Towards Practical Applications of THz Josephson Oscillators with Sub-mW Power and 500 GHz Frequency Tunability

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***Abstract*—Using a double-sided fabrication method, we fabricated $Bi_2Sr_2CaCu_2O_8$ (BSCCO) intrinsic Josephson junctions (IJJs) with a gold-BSCCO-gold structure. Coherent emission is observed at large dc input power, where a hot spot and "cold" part of the stack, coexist. The power, directly *detected* with a bolometer, is as high as 25 µW, implying the integrated power should be already in the order of sub-mW. We have successfully pumped a Nb-based Josephson junction and a grain boundary Josephson junction. Also with a wide tunable frequency range, BSCCO THz emitters will find themselves many practical applications, e.g., local oscillators of SIS, HEB, and Josephson mixers.**

I. Introduction And Background

In recent years coherent terahertz (THz) emission have been obtained from stacks of intrinsic Josephson junctions (IJJs) made of the high temperature superconductor $Bi_2Sr_2CaCu_2O_8$ (BSCCO). An IJJ is formed naturally in the BSCCO unit cell, as shown in the inset of Fig. 1(a), with the CuO_2 layers forming the superconducting electrodes and the BiO and SrO layers forming the barrier layer[1]. A crystal of 1 µm thickness consists of about 670 IJJs. In 2007 it was reported that such stacks can emit coherent radiation at frequencies up to 0.85 THz, however, with a directly *detected* power of only 10 nW[2], which is much lower than that required for practical applications. For example, power of 100 nW is needed for pumping a hot electron bolometer or a superconductor-insulator-superconductor (SIS) mixer. Therefore, How to increase emission power becomes the most important mission in the IJJs community. In this talk, we reported THz emission from IJJs with a detected power as high as 25 µW, three orders as high as that in the first report[2].

II. Results

The fabrication process of the IJJ emitter is very similar to the one for a Au/BSCCO/Au structure developed earlier[3]. The BSCCO emitter, mounted on the Si lens, was characterized in terms of transport and THz emission measurements. Fig. 1 shows the IVC, as measured near 25 K, together with the emission power detected by the Si bolometer. Besides the maximum detected power of 25 µW, the frequency can be tuned by either bias current or bath temperature from 10 K to 70 K, over a frequency range of between 234 GHz and 876 GHz. The wide range tunability is related to the hotspot resulted from the self-heating[4]. Photon-assisted current steps or Shapiro steps have been observed either in an SIS Josephson junction or a grain boundary Josephson junction[5], indicating the power is sufficient to pump most of the superconducting THz detectors.

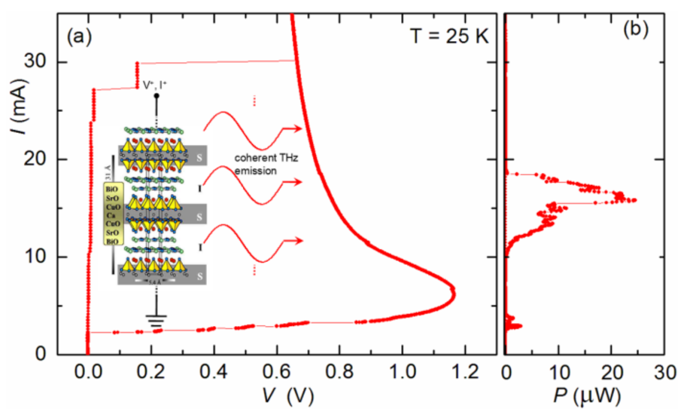

Fig. 1. Properties of the THz emitter. (a) Current voltage characteristic and (b) THz emission power vs. bias current, as detected by a Si bolometer. The maximum *detected* power at 25 K is about 25 µW. The inset in (a) shows the crystalline structure and how the Josephson junction array is biased with dc current.

References

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