Doping Dependence of Upper Critical Field in $Sr(Fe_{2-x}Ni_x)As_2$ Single Crystals

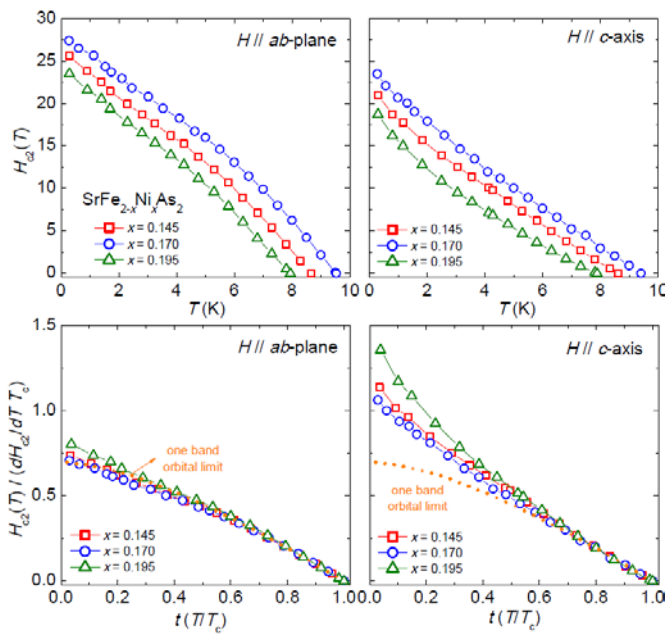
Seunghyun Khim, Bumsung Lee, Byung-Gu Jeon, Ki-Young Choi (Seoul National Univ., Korea, Physics), Eun Sang Choi (FSU, Physics) and Kee Hoon Kim (Seoul National Univ., Korea, Physics)

Introduction

One of the unique feature in multi-band superconductors is its unusual upper critical field (H_{c2}) behavior.[1,2] While the H_{c2} of single-band BCS superconductors is linearly increasing near the transition temperature (T_c) and saturated at low temperature, the H_{c2} of multi-band superconductor is depicted as a linearly increasing or upward curvature. In the multi-band model, the curvature of the H_{c2} is affected by the difference of the electronic properties between individual bands as well as by the intra- / inter-band impurity scattering and superconducting coupling. In this work, we measured the H_{c2} of Ni-doped $SrFe_2As_2$ single crystals in the under-doped, optimal-doped and over-doped compositions and discuss the evolution of the H_{c2} curves within the multi-band picture.

Experimental

To determine the temperature dependence of $H_{c2}(T)$, we have measured the field dependence of the resistivity up to 35 T on the rotator probe with ^{3}He cryostat down to 0.5 K.



Results and Discussion

The upper panels of the left figure shows the H_{c2} phase diagrams for of electron doped $Sr(Fe_{2-x}Ni_x)As_2$ single crystals. To compare the different H_{c2} curves, the $H_{c2}(T)$ is reduced by the initial slope of H_{c2} and T_c with reduced temperature $t = T/T_c$ as shown in the lower panels. In *H*//*ab*-plane, the overall curves nearly follow the one-band orbital limiting field. In *H*//*c*-axis, the linear and upward curvature is clearly observed as the multi-band feature. Furthermore, the upward curvature of H_{c2} is the most pronounced in the over-doped sample (x = 0.195).

In the rigid band picture, the Ni substitution on the Fe site introducing additional electron charges suppresses the hole FSs but expands the electron FSs. The linear or upward curvature of H_{c2} can be understood as the multiple contribution of the hole bands with small v_F which gives a higher H_{c2} at low temperature and the higher v_F electron bands giving smaller H_{c2} near T_c. In the over-doped sample, the further suppressed small hole bands could give a more higher H_{c2} at low temperature and eventually produces the strong upward feature.

Conclusions

In the $Sr(Fe_{2-x}Ni_x)As_2$ single crystals, the $H_{c2}(T)$ is nearly independent to the doping level and almost follows the one-band orbital limiting field for the *H*//*ab*-plane. For the *H*//*c*-axis, the linearly increasing and upward curvatures are observed in the $H_{c2}(T)$ as the multi-band feature and the upward behavior is most pronounced in the over-doped sample. We expect that the small hole FS with small v_F would play a role to give the increasing behavior in low temperature.

Acknowledgements

This work in SNU was supported by the National Creative Research Initiative (Grant No. 2010-0018300). The work performed at NHMFL is supported by National Science Foundation Cooperative Agreement No. DMR-0654118, the State of Florida, and the U.S. Department of Energy.

References

[1] S. Khim *et al*., Phys. Rev. B **81**, 184511 (2010).
[2] S. Khim *et al*., Phys. Rev. B **84**, 104502 (2011).