Upper Critical Fields of Electric-Field-Induced Superconductivity in $SrTiO_3$

T. Nojima[a], K. Ueno[b, c], S. Yonezawa[d], M. Kawasaki[e, f], Y. Maeno[d], and Y. Iwasa[e, f]

[a]Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan
[b]Department of Basic Science, The University of Tokyo, Tokyo 153-8902, Japan
[c]PRESTO, Japan Science and Technology Agency, Tokyo 102-0075, Japan
[d]Department of Physics, Kyoto University, Kyoto 606-8502, Japan
[e]QPEC and Department of Applied Physics, The University of Tokyo, Tokyo 113-8656, Japan
[f]CREST, Japan Science and Technology Agency, Tokyo 102-0075, Japan

Recently we succeeded in converting an insulating surface of $SrTiO_3$ to a superconducting one with the critical temperature $T_c = 0.4$ K purely by electric field effect.[1] This conversion was made possible by high-density electrostatic carrier doping using an electric double layer transistor structure. In this work, the upper critical magnetic fields parallel ($H_{c2\parallel}$) and perpendicular ($H_{c2\perp}$) to the conducting surface were examined by the measurements of the transport properties at temperatures T down to 0.1 K. A vector superconducting magnet allowing precise and accurate alignment of the magnetic field direction with respect to the sample surface was used. The observed H_{c2} data were strongly anisotropic; At $T =$ 0.1 K, $H_{c2\parallel}$ is about fifteen times larger than $H_{c2\perp}$. We also found that $H_{c2\parallel}(T)$ obeys a $(1\text{-}T/T_c)^{1/2}$ law near T_c. These results are consistent with the fact that the electric-field-induced superconductivity occurs at the two-dimensional surface.

[1]Ueno *et al.* Nature Mater. **7**, 855 (2008).