MAR15-2014-020118

Abstract for an Invited Paper
for the MAR15 Meeting of
the American Physical Society

Why are the T_cs so high in rare-earth doped $CaFe_2As_2$ single crystals and ultrathin FeSe epi-films?[1]

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Recent reports of non-bulk superconductivity with unexpectedly high onset-T_cs up to 49 K in the Pr-doped $CaFe_2As_2$ [(Ca,Pr)122] single crystals [1] and up to 100 K in one-unit-cell (1UC) FeSe epi-films [2], respectively, offer an unusual opportunity to seek an answer to the question posed in the title. Through systematic compositional, structural, resistive, and magnetic investigations on (Ca,R)122 single crystals with R = La, Ce, Pr, and Nd, we have observed a doping-level-independent T_c, a large magnetic anisotropy, and the existence of mesoscopic-2D structures in these crystals, thus providing evidence consistent with the proposed interface-enhanced T_c in these naturally assembled Fe-based superconductors. Similar resistive and magnetic measurements were also made on the 1-4UC FeSe ultra thin epi-films. We have detected a Meissner state below 1 Oe with extensive weak-links up to $\sim$ 20 K, unconnected small superconducting patches up to $\sim$ 40 K, and an unusual dispersion of diamagnetic moment with frequency up to 80 K. The unusual frequency dependences of the diamagnetic moment observed in the films at different temperature ranges suggest that collective excitations of electron and/or spin nature may exist in the FeSe films below 20 K and 40-80 K. The experimental results will be presented and the implications discussed.

[1] Q. Y. Wang et al., Chin. Phys. Lett. 29, 037402 (2012); J. F. Ge et al., arXiv:1406.3435 [cond-mat.supr-con] (2014).
[2] L. Z. Deng et al., arXiv:1311.6459 [cond-mat.supr-con] (2013); B. Lv et al. PNAS USA 108, 15705 (2011); B. Lv. et al., MRS Symp. Proc. 1684 (2014).

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