An HTS MMIC Josephson Mixer with a Near-zero Conversion Loss

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September 22, 2014 (HP85). The unique properties of high-temperature superconducting (HTS) materials, such as very low microwave surface resistance and the non-linear, low-noise characteristics of Josephson junctions, have been applied to a variety of high-frequency devices. Many passive HTS elements like high-Q resonators and ultra low loss filters have been well developed and applied in wireless communication receiver front-ends. They are, however, integrated with active semiconductor devices (oscillator, mixer and amplifier) in a hybrid configuration to form a practical front-end receiver. Novel nonlinear high-frequency devices based on the unique features of the AC Josephson effect are being developed, but are far less mature due to the rather challenging junction technology for HTS thin-film materials. Recently, important progress has been made in developing HTS Microwave Monolithic Integrated Circuit (MMIC) mixers/frequency down-converters [1, 2]. Integration of HTS Josephson junction-based active device such as the mixer with HTS passive devices such as antenna, resonators and filters offers a potentially complete solution, that is, an ultra-sensitive and tuneable front-end receiver technology.

Recently, we achieved a 10-12 GHz HTS MMIC Josephson down-converter with a near-zero conversion loss [3]; such performance has never been demonstrated in any HTS Josephson mixers to date. The high conversion efficiency is achieved by optimising the step-edge junction parameters and the properties of the bandpass filter (BPF). On-chip integration of the HTS passive and active components also results in more efficient RF signal coupling and isolation between RF, IF and LO ports, and elimination of the wire bonding related resistive losses. Fig. 1 shows the described MMIC down-converter, where a single Josephson junction mixer, a 10-12 GHz compact bandpass filter, a lowpass filter with ~ 4 GHz cut-off frequency and a 8 GHz microstrip line resonator are fabricated on a single 10 mm × 20 mm chip of $YBa_2Cu_3O_{7-x}$ film on MgO substrate using a CSIRO developed step-edge Josephson junction technology [4, 5]. Fig. 2 shows the RF frequency response of the down-converter at 20 K, which was determined by the transmission frequency response of the 10-12 GHz bandpass filter. The best conversion efficiency in band is around -1 dB including all losses from filters and impedance mismatch. This work has been published in *Supercond. Sci. Technol.* **27** 065007 (2014), doi:10.1088/0953-2048/27/10/105002.

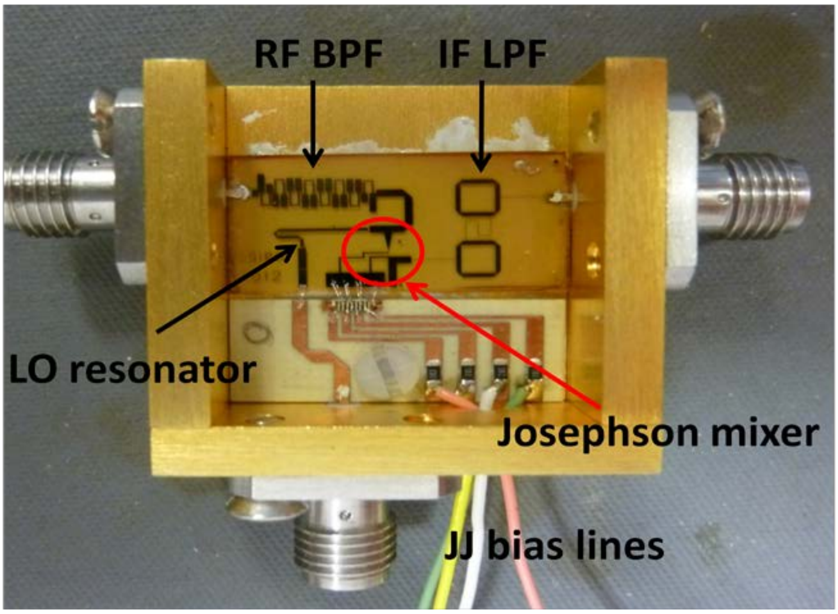

Fig.1. Photograph of the packaged 10-12 GHz HTS MMIC frequency down-converter.

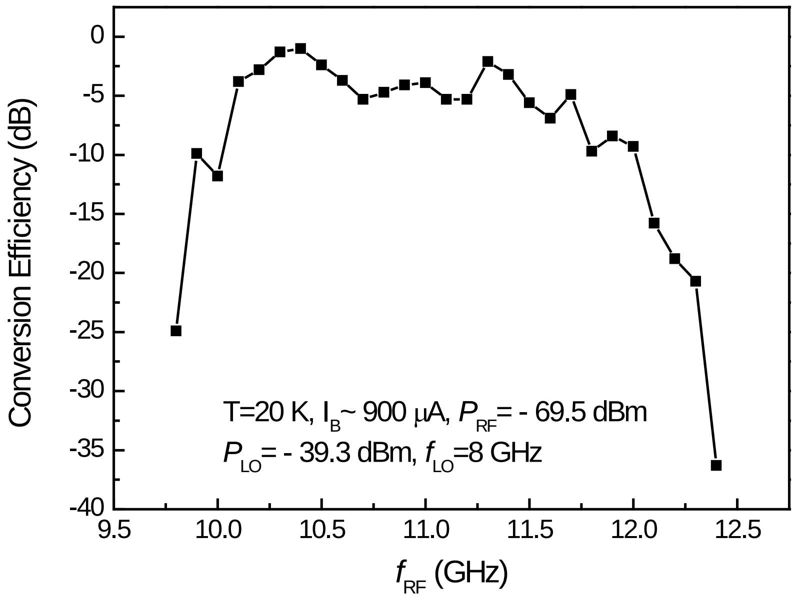

Fig. 2. Frequency response of the 10-12 GHz HTS MMIC frequency down-converter.

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