Advances towards investigating electronic and optical transformation of La_2CoMnO_6

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Double perovskites have been of great interest over the last decades. One of its promising physical properties is the colossal magnetoresistance (CMR) effect. This effect is a metal-insulator transition describing the electronical and optical transformation of the material, such as the change in resistivity, when applying a magnetic field. In particular, La_2CoMnO_6 shows a CMR effect which is very sensitive to defects and strains as caused, e.g., by the lattice misfit between thin film and substrate. Thus, it is particularly important to characterise the CMR on the microscopic scale. In this work, we introduce a novel approach for detecting the CMR effect on the nanometre scale by means of electron energy loss spectrometry (EELS) in transmission electron microscopy (TEM) [1]. By combining valence EELS (VEELS) and energy loss magnetic chiral dichroism (EMCD) within this new approach, precise results concerning the change of the magnetisation and the resistivity both above and below the Curie temperature T_C are obtained.

The investigated La_2CoMnO_6 thin films exhibit a particularly interesting electronic and magnetic behaviour [2]. Thus, this material is an ideal model system for investigating the consequences of the CMR effect by means of TEM-EELS. Depending on the temperature and the external magnetic field, which is supplied by the objective lens of the TEM, a variation of the band gap width and, consequently, the resistivity is observed by means of VEELS. A qualitative change in the band gap observed at 40 keV is shown in fig. 1A. Moreover, a change of temperature influences the observed EMCD effect on the L-ionization edges of both Co and Mn as shown in fig. 2. To support these experiments, the spin-dependent electronic density of states is calculated by density functional theory (DFT) using the WIEN2k code [3]. These simulations corroborate that La_2CoMnO_6 is a half-metal (fig. 1B) at low temperatures. The insights gained by combining VEELS and EMCD at high spatial resolution open new possibilities for solving challenging questions in the field of nanotechnology and its application in high-end healthcare techniques as well as information technology systems, spintronics and multiferroics [4,5].

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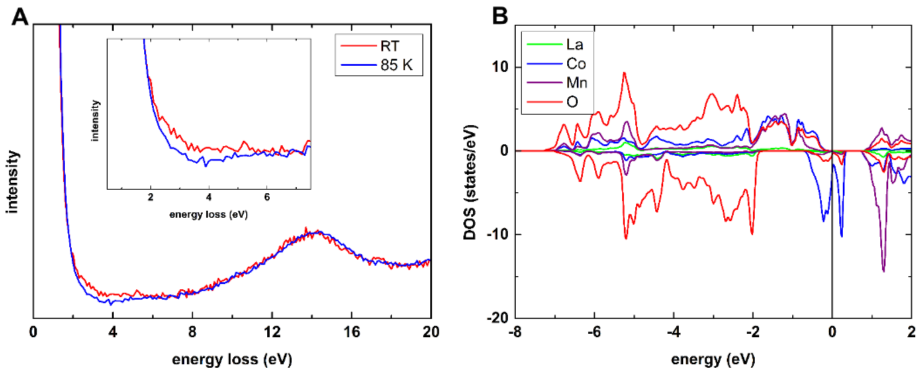

Figure 1: (A) Comparison of the VEELS data recorded at 85 K and at room temperature for 40 kV acceleration voltage. The inset shows the enlarged band-gap region. (B) Spin-polarized density of states of La, Co, Mn and O within the monoclinic phase $P2_1/n$ of La_2CoMnO_6.

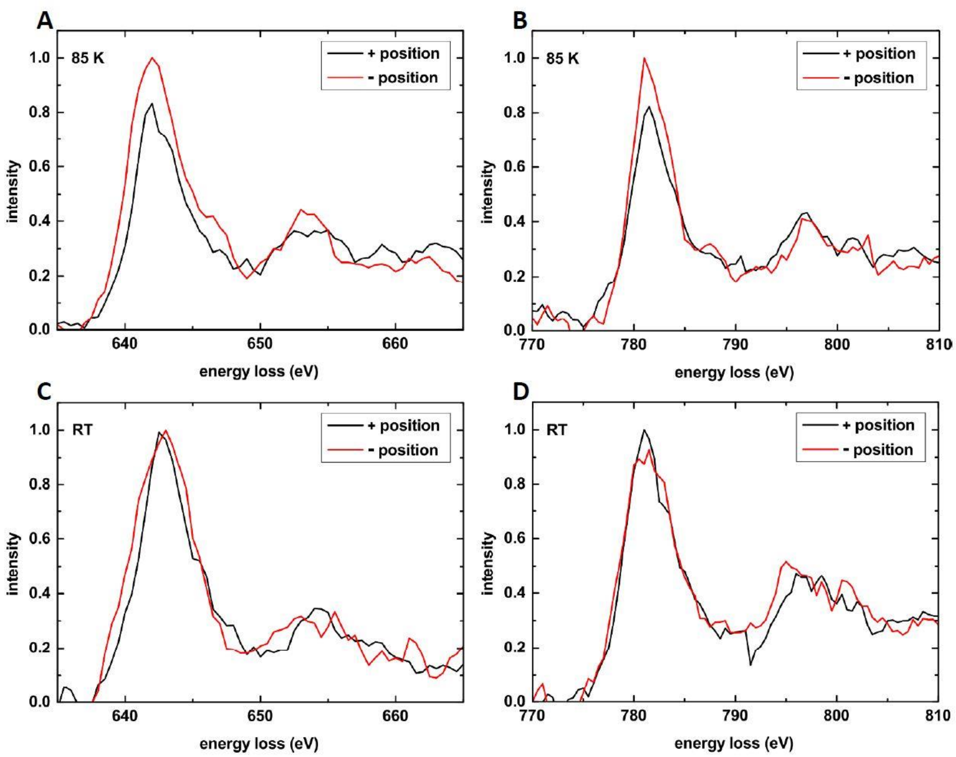

Figure 2: Normalised EMCD spectra of La_2CoMnO_6. The (A) Mn and the (B) Co edges show induced chiral electronic transitions at 85 K. At room temperature, no EMCD effect is observed in either (C) Mn or (D) Co.