Photo-induced effect on the electron-spin resonance in $La_{0.5}Pr_{0.5}CrO_3$

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Abstract

We report the influence of light on magnetic properties of $La_{0.5}Pr_{0.5}CrO_3$. During the illumination of near-infrared light, photo-induced electron-spin resonance appears around the spin-canted antiferromagnetic transition at 261 K. Transient magnetization changes with the characteristic thermal activation energy of 130 meV. The present results open up an intriguing possibility of collective photo-induced magnetism in chromites.

Key words: chromite; transient magnetism; near-infrared light; electron-spin resonance

1. Introduction

The photo-induced phenomena in perovskite-type materials attract a considerable interest. In case of the photoconductivity in manganites and their films, there are two types of photo-induced effects. One is the persistent photoconductivity and the other is the transient one [1]. For example, $La_{1-x}Sr_xMnO_{3-d}$ with a mixed Mn^{3+} and Mn^{4+} shows ferromagnetic metal transition for $0.2 \leq x \leq 0.5$. Around the transition temperature, it shows the so-called colossal magnetoresistance. At small oxygen deficiency, the low-temperature metallic behavior in dark exhibits a persistent increase of photoconductivity upon a white light illumination. At large oxygen deficiency, the film is semiconductor in darkness and light induces a transient photoconductivity. In particular, an insulator to metal transition induced by near-infrared photocarrier excitation in charge-ordered state has been reported in a spin-canted antiferromagnetic (CAF) phase of $Pr_{0.65}Ca_{0.35}MnO_3$ [2,3]. Electron spin resonance (ESR) and X-ray diffraction have signed a melting of the charge-ordered phase by near-infrared light illumination [4,5]. Near-infrared light may induce a collective modification of the spin order as well as the orbital order via photo-excited charge transfer resonance between t_{2g} and e_g levels. As well as manganites, chromites have to be focussed in this respect. We report the transient photo-induced ESR in $La_{0.5}Pr_{0.5}CrO_3$. This compound shows a spin-CAF transition at 261 K (T_N) [6]. It is another candidature of photo-induced transient magnetism and/or conductivity coming from the electrons and spins of Cr^{3+} ($3d^3$).

2. Experimental Results and Discussion

The powder samples of $La_{0.5}Pr_{0.5}CrO_3$ were prepared by calcining the mixture of a prescribed amount of Pr_6O_{11} (99.9 %), Cr_2O_3 (99.98 %) and La_2O_3 (99.99 %). The mixture was ground, pelletized and fired in the air at 1100 °C for 24 h. Then, they were ground, pelletized again and fired in oxygen atmosphere at 1350 °C for 24 h. The crystal structure was assessed well with X-ray powder diffraction and the Rietveld analysis. The space group is Pnma, a = 5.475 Å, b = 7.741 Å, and c = 5.480 Å[7]. The magnetization indicated a spin-CAF transition at 261 K, i.e., T_N and it is in good quantitative agreement with the previous report [6]. X-band ESR was carried out using a JEOL JES-RE1X

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spectrometer with a 100 kHz filed modulation. Light illumination was performed with a 160 mW Nd-YAG laser with the photon energy 1.17 eV. Figure 1 exhibits the ESR profiles for a $La_{0.5}Pr_{0.5}CrO_3$ in dark (broken curves) and under light illumination (solid curves). A few sharp dips in 300 mT - 330 mT in the resonance profile are coming from Mn^{2+} diluted in MgO as a reference. The photo-induced ESR response is transient and its intensity gradually increases with increasing temperature up to 270 K. Above T_N, i.e., in the paramagnetic phase, the resonance intensity tends to grow up dramatically. No remarkable change of the ESR profile occurred upon light illumination in both $LaCrO_3$ and $PrCrO_3$. Thus, we conclude that the observed photo-induced magnetism is coming from the solid solution $La_{1-x}Pr_xCrO_3$ ($0 < x < 1$). Figure 2 shows the temperature dependence of the photo-induced ESR intensity, i.e., the transient magnetism. It decreases with decreasing temperature below 261 K and follows the thermal activation type with the characteristic energy of 130 meV. The photo-induced magnetization is enhanced above 261 K and the magnetization at 300 K was large. Time dependence of the magnetization before, during and after illumination was also measured. It is worth to note that the relaxation of the photo-induced magnetism is rather rapid. Further study will include the measurements of the spectral dependence of the photo-induced magnetism. The precise mechanism of the near-infrared photo-induced magnetism in $La_{0.5}Pr_{0.5}CrO_3$ is not clear in the present stage. It may be important that Cr^{3+} ($3d^3$) is mostly similar to Mn^{4+} ($3d^3$). Either spin is $S = 3/2$ in t_{2g} state. By analogy with the manganites, the irradiated photons excite the t_{2g} electrons to the e_g state. They contribute to the ESR above T_N. Below T_N, according to the CAF order, the activation energy 130 meV is necessary to get a photo-excited spin state due to some kind of collective mechanism. The present results open up an intriguing possibility of collective photo-induced magnetism in chromites.

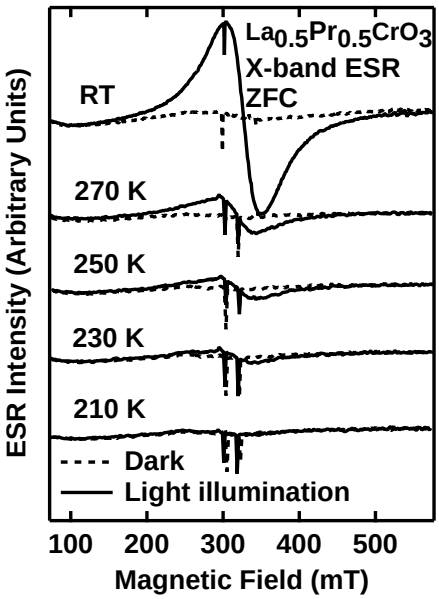

Fig. 1. Temperature dependence of the X-band ESR intensity in powder form $La_{0.5}Pr_{0.5}CrO_3$. Broken and solid curves show resonance profiles under dark and under light illumination, respectively. They are taken in heating after the zero-field cooling.

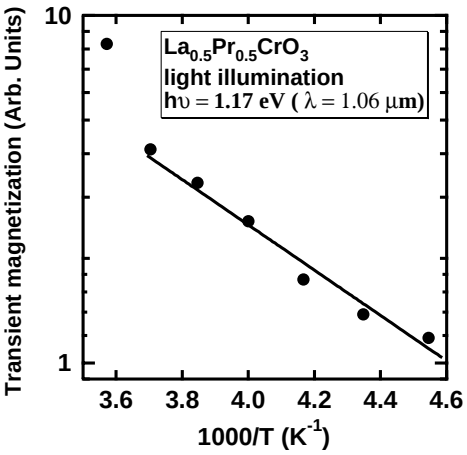

Fig. 2. Light-induced transient magnetization as a function of temperature in powder from $La_{0.5}Pr_{0.5}CrO_3$.

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