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Local Structure Study of Undoped T' Cuprate Superconductors

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Introduction

Cuprates are believed to be classified as charge transfer (CT) insulators because of strong electronic correlation. High-temperature superconductivity (HTSC) is found only after carrier doping host materails. The lanthanide cuprates Ln_2CuO_4 (Ln = lanthanide element) crystallize into the K_2NiF_4 (*T*) structure with an octahedral coordination that show superconductivity as Ln sites are replaced with alkaline earth ions such as Sr^{+2}. On the other hand, electron doping of Ln_2CuO_4 having the Nd_2CuO_4 structure (*T'*) with a square-planar coordination become superconductive at slightly lower temperatures as electron is doped. In both cases, cuprates are chemically doped with hetero-valency ions. On the contrary, the recent report of undoped superconductivity in *T'*-La_2CuO_4 by substituting La^{3+} sites with rare earth ions made this basic understanding controversial. In this work, polarized extended x-ray absorption fine structure (EXAS) is used to probe the local structure of *T'*-$(La^{3+},Y^{3+})_2CuO_4$ (LYCO) as a typical example of "undoped" superconductors. Our detailed analysis of the in-plane Cu-O_p radial distribution shows unusually large mean-square relative displacement indicating a large degree of local lattice distortion.

Experimental

All XAS measurements were performed in a fluorescence detection mode at BL-13B1, 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 Polarized Cu K-EXAFS data were collected for LSCO thin film single crystal samples under strain. Samples are mounted on an aluminum holder and attached to a closed-cycle helium refrigerator.

Results and Discussion

The nearest neighbor radial distribution function (RDF) was analyzed by a mean-square relative displacement for a particular *ij* pair σ^2_{ij}. Solid lines in Fig. 1 shows the experimental FT magnitude peak measured at 10 K for LYCO. The experimental data was fitted by a single scattering formula with theoretical phase shift functions and a reference $\sigma^2_{Cu\text{-}Op}$ taken from the data of *T*-LSCO (10 K). Fitting the experimental data with distorted models gave good agreement. Here we consider possible local distortions, such as distorted local structure model with short and long Cu-O_p distances separated by 0.1 Å. Such a distortion is likely to contribute to the metallic nature of undoped cuprates, which is against the populkar scenario of Mott insulators [1].

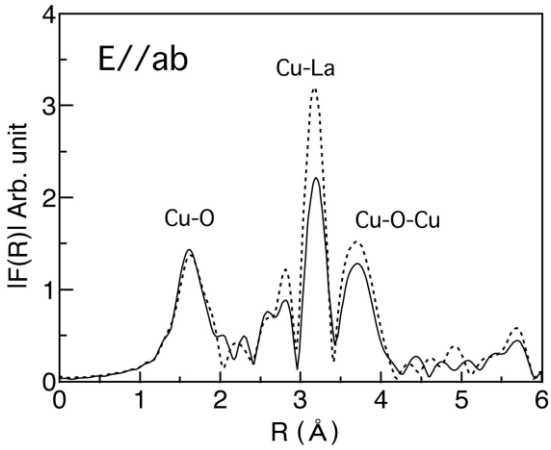

Fig. 1 FT magnitude of undoped LYCO

Reference

[1] H. Oyanagi et al., J. of Phis. And Chem. 2008, in press.

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