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Relaxor ferroelectric behavior in $Tb_{1-x}Ca_xMnO_3$

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Abstract

A discovery of ferroelectricity induced by the change of magnetic order state has received much interest in material research. In class of material, namely multiferroic, the spatial inversion symmetry and the time reversal symmetry are simultaneously broken. This occurs due to a strong coupling between the magnetization and polarization in this material. This has offered a flexibility to change the polarization by applying magnetic field or to change the magnetization by applying electric field, and also has challenged to use this material for nonvolatile data storage where the information could be written electrically and read magnetically.

Most of the study in the magnetic ferroelectric system has been focused to increase the coupling strength between magnetization and polarization order parameter and to make the ferroelectric transition higher. However the effect of introducing charge carriers in the multiferroic materials has not been much explored yet. To study this effect, we have synthesized and characterized the crystallographic and magnetic structure, magnetocapacitance, and electric polarization of the Ca-doping in single-crystal, $Tb_{1-x}Ca_xMnO_3$ with x less than 0.1. At low doping x=0.05, the presence of Mn^{4+} ions gives rise to a state with behavior resembling that of a relaxor ferroelectric. The neutron scattering measurement show that the coherence length of the Mn magnetic spin spiral is reduced, while the Mn-modulation wave vector is unchanged. For doping larger than 5%, the ferroelectric state is suppressed, which we ascribe to breakdown of the spiral magnetic structure [1]. In order to understand the change of spiral magnetic structure in magnetic field, we also investigate the field dependent measurement of electrical polarization of the $Tb_{1-x}Ca_xMnO_3$ single crystal and neutron diffraction in magnetic field. A cross over from ferroelectric to relaxor behavior is observed at x=0.02 at temperature close to the ferroelectric transition. The commensurability of the spiral and the field-induced crossover mechanism which involves the coherence length will be presented [2].

[1] M. Mufti, A. A. Nugroho, G. R. Blake, and T.T.M. Palstra, Phys. Rev. B 78, 24109 (2008)
[2] M. Mufti, A. A. Nugroho, G. R. Blake, and T.T.M. Palstra, submitted for publication (2009)