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THz emission from a slice of high-*Tc* superconducting single crystal

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Copper oxide superconductors possess intrinsically a layered crystalline structure, in which superconducting and non-superconducting layers interleave each other. Therefore the crystal itself consists of a number of superconducting junctions sequentially stacked along the c axis of the crystal, and these junctions are often referred to as intrinsic Josephson junctions (IJJs). In the case of $Bi_2Sr_2CaCu_2O_{8+\delta}$ (BSCCO), each IJJ measures approximately 1.5 nm thick. Many groups have been exploring the possibilities to develop terahertz (THz) detectors and oscillators based on IJJs, due to the high collective plasma frequencies (up to THz region), the uniformity in junction properties, the easiness to make a large junction array, and the low loss at high frequencies. Some years ago, in IJJs singled out from inside a slice of BSCCO single crystal with a double-sided process, THz response was successfully observed as sharp Shapiro steps at frequencies up to 2.5 THz, and harmonic mixings were carried out with harmonic numbers as large as 90. Recently observed have been THz oscillations in various structures of BSCCO IJJs, which can be excited by dc bias, in-plane magnetic fields, or microwave irradiations at several gigahertz. Needless to say, for practical applications, it is necessary to synchronize the emissions from IJJs, couple the THz oscillations into a finite space, guide them in a controllable way, monitor the frequencies and power levels, and preferably do the jobs using an integrated system. We have been making extensive efforts to explore these ideas, and will report our latest results at the meeting.