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Viewpoint

Is there a link between the high temperature structural modulation and superconductivity in the 112 pnictides?

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This is a viewpoint on the fast track communication by Joseph *et al* 2015 *Supercond. Sci. Technol.* **28** 092001.

Observation of superconductivity in iron-based compounds has given us a new playground to explore high temperature superconductivity [1]. Thanks to the discovery of several families of compounds, it is a good time for experimentalists and theorists to look into a large amount of data. There are already several generic features that have clearly emerged. Two-dimensionality of the active layer where the superconductivity exisits is one such observation.

Of recent interest are the newly discovered 112 systems [2] with a peculiar spacer-layer, containing one-dimensional zig-zags as chains. A recent systematic structural study of the system [3] revealed distinct changes in the thermal expansion along the out-of-plane and in-plane lattice parameters. The authors employed careful synchrotron x-ray diffraction measurements focusing on two important d-spacings, i.e. (100) and (001), with a dense temperature sampling. This, coupled with temperature dependent measurements of the full XRD pattern, enabled them to reveal a subtle high temperature modulation in the $Ca_{0.82}La_{0.18}FeAs_2$ pnictide with a superconducting transition at about 41 K. In particular, they observed that the thermal expansion along the c-axis displays a change in the slope within the 100–300 K range, whereas in this temperature range, the in-plane axes show a minimal thermal expansion with no particular features [3].

The far-from-equilibrium evolution of the out-of-plane and in-plane lattice parameters of the oxygen interstitial domains were observed in a cuprate superconductor and correlated with its critical temperature [4]. Indeed, the tuning of the superconducting properties in the active layers is inseparably given by the properties of the spacer layers [5]. The spacer layers determine the misfit-strain on the active layers through a natural lattice mismatch that is compensated by the superlattice heterostructure [6]. The misfit-strain (e.g. lattice mismatch, internal chemical pressure) creates a complex space for superconductivity. This space arises within an inhomogeneous nanoscale phase separation of the quenched disorder (e.g. oxygen interstitials) in the spacer layer and of the charge order accompanied by local lattice distortions in the active layers [7]. How relevant a controlled complex space for superconductivity is for the determination of its properties is a matter of current research. However it has been already shown by recent works that a complex space for superconductivity influences both the superconducting property of the material [8] and its far-from-equilibrium critical phenomena [9].

A link between the structural landscape of the spacer layers and the superconductivity has been shown in several works of the 122 pnictide system [10–12], underlining the existence of nematic fluctuations in the entire phase diagram. Due to their multiband nature, temperature driven Lifshiftz transitions can result in the resistivity anisotropy, in particular the sharp drop in resistivity to below the Neel transition in 122 systems [11]. Although significantly weakened, such effects are found to be persistent in the entire phase diagram of the 122 pinctide systems. The work of Joseph *et al* [3] clearly reveals a close correlation of the out-of-plane lattice parameter changes to the resistivity behavior in the 'high temperature' phase of the 112 systems. The out-of-plane lattice parameter is the key player in the $Ca_{0.82}La_{0.18}FeAs_2$ and implies the importance of interlayer interaction where the otherwise passive 'spacer layer' is the 'active' player. Apart from the relevance of the nematic fluctuations in the $Ca_{0.82}La_{0.18}FeAs_2$ system, the work of Joseph *et al* also shows the importance of inter-layer interactions. It is to be noted that such interlayer tuning, more visibly seen in the 1111 pinctides [1, 13], is also found to be important in other unconventional superconductors, for example BiS2-based systems [14]. The new work in the 112 pnictide correlating the structural parameters to the resistivity [3] will stimulate systematic investigations of the structural parameters in other families as well. Indeed, such studies will be of more impact when combined with the *in situ* resistivity measurements on single crystals.

References

[1] Ishida K *et al* 2009 *J. Phys. Soc. Japan* **78** 062001
[2] Katayama N *et al* 2013 *J. Phys. Soc. Japan* **82** 123702
[3] Joseph B *et al* 2015 *Supercond. Sci. Technol.* **28** 092001
[4] Poccia N *et al* 2011 *Nat. Mater.* **10** 733
Poccia N *et al* 2012 *Supercond. Sci. Technol.* **25** 124004
[5] Kugel K *et al* 2008 *Phys. Rev.* B **78** 165124.
[6] Poccia N *et al* 2010 *Adv. Condens. Matter Phys.* **2010** **1**
[7] Fratini M *et al* 2010 *Nature* **466** 841
Poccia N *et al* 2012 *Proc. Natl Acad. Sci.* **109** 15685–90
Ricci A *et al* 2013 *Sci. Rep.* **3**
Campi G *et al* 2015 *Nature* **525** 359
[8] Eley S *et al* 2011 *Nat. Phys.* **8** 59
[9] Poccia N *et al* 2015 *Science* **349** 1202–5
[10] Bohmer A E *et al* 2014 *Phys. Rev. Lett.* **112** 047001
[11] Wang Y *et al* 2015 *Phys. Rev. Lett.* **114** 097003
[12] Kuo H-H and Fisher I R 2014 *Phys. Rev. Lett.* **112** 227001
[13] Iadecola A *et al* 2012 *Phys. Rev.* B **85** 214530
[14] Sugimoto T *et al* 2014 *Phys. Rev.* B **89** 201117