Development of superconducting high kinetic inductance devices

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Abstract: We develop cutting-edge superconducting quantum devices based on NbTiN high kinetic inductance films, such as Travelling Wave Parametric Amplifiers (TWPAs), tunable resonators for multiplexed read-out of cryogenic detectors, and pulse-shape preserving on-chip microwave frequency shifters.

High kinetic inductance devices have emerged as a promising platform for advancing quantum sensing and quantum computing technologies. These devices exploit the unique properties of kinetic inductance, which arises from the finite response time of superconducting charge carriers to changes in current, as opposed to conventional geometric inductance. This enables the realization of compact, highly non-linear, tunable, and versatile circuits, making them particularly valuable for quantum sensing applications. Additionally, these circuits prove optimal performance for quantum noise-limited microwave signal amplification [1,2], which is crucial for frequency-multiplexed read-out of qubit circuits and of cryogenic detector arrays [3].

We have developed and optimised high kinetic inductance films based on NbTiN, focusing on key properties such as critical temperature, non-linearity, uniformity, and reproducibility, making them suitable for superconducting quantum devices [4,5]. With this technology, we have addressed several aspects critical to the read-out chain of quantum processors and arrays of cryogenic detectors. In this presentation, we will highlight three key examples of our work: First, we will present our latest results on a prototype Kinetic Inductance Traveling Wave Parametric Amplifier (KI-TWPA) in a coplanar waveguide geometry [5], as well as our ongoing efforts to improve the design with an inverted microstrip geometry. Second, we will provide an overview of the development of tunable kinetic inductance microwave resonators (Fig. 1), which are well-suited for implementation in Kinetic Inductance Current Sensors used for the multiplexed read-out of cryogenic detector arrays. Finally, we will offer an outlook on novel superconducting high kinetic inductance devices, including cryogenic pulse-shape preserving on-chip frequency shifters for quantum processors, and devices designed for distributed quantum sensing applications.

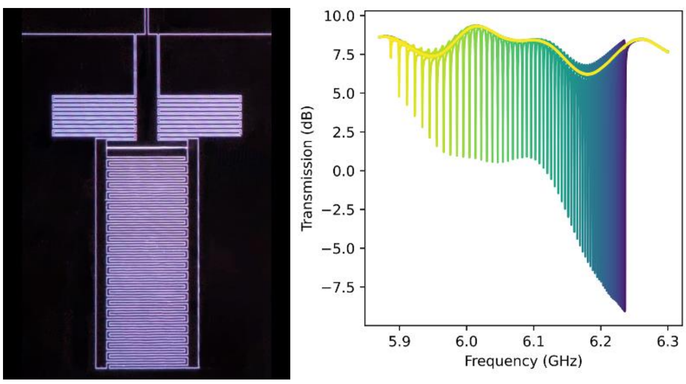

Fig. 1 *Left:* Darkfield optical microscope image of a tunable superconducting lumped element microwave resonator coupled to a microstrip transmission line. *Right:* Measured transmission spectra of the resonator for bias currents between 0 mA (blue) and 1.8 mA (yellow)

References

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