An HTS MMIC Josephson Down-converter with High Conversion Efficiency

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High-performance HTS (high-temperature superconductor) *passive* devices like high-*Q* resonators and filters of narrow bandwidth and low loss have been well developed in past two decades and applied in wireless base stations. The HTS Josephson-junction-based microwave *active* devices, such as oscillators, amplifiers and mixers, are far less mature due to the rather challenging junction technology. It is even a greater challenge to integrate the HTS passive and active components onto a single chip to form a functional circuit. A hybrid configuration of HTS passive components with semiconducting active devices has been typically employed in HTS RF front-end receiver circuits. Nevertheless, in recent years, CSIRO has made major progress in developing HTS microwave active devices for wireless communications [1-4] using own step-edge junction technology [5, 6].

Recently, we reported a compact HTS monolithic microwave integrated circuit (MMIC) Josephson down-converter with high conversion efficiency [7]. As shown in Figure 1, the circuit consists of a single Josephson junction mixer, a bandpass filter, a lowpass filter and a resonator for local oscillator, fabricated on a single 10 mm × 20 mm chip of $YBa_2Cu_3O_{7-x}$ film on MgO substrate. Different from the previously demonstrated self-pumped Josephson heterodyne Resistive-SQUID (R-SQUID) oscillator-mixer device [2-4], an externally pumped single Josephson junction mixer is used in this work. The down-converter (6.5 to 8.5 GHz) demonstrates superior performance in terms of conversion efficiency, dynamic range, linearity and a low local oscillator power (~ -32 dBm) with stable operation from 20 to 77 K. Figure 2 shows the experimental result of the operating range and linearity at 40 K and the temperature dependence of the conversion gain. A highly linear relationship between the IF output and the RF input was demonstrated; it is an ideal mixer behaviour. A maximum conversion gain of - 4.7 dB was measured at 20 K and -12.8 dB at 70 K. This is the highest conversion gain reported to date for HTS mixers at comparable frequencies and temperatures. We believe, the high conversion efficiency is due to: (1) high junction resistance (R_n) value improving the coupling of RF power into the junction, (2) high dynamic resistance (R_D) value increasing the IF output, (3) on-chip HTS filters and resonator provide effective RF signal coupling, isolation and prevention of leakage between RF, LO and IF ports, and (4) low-loss connections between the components. The results demonstrated the potential of HTS technology for application in wireless communication systems. This work has been published in *Applied Physics Letters*, **102**, Issue 21, (2013), DOI: 10.1063/1.4808106, with the link for *APL* subscribers: http://link.aip.org/link/?APL/102/212602.

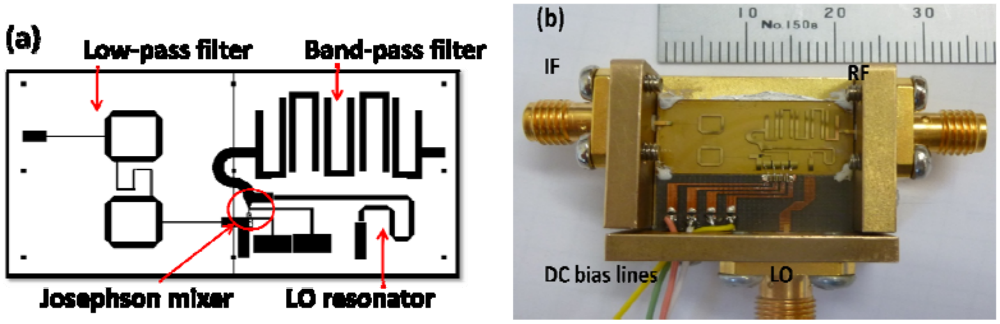

Fig. 1. (a) the layout of a monolithic HTS Josephson frequency down-converter and (b) a photograph of the packaged HTS circuit module.

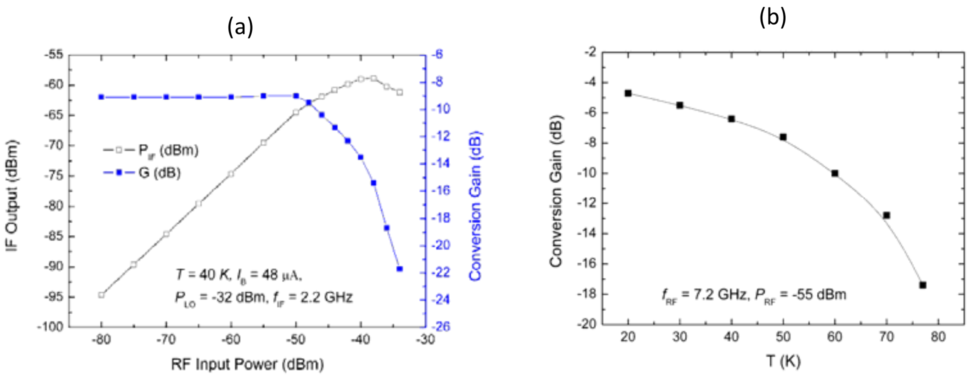

Fig. 2. (a) IF output power and conversion gain as function of the input RF signal power at T = 40 K and (b) the conversion gain versus operating temperature.

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