Superfluid Density Estimated from the Josephson Vortex Flow in $Bi_2Sr_2CaCu_2O_{8+x}$ Intrinsic Josephson Junctions

Myung-Ho Bae, Hu-Jong Lee

Department of Physics, Pohang University of Science and Technology, Pohang 790-784, Republic of Korea

The Josephson vortex lattices in serially staked intrinsic Josephson junctions of $Bi_2Sr_2CaCu_2O_{8+x}$ can resonate with the transverse plasma modes when the speed of the lattice matches with any specific mode velocity. In current-voltage characteristics of Josephson vortex-flow regime, these resonances are represented by voltage jumps in current bias configuration. The speed-matching voltage of Josephson vortex-flow branch in a certain plasma mode at different temperatures provides the information on the temperature dependence of plasma frequency, because the plasma frequency is proportional to the speed of plasma mode. The square of Josephson plasma frequency is also directly proportional to the superfluid density. Thus, the superfluid density can be obtained using the speed-matching voltage of Josephson vortex lattice. A stack of intrinsic Josephson junctions with the lateral size of 15×1.4 μm^2 was fabricated by using the double-side cleaving technique. External fields in parallel with the CuO_2 planes to generate Josephson vortices were varied from 3 T to 5 T in the temperature range of $0<T/T_c<0.7$. The temperature dependence of the superfluid density estimated from the maximum-conductance voltage for $n=1$ mode is in good agreement with the previous results using the infrared [1] and microwave [2] absorption.

keywords : Josephson vortex lattice, Josephson plasma frequency, superfluid density.

[1] A. A. Tsvetkov et al., Nature 395, 360 (1998).
[2] M. B. Gaifullin et al., Phys. Rev. Lett. 83, 3928 (1999)