

Fabrication of Nano-Periodic Josephson junction array in $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10+\delta}$ (Bi-2223) single crystal whiskers

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Whiskers can be used in the fabrication of new electronic devices using intrinsic Josephson effects and related phenomena. Growth and characterization of high T_c superconductor single crystal whiskers have always been focused by researchers. CuO_2 planes are one of the promoters for superconductivity in layered high T_c superconductors^{1,2}. $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10+\delta}$ (Bi-2223) have more CuO_2 planes in a unit cell rather than any other phase. We are reporting the nano-periodic Josephson junction array fabrication in Bi-2223 single crystal whiskers.

We grow single crystal whisker from solid state reaction. We used 99.9% pure powder of Bi_2O_3 , SrCO_3 , CuO , and TeO_2 . Te was used to enhance the growth of whiskers. We mixed these powders in the proportional ratio of $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_{2.5}\text{Te}_{0.5}\text{O}_x$. After the calcinations at 820°C we made the pellet and the pellet kept in a pure alumina boat and annealed at 880°C for 100 hours. During the process we used an oxygen atmosphere with constant flow of 150 ml/min. The whiskers were grown on the surface of pellet. We found whiskers 0.5~3 mm in length and 10 to 30 μm in width (Fig.1).

We fabricated nano-periodic Josephson junction array in Bi-2223 single crystal whisker using FIB, in ab -plane with size of $2\ \mu\text{m} \times 2\ \mu\text{m}$. We tilted sample stage of FIB and etched in c -axis with junction height of about 150 nm, which have few hundred of elementary Josephson junction arranged in the series as an array. Figure 2 shows the FIB image of stack junction and inset shows schematic diagram of stack junction fabrication. We performed resistance (R) - temperature (T) characteristics and found critical temperature (T_c) about 108 K (Fig. 3). Figure 4 shows current (I) - voltage (V) characteristics using four probe technique to characterize these junctions. We found a well defined voltage gap of about 1.5 V and critical current density of about $1 \times 10^3\ \text{A}/\text{cm}^2$ which shows the number of elementary junctions and their arrangement in an array with spacing in nano range. We will discuss fabrication and electrical properties of nano-periodic Josephson junction array in Bi-2223 single crystal whiskers.

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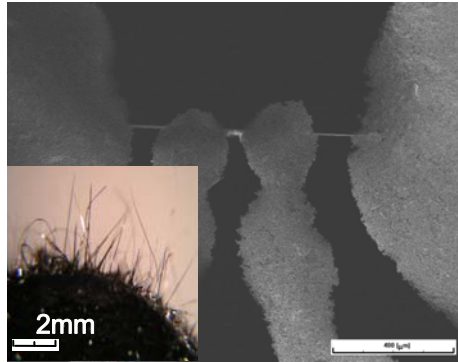


Fig.1 Four probe configuration on whisker, inset shows optical microscopy image of *Bi-2223* single crystal whiskers on precursor pellet.

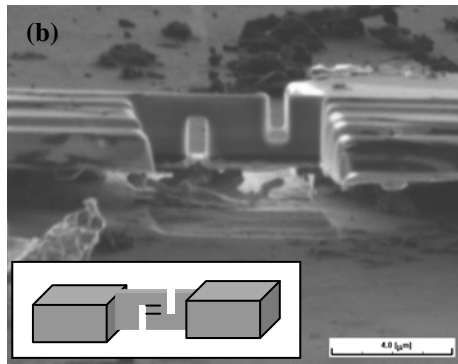


Fig.2 Image of *c*-axis junction through FIB. Inset shows schematic diagram for array fabrication.

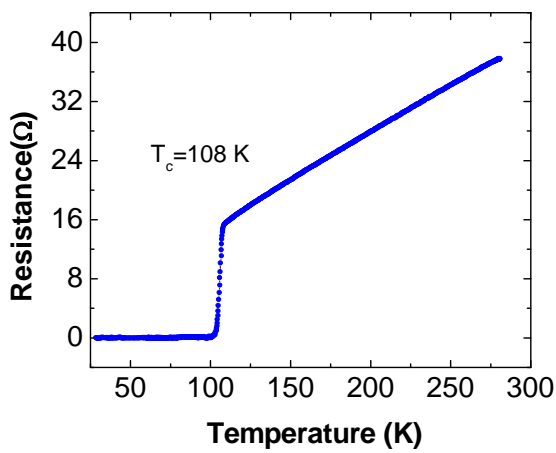


Fig. 3 *R-T* characteristics in *ab*- plane of *Bi-2223* single crystal whisker.

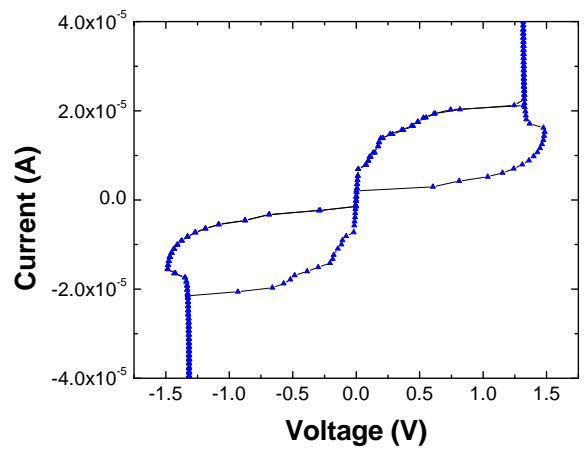


Fig. 4 *I-V* characteristics of *Bi-2223* whiskers at 30 K.