Depairing current density in the *c*-axis microbridge devices of Co-doped $BaFe_2As_2$ single crystals

Shintaro Suzuki[1], Yuki Mizukoshi[1], Shigeyuki Ishida[2], Hiroshi Eisaki[2], Haruhisa Kitano[1]

[1] *Department of Physics, Aoyama Gakuin University, Sagamihara 252-5258, Japan*
[2] *Research Institute for Advanced Electronics and Photonics, AIST, Tsukuba 305-8568, Japan*

The depairing process in the supercurrent flow occurs when the kinetic energy of the Cooper pairs exceeds the condensation energy. The experimental determination of the depairing current density ($J_{\mathrm{depairing}}$) is significant for understanding both the superconducting (SC) pairing mechanism and the upper limit of supercurrent application. However, the critical current in transport measurements is often limited by the depinning current density ($J_{\mathrm{depinning}}$) of pinned vortices, which is much lower than $J_{\mathrm{depairing}}$, due to the current crowding and the vortex intrusion near the edge of the SC strips. Thus, it is essentially important to fabricate the SC microbridge devices with sufficiently narrow widths [2]. We succeeded in fabricating the *c*-axis microbridges from Fe(Te,Se) [3] and $BaFe_2(As_{1-x}P_x)_2$ [4] single crystals, by using the focused ion beam technique.

Here, we report the study of $J_{\mathrm{depairing}}$ in the *c*-axis microbridges fabricated from $Ba(Fe_{1-y}Co_y)_2As_2$ (y = 0.06-0.08) single crystals, as shown in Fig. (a). We obtained the *c*-axis critical current density J_C (~3.3-4.2 MA/cm^2 at 4 K for y = 0.06), roughly one order of magnitude larger than $J_{\mathrm{depinning}}$ in the *ab* plane [5]. As shown in Fig. (b), the temperature dependence of $(J_c/J_{c0})^{2/3}$ shows a good agreement with the curves given by the KL theory [6]. Both results clearly indicate the achievement of the depairing limit along the *c* axis in Co-doped $BaFe_2As_2$. We also discuss the composition dependence of the *c*-axis depairing current density of P-doped and Co-doped $BaFe_2As_2$.

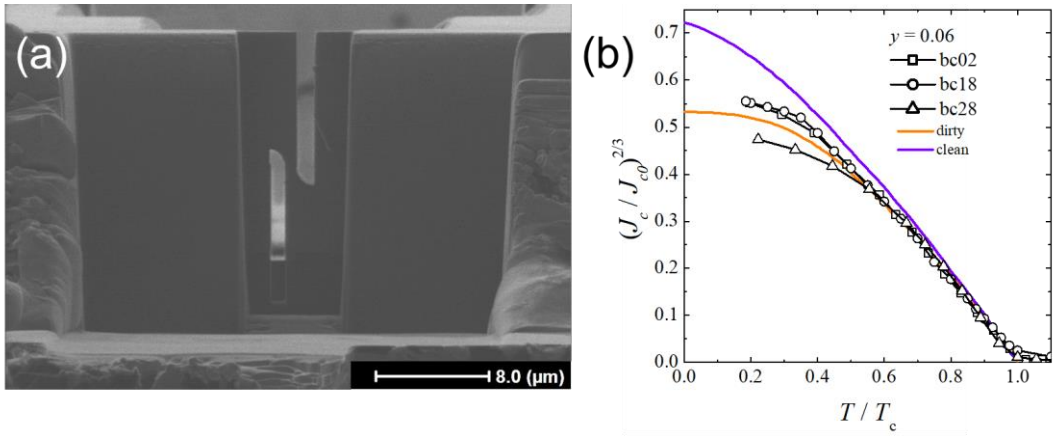

Figure (a): A SIM image of the *c*-axis microbridge of $Ba(Fe_{1-y}Co_y)_2As_2$ (y = 0.06). (b) The temperature dependence of $(J_c/J_{c0})^{2/3}$ for 3 microbridges with y = 0.06, where J_{C0} is the GL limit at T = 0. The purple and orange lines are $J_{\mathrm{depinning}}$ in the clean and dirty limits given by the KL theory [6], respectively.

References

[1] D. Dew-Hughes, *Low Temp. Phys.* **27**, 713 (2001).
[2] S. Nawaz, R. Arpaia, F. Lombardi, and T. Bauch, *Phys Rev. Lett.* **110**, 167004 (2013).
[3] Y. Sun *et al.*, *Phys. Rev. B* **101**, 134516 (2020).
[4] Y. Mizukoshi *et al.*, *Phys. Rev. B* **110**, 104501 (2024).
[5] S. Ishida, D. Song, H. Ogino, A. Iyo, and H. Eisaki, *Phys. Rev. B* **95**, 014517 (2017).
[6] M. Y. Kupriyanov and V. F. Lukichev, *Fiz. Nizk. Temp*. **6**, 445 (1980).