

Chemical potential shift in $\text{Pr}_{1-x}\text{Ca}_x\text{MnO}_3$

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Introduction

Half-doped manganites have been a focus of recent studies because most of them exhibit a so-called CE-type antiferromagnetic (AFM) charge-ordered (CO) state. The compound $\text{Pr}_{1-x}\text{Ca}_x\text{MnO}_3$ (PCMO) in which the bandwidth W is small in comparison with other manganites has a particularly stable CO state in the broad hole doping region between $x = 0.3$ and 0.75 . CMR in the CO state of PCMO is remarkable [1]. The origin of the CMR effect has been debated in recent years since it was pointed out that double-exchange interaction alone is insufficient to explain the large resistivity change with magnetization [2]. Recently, the possibility of a phase separation (PS) scenario as the origin of the CMR effect has been discussed in theoretical and experimental work [3, 4]. In general, electronic "PS" results in the pinning of the chemical potential μ . Also, electronic "PS" on a nanometer scale, namely stripe formation would lead to the pinning of the chemical potential, in analogy to the case of high- T_C cuprates [5]. The chemical potential shift can be deduced from the core-level shifts as a function of carrier concentration by measurements of photoemission spectroscopy. In this paper, we report on a precise core-level photoemission study of the chemical potential shift $\Delta\mu$ in single crystals of PCMO as a function of carrier concentration.

Experimental

Single crystals of PCMO with the carrier concentrations of $x = 0.2, 0.3, 0.45, 0.5$ and 0.65 were grown by the floating-zone method. The photoemission spectroscopy measurements were performed at BL-2C of Photon Factory, High Energy Accelerators Research Organization (KEK) using photon energy of $h\nu = 800$ eV. All the measurements were performed under an ultrahigh vacuum of $\sim 10^{-10}$ Torr at room temperature. Clean surfaces were obtained by repeated *in situ* scraping with a diamond file.

Results and Discussion

We have deduced the chemical potential shift $\Delta\mu$ from a set of core-level shift data. The observed binding energy shifts with x are common to the O 1s, Ca 2p and Pr 4d

core levels, whereas the shift of the Mn 2p core level is different from them because of the additional chemical shift. Therefore, we consider that the shifts of the O 1s, Ca 2p and Pr 4d core levels are largely due to $\Delta\mu$, and take the average of the shifts of the three core levels as a measure of $\Delta\mu$ in PCMO.

In Fig. 1, we have plotted $\Delta\mu$ in PCMO thus deduced as a function of carrier concentration and compared that in LSMO [6]. For $0.2 \leq x < 0.3$, both $\Delta\mu$ curves show similar doping dependences in the sense that the shifts are monotonous. The difference between the two is clearly observed for $x \geq 0.3$, where the CO state occurs in PCMO but not in LSMO. Therefore, the different chemical potential shifts in PCMO and LSMO indeed reflect the CO in PCMO, and the μ pinning in the CO state of PCMO can be understood as due to the electronic "PS" such as stripe formation.

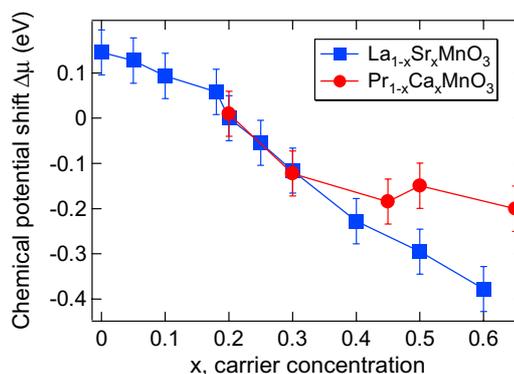


Fig. 1: Comparison of the chemical potential shift in $\text{Pr}_{1-x}\text{Ca}_x\text{MnO}_3$ with $\text{La}_{1-x}\text{Sr}_x\text{MnO}_3$ [6].

References

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