decoherence and preserves quantum information fidelity.
- **Scalability:** Designs using silicon or integrated photonics allow mass fabrication for large quantum networks.
- **Room-Temperature Optical Transmission:** Converts microwave qubits to optical photons that can travel long distances in fiber without cryogenic support .
- **High Bandwidth and Tunability:** Traveling-wave designs support flexible frequency conversion, essential for multi-node quantum networks .

Future Outlook

Energy-efficient quantum transducers are a key enabling technology for the quantum internet, bridging superconducting qubits and optical communication channels. Ongoing research focuses on improving conversion efficiency, reducing noise, and integrating transducers into chip-scale quantum devices, paving the way for practical, large-scale quantum communication systems .

Article Content

Microwave-to-Optical Transduction | Laboratory for Nanoscale Optics

For this application, transducers based on the electro-optic (EO) effect are promising for their direct conversion mechanism, high

Electro-optic Devices for Quantum Transduction

This dissertation describes my work towards building this microwave-to-optical transducer, pushing electro-optic modulators towards

Design and Optimization of a Hybrid Design for Quantum Transduction

This study presents the mechanical design and analysis of a quantum electro-optical transducer engineered to operate at millikelvin

Microwave-to-optical transduction with erbium ions coupled to planar ...

Interfacing superconducting quantum information processors with long-distance optical networks would require coherent interfacing

Optimized Quantum Transduction for Long-Distance Quantum Communication ...

Researchers at Stanford have developed an approach to dramatically improve the efficiency of microwave-to-optical quantum

QphoX Launches Quantum Transducer Allowing Distributed Quantum ...

QphoX has introduced a quantum transducer that connects microwave-based qubits with optical telecom networks to

Microwave-to-optical transduction with erbium ions coupled to planar ...

Efficient, low-noise, and high bandwidth microwave-to-optical quantum transducers can permit superconducting circuits

New microwave-to-optical transducer uses rare-earth ions for efficient ...

"In the context of quantum technologies, the vision is that one day we will have quantum computers interconnected in

A router for photons: Transducer could enable superconducting quantum ...

Effectively a router for photons, the transducer bridges the large energy gap between microwave and optical photons,

Quantum transducer enables optical control of a superconducting qubit

The team used the CEO-MOQT to facilitate coherent optical driving of a superconducting qubit (controlling the state of

Microwave-optical transducer efficiency boost

A record-breaking microwave-to-optics conversion efficiency of 82% over a 1 MHz bandwidth for low photon numbers is

Optical readout of a superconducting qubit using a piezo ...

Here we demonstrate optical readout of a superconducting transmon qubit through an optical fibre connected via a

Bidirectional microwave-optical transduction based on integration of ...

Here, we present a compact microwave-optical transducer based on monolithic integration of piezoelectric actuators

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This document is for preliminary research. Verify specifications against current standards, product documentation and project requirements.

