Shapiro-steps in Bi₂Sr₂CaCu₂O₈ (Bi2212) intrinsic Josephson Junctions (IJJ)

Single crystals and thin films of very anisotropic high-transition-temperature superconductors (HTS) show Josephson coupling in the c-axis direction between adjacent (clusters of) Cu-O planes [1]. Bi2212 belongs to this group of compounds and single crystals are composed of large series arrays of Josephson tunnel junctions in the c-axis direction. Mesas composed of a few (even one) or up to thousands of these intrinsic Josephson junctions (IJJ) can be patterned in the crystal to make devices. IJJ could be attractive both for SIS-mixers due to the large gap frequency and as voltage standards, due to the stacked nature of the junctions, making it possible to add Shapiro steps in series easily up to the Volt range. Shapiro steps have been detected for frequencies up to 2,5 THz [2], results which might be used for designing a Josephson voltage standard based on HTS.

In this work, we present preliminary results on both fabrication and measurements on IJJ coupled to Bow-tie and log-periodic antennas operating in the range of 300 GHz. The IJJ are fabricated from single crystals of Bi2212, by using photolithography and ion-beam etching. A wiring layer contacts the mesas and also forms the structure of the antennas. Fig. 1 shows a photo of one of our devices. A measurement of this device at 300 GHz is presented in Fig. 2, where the Shapiro steps are clearly seen.

We are now working on improving the coupling of the device to the antenna and to the external quasi-optical set-up to bring the operating frequency up to beyond a THz.



Fig. 1 (left) Photograph of one of our devices. The single crystal Bi2212 can be seen on the middle of the sapphire substrate. The IJJ are located in the bridge in centre of the structure.

Fig. 2 (right) Current voltage characteristic of a device with 20 IJJ. Up to 7 Shapiro steps at 300 GHz can be seen in this plot.

[1] R. Kleiner, F. Steinmeyer, G. Kunkel, and P. Mu⁻Iler, Phys. Rev. Lett. **68**,2394 ~1992.

[2] H.B Wang, P.H Wu and T. Yamashita, "Terahertz responce of intrinsic Josephson junctions in high Tc superconductors" Phys. Rew. Lett. 87, 107002