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KINETIC INDUCTANCE TRAVELLING-WAVE PARAMETRIC AMPLIFIERS USING NbTiN FILMS ON HIGH DIELECTRIC CONSTANT SUBSTRATES

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Travelling-wave parametric amplifiers (TWPAs) are critical components for improving the readout fidelity of superconducting qubit systems [1]. While Josephson junction-based TWPAs offer excellent broadband noise performance and are widely adopted in quantum computing architectures, their limited dynamic range, fabrication complexity, and sensitivity to magnetic fields and elevated temperatures present significant limitations. These challenges have driven the development of kinetic inductance-based TWPAs (KITWPAs) [2], which utilize the intrinsic nonlinearity of a superconducting film's kinetic inductance rather than relying on engineered Josephson junctions. KITWPAs inherently support higher dynamic range, greater resilience to magnetic fields, higher operation temperature, and enable simpler, single-layer fabrication. Despite these advantages, KITWPAs demonstrated so far [2-3] require transmission lines with lengths of several tens of centimeters. While meandering helps reduce the physical footprint, the long propagation paths still limit scalability and lower fabrication yield. To address this, we explore an alternative design approach that combines high-kinetic-inductance superconducting films with non-standard substrates possessing high dielectric constants. This strategy reduces the phase velocity of propagating signals—allowing for substantial device miniaturization. In this work, I present our experimental efforts focused on this approach, including precise extraction of substrate dielectric constants, measurement of film kinetic inductance, and nonlinear response characterization through a narrowband kinetic-inductance parametric amplifier (KIPA). These results demonstrate a promising pathway toward scalable KITWPAs with wideband, quantum-limited gain, extended dynamic range, and enhanced robustness—key attributes for next-generation superconducting quantum technologies.

References

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