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Atomic-Resolution Imaging and In-situ EELS Study of Ferroelastic and Ferromagnetic Ordering in $LaCoO_3$

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The perovskite oxide $LaCoO_3$ has attracted increasing attention due to its reported room-temperature ferroelastic behavior,[1] and a ferromagnetic transition observed at around 80K in epitaxially strained thin films.[2] To advance our understanding of these properties, a combination of atomic-resolution Z-contrast imaging and electron energy-loss spectroscopy (EELS) with in-situ cooling experiments has been used to study the $LaCoO_3$ microstructures associated with the multiple ferroic transitions in bulk $LaCoO_3$.

In particular, $LaCoO_3$ exhibits a hysteretic stress-strain behavior as a ferroelastic material at room temperature. The coercive stress marks the point where the ferroelastic transitions occur. Therefore, we study polycrystalline $LaCoO_3$ samples compressed both above and below the coercive stress. By energy-loss magnetic circular dichroism (EMCD) method, we obtained angular-resolved EELS of Co L-edges at low temperature in the diffraction mode for $LaCoO_3$ compressed below and above the coercive stress.[3] (Figure 1) It suggest that there may be ferromagnetic transitions at low temperature for the polycrystalline $LaCoO_3$ sample compressed above the coercive stress.

Moreover, for untreated and compressed polycrystalline bulk $LaCoO_3$ samples, we find that both Co L_3/L_2 ratios are slightly different at room temperature and low temperature. (Figure 2) On the other hand, the Co L-edges does not change at room temperature and low temperature in pure single crystalline $LaCoO_3$. This unusual result may be caused by defects, oxygen vacancies or large concentration of twinning structure found in polycrystalline bulk $LaCoO_3$. (Figure 3) We study these defects in the polycrystalline LaCoO3 by atomic-resolution EELS.[3]

In this presentation, we will show how the microstructures in LaC-O_3 influence the ferromagnetic order in $LaCoO_3$. We will also explore the relationship between the observed ferroelastic and ferromagnetic properties of $LaCoO_3$.[4]

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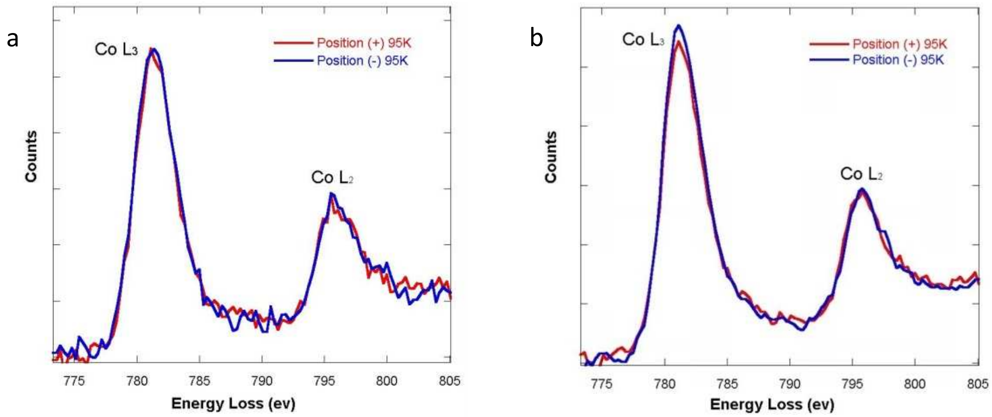

Figure 1: Angular-resolved EELS of Co L-edges at low temperature in $LaCoO_3$ compressed (a) below (b)above coercive stress following EMCD method

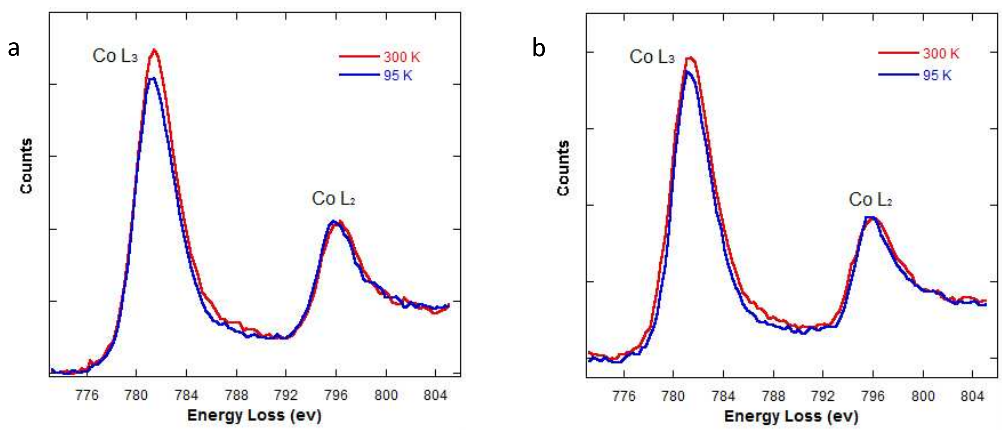

Figure 2: Angular-resolved EELS of Co L-edges for (a) untreated (b) compressed polycrystalline $LaCoO_3$ sample at room temperature and low temperature

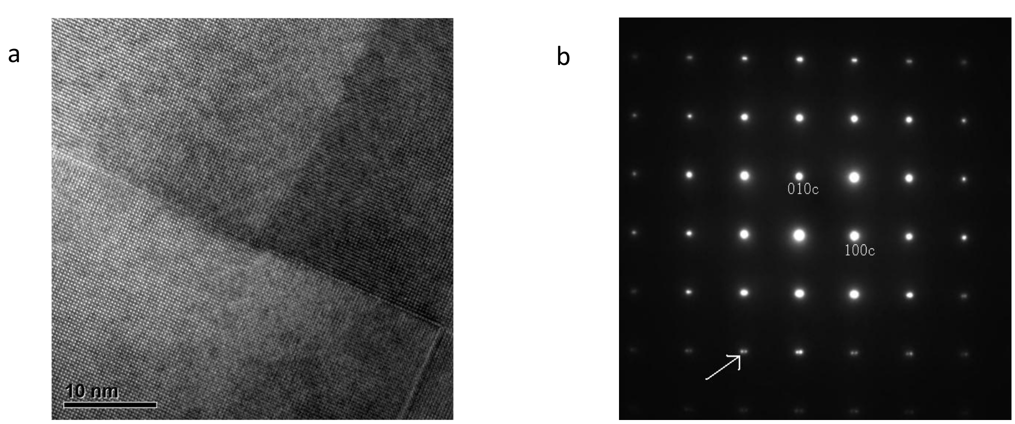

Figure 3: (a) High resolution image and (b) diffraction pattern of the twinning structure along [1 0 0] direction in untreated polycrystalline $LaCoO_3$ bulk sample. The splitting peak pointed by an arrow show the existence of the twinning structure.

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