Advances in nonreciprocal superconducting electronics and coherent tones microwave generation

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Abstract: We present the cryogenic characterization of SQUID-based supercurrent diodes and a coherent microwave frequency comb generator

We present the results of conceptualizing and realizing three different phase coherent superconducting devices for quantum electronics applications. These building blocks can be adopted for technological and fundamental purposes in developing superconducting electronics. In particular, we present two SQUID-based supercurrent diodes with high rectification and magnetic flux tunability and a Josephson Comb Generator (JCG).

A supercurrent diode is a device that realizes nonreciprocal transport of dissipationless current, meaning that different magnitudes of the latter can flow in different directions. It has been shown that the supercurrent diode effect [1-2], as a consequence of the high harmonic content of superconducting weak links, offers a reliable platform to study fundamental properties of superconducting systems, together with rectification efficiency as high as 20%. We report in detail the fabrication of these devices and their cryogenic characterization.

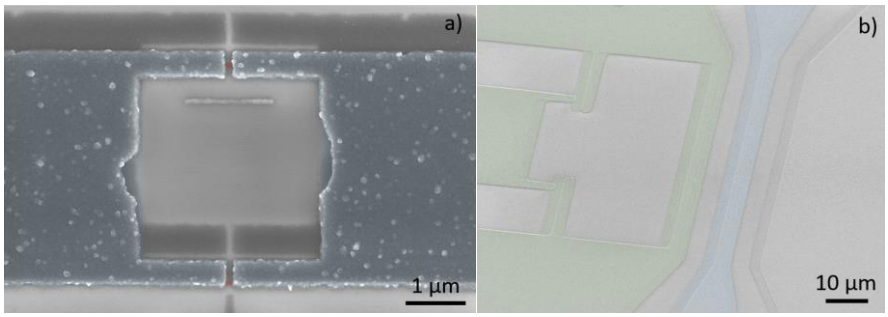

Fig. 1: a) Micrograph of a single-loop supercurrent diode. the loop structure (blue) and nanowire weak links (red) are highlighted. b) Micrograph of a JCG. Here one can see the flux line used to drive the device (blue) and the SQUID generating the voltage spikes (green).

The JCG [3] is based on a dc-SQUID driven by an external AC plus DC magnetic field. Under an appropriate magnetic flux driving the SQUID generates a train of evenly spaced voltage pulses, which in the frequency domain correspond to a frequency comb. We demonstrate the generation of tens of harmonics in the range 4-8 GHz, with an output power at the device level ranging between 140-120 dBm per single comb tone. Moreover, full tunability of amplitude and position of even and odd harmonics is shown, together with a coherence time exceeding seconds.

References

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