A HAADF-STEM study of incongruent defects in $Ca_{1-x}Sr_xCuO_2$

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Oxygen vacancies are known to affect electronic correlations in complex transition metal oxides and in particular high-T_c cuprates. In $XCuO_2$ (X = Sr, Ca), CuO_2 planes are separated by X and Cu is square planar coordinated [1]. This infinite layer structure of Cu has been proven to be challenging to synthesize and reactive molecular beam epitaxy (MBE) is capable to accomplish the goal of single crystals [2,3,4]. Similarity to recent advances on superconductivity in Pr_2CuO_4 [5], superconductivity is to be expected for infinite layer cuprates. As these undoped infinite layer cuprates have not been subjected to in-depth scrutiny in terms of crystalline defects, little is known on the defect formation itself. Here we present a systematic investigation of $Ca_{1-x}Sr_xCuO_2$ thin films with $0 \leq x \leq 1$ using double aberration corrected high-angle angular dark-field (HAADF) and bright-field (BF) high resolution scanning transmission electron microscopy (HRSTEM) and X-ray diffraction (HRXRD). $Ca_{1-x}Sr_xCuO_2$ thin films are grown on (110)$NdGaO_3$, (001)$(LaAlO_3)_{0.3}(Sr_2AlTaO_6)_{0.7}$ (LSAT), (001)$SrTiO_3$, and (110)$DyScO_3$ substrates by MBE. In contrast to X = Sr, the oxidizing potential of Ca is insufficient to terminate oxygen vacancies even by usage of RF oxygen as an oxidizing agent. Nonetheless the phase formation can be confirmed and HRSTEM analysis reveals a high defect concentration (columnar defects). While those defects deteriorate the sustainability of the CuO_2 plane, substitution of Ca by Sr is beneficial. In Fig. 1, reciprocal space map of $Ca_{0.95}Sr_{0.05}CuO_2$ thin film on LSAT shows that the film is coherently grown on the substrate. We find that $Ca_{0.95}Sr_{0.05}CuO_2$ thin films quenched under oxidizing conditions with ozone (~10^{-4} Torr) show superconductivity.

References

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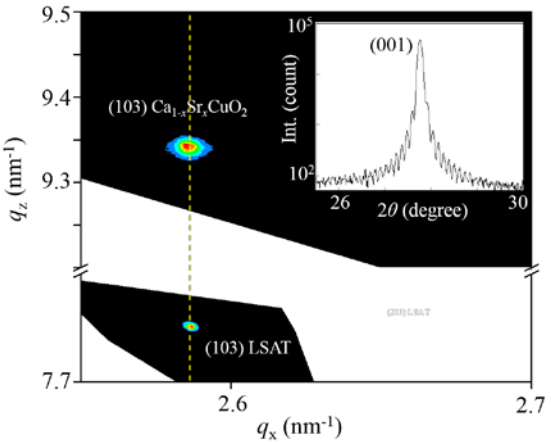

Figure 1. Reciprocal space map of $Ca_{0.95}Sr_{0.05}CuO_2$ thin film grown on LSAT. The inset shows $2\theta/\omega$ scan around the (001) peak of the infinite layer structure. The film thickness determined is 740 Å.