A superinductor in a 22nm FDSOI process

Thomas H Swift
F. Olivieri, G. Aizpurua-Iraola, J. Kirkman, G. M. Noah, M. de Kruijf, F. E. von Horstig, A. Gomez-Saiz, J. J. L. Morton, M. F. Gonzalez-Zalba

Quantum Motion, 9 Sterling Way, London, N7 9HJ, United Kingdom

tom@quantummotion.tech

Superinductors are circuit elements characterised by an intrinsic impedance in excess of the superconducting resistance quantum ($R_Q \approx 6.45$ kΩ), with applications from metrology and sensing to quantum computing. However, they are typically obtained using exotic materials with high density inductance such as Josephson junctions [1], superconducting nanowires [2] or twisted two-dimensional materials [3]. Here, we present a superinductor realised within a silicon integrated circuit (IC), exploiting the high kinetic inductance (~ 1 nH/□) of TiN thin films native to the manufacturing process (22-nm FDSOI). By interfacing the superinductor to a silicon quantum dot formed within the same IC, we demonstrate a radio-frequency single-electron transistor (rfSET), the most widely used sensor in semiconductor-based quantum computers. The integrated nature of the rfSET reduces its parasitics which, together with the high impedance, yields a sensitivity improvement of more than two orders of magnitude over the state-of-the-art, combined with a 10,000-fold area reduction. Beyond providing the basis for dense arrays of integrated and high-performance qubit sensors, the realization of high-kinetic-inductance superconducting devices integrated within modern silicon ICs opens many opportunities, including kinetic-inductance detector arrays for astronomy [4] and the study of metamaterials and quantum simulators based on 1D and 2D resonator arrays [5].

References

[1] M. T. Bell et al. Quantum Superinductor with Tunable Nonlinearity, Physical Review Letters 109, 137003 (2012).
[2] D. Niepce el al. High Kinetic Inductance Nb N Nanowire Superinductors, Physical Review Applied 11, 044014 (2019).
[3] M. Tanaka, et al. Superfluid stiffness of magic-angle twisted bilayer graphene, Nature 638, 99 (2025
[4] P. K. Day et al. A broadband superconducting detector suitable for use in large arrays, Nature 425, 817 (2003).
[5] X. Zhang et al. A superconducting quantum simulator based on a photonic-bandgap metamaterial, Science 379, 278

Figures

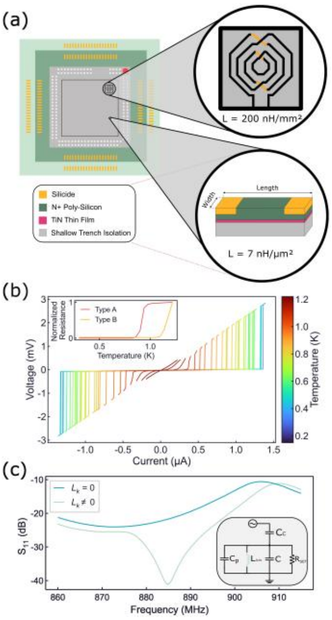

Figure 1: (a) 22-nm CMOS chip diagram with insets showing sizes of the spiral inductor and TiN thin film superinductor. (b) Four point I-V curve for different temperatures for Type B superconducting TiN thin film, with the inset showing the resistance vs temperature for both Type A and Type B thin film types, normalized to the maximum resistance of Type A. (c) S11 measurement of the resonant circuit shown in the inset, for the superconducting (green) and normal (blue) states of the film, the latter achieved using an rf power above the critical rf power.