Terahertz Detector Combining Superconductor $GdBa_2Cu_3O_{7-x}$ and Nanogaps

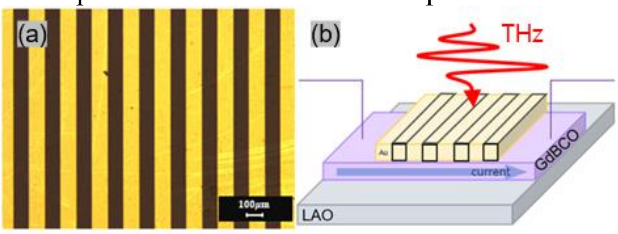
Jiyun Lee[1], Jiyun Lee[1] Han-seok Park[2], Gangseon Ji[1], Seonhye Eom[1], Joonyoung Kim[1], Byeongwon Kang[2], C Hyeong-Ryeol Park[1]

1- Department of Physics, Ulsan National Institute of Science and Technology, UNIST-gil 50, Ulsan 44919, Korea
2- Department of Physics, Chung-buk National University, Chungdae-ro 1, Seowon-gu, Cheongju-si, Chungcheongbuk-do 28644, Korea

jiyunlee@unist.ac.kr

Josephson junction composed of 2D materials [1], this study focuses on the development of a detector capable of detecting terahertz waves, which are currently used in the 6G communication wavelength range. In this study, we fabricate a sensitive THz detector by combining GdBa2Cu3O7-x (GdBCO), a cuprate high-temperature superconductor, with nanostructured gaps to achieve enhanced THz performance.

A structure was fabricated on a 100 nm thick GdBCO film deposited on a single-crystal LaAlO3 substrate using pulsed laser deposition. The structure consisted of nanogap made of Au/20 nm Al2O3/Au layers using atomic layer lithography [2], as shown in Fig.1 (a) and (b). By irradiating terahertz waves onto nanostructures with a 20 nm gaps, the electric field is concentrated through the funneling effect [3]. This maximizes the local temperature variation and enables the sensitive measurement of resistance changes in superconductors. In order to examine the electrical response of the sample to terahertz waves, a setup combining terahertz time-domain spectroscopy with current-voltage measurements of the superconductor at ultra-low temperatures was employed.



When terahertz pulses were incident through the nanogaps near the critical temperature of approximately 90 K, a slight increase in temperature near the nanogaps occurred due to the localized electric field. This resulted in a significant thermosensitive change, thanks to the high temperature coefficient of resistance near the critical temperature. Consequently, even at extremely low intensities, the detection of terahertz waves at a subtle level became feasible. This work opens up a new avenue for ultrasensitive long-wavelength detector, allowing us to develop a single photon detector operating at terahertz frequencies.

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