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Low-temperature lattice anomaly in $LaFeAsO_{0.93}F_{0.07}$ probed by x-ray absorption spectroscopy: Evidence for strong electron-lattice interaction

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Introduction

The recently discovered high temperature superconductivity (HTSC) in fluorine doped LaFeAsO have stirred new interest in the research of high-T_C superconductors [1], outside of the cuprate family. The first and most important question about the LaFeAsO-based new superconducting system is whether it has similar mechanism for superconductivity with cuprate superconductors or not. In order to find the appropriate mechanism, lattice effects can provide key information. In this work we present results from Fe and As *K* edge EXAFS measurements indicating that local Fe-As lattice fluctuation occurs well above T_C. Similar to that in cuprates, this local lattice fluctuation is closely correlated with the onset of superconducting transition, indicating that the local lattice fluctuation is involved in the superconducting coherence in both systems [2].

Experimental

All EXAFS measurements were performed in a fluorescence detection mode at BL13B1, Photon Factory. A novel Ge pixel array detector (PAD) with 100 segments was used in order to gain high throughput and energy resolution and as a result, high signal-to-noise Fe and As K-edge XAFS spectra for fluorine doped LaFeAsO are achieved. Samples were mounted on an aluminium holder and attached to a closed-cycle helium refrigerator. The hold rotated on a high-precision goniometer (Huber 420) to change the incidence angle.

Results and Discussions

In Fig. 1 we plot the temperature dependence of the mean-square relative displacement for the nearest neighboring Fe-As shell derived from both Fe *K* edge EXAFS (labeled as $\sigma^2_{Fe\text{-}As}$ and As *K* edge EXAFS (labeled as $\sigma^2_{As\text{-}Fe}$ for the $LaFeAsO_{1-x}F_x$ (x=0.07) sample together with that of the undoped LaFeAsO sample. Significantly, an anomalous upturn of $\sigma^2_{Fe\text{-}As}$ appears at T<70 K. This anomaly is accompanied by a sharp drop at the temperature where the onset of superconducting transition occurs (T_c^{onset}≈29 K). Similar anomalous behavior was previously Found in $La_{2-x}Sr_xCuO_4$ samples where an upturn of $\sigma^2_{Cu\text{-}O}$ (mean-square relative displacement of the in-plane Cu-O bond) occurs at T<80 K which is also accompanied by a sharp decrease at T_c^{onset}. In order to clearly see the low temperature local lattice instability and its relation to the T_c^{onset} value, we plot in the inset of Fig. 1 the normalized temperature (T_c/T_c^{onset})

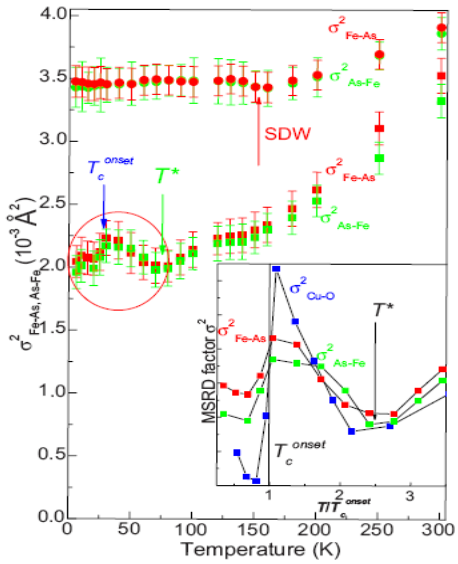

Fig. 1 Temperature dependence of Fe-As bond mean-square relative displacements for $LaFeAsO_{0.93}F_{0.07}$ (squares) and LaFeAsO (circles). The red symbols are derived from Fe *K* edge EXAFS measurements and the green symbols are derived from As *K* edge EXAFS measurements. The inset shows an enlarged view of low temperature (T<100 K) mean-square relative displacements (MSRD) for the $LaFeAsO_{0.93}F_{0.07}$ sample plotted as the function of normalized temperature (T/T_c^{onset} and the comparison with $La_{1.85}Sr_{0.15}CuO_4$.

dependence of the mean-square relative displacements for both $LaFeAsO_{0.93}F_{0.07}$ and $La_{2-x}Sr_xCuO_4$ samples. It can be seen that a sharp decrease in the mean-square relative displacement occurs exactly at T_c^{onset} in both systems. This result indicates that the local lattice instability might play an important role in the superconducting coherence in both systems.

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References

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