Detection of 0.5 THz radiation from $Bi_2Sr_2CaCu_2O_8$ single crystals using a superconducting integrated receiver

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Josephson junctions utilizing high-temperature superconductors were considered as promising candidates for terahertz oscillators, but experimental demonstrations of their performance are still lacking. The most promising devices that have been proposed so far are based on intrinsically layered $Bi_2Sr_2CaCu_2O_8$ single crystals, which consist of natural stacks of Josephson tunnel junctions.

We report on detection of electromagnetic radiation at about 500 GHz from current-biased intrinsic $Bi_2Sr_2CaCu_2O_8$ single crystal Josephson junctions[1]. We used two silicon lenses to quasi-optically couple radiation from our samples to an integrated superconducting heterodyne receiver. The samples were prepared in a step-like geometry, by defining a mesa in the shape of bow-tie antenna using electron beam lithography and argon ion milling on the upper surface of the crystal. The microwave radiation was detected by a low-noise all-superconducting heterodyne receiver. The receiver consists of an SIS mixer integrated on the single chip with a superconducting flux-flow oscillator acting as a local oscillator[2].

From our data we can identify the emission of individual intrinsic Josephson junctions from a stack consisting of over 100 junctions. The estimated maximum Josephson radiation power which reached the receiver antenna was about 1 pW. We suppose that the possibility of mutual phase locking of a large number of stacked junctions strongly depends on several factors such as spread in junction parameters, heating effects, and presence of an external magnetic field. For their frequency locking, series-connected junctions biased by the same current need to have a very small spread in resistances. This requirement seems hard to achieve even in very uniform stacks due to unavoidable resistance changes induced by the dissipated heat.

[1] I. E. Batov, X. Y. Jin, S. V. Shitov, Y. Koval, P. Mueller, and A. V. Ustinov, *Appl. Phys. Lett.* **88**, 262504 (2006).
[2] V. P. Koshelets and S. V. Shitov, *Supercond. Sci. Technol.* **13**, R53 (2000),