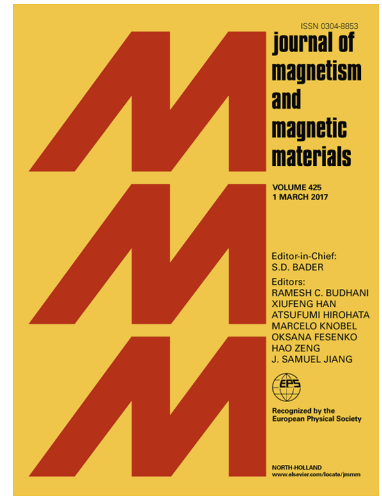

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Magnetooptical response to tunnel magnetoresistance in manganite films with a variant structure

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Abstract. The optical, magnetooptical, electrical, and magnetic properties of $La_{0.67}Ba_{0.33}MnO_3$ films grown on the $SrTiO_3$ and $ZrO_2(Y_2O_3)$ substrates have been studied. The temperature and magnetic field dependences of magnetotransmission of light in the $La_{0.67}Ba_{0.33}MnO_3/ZrO_2(Y_2O_3)$ film with a variant structure exhibit features which can be attributed to an optical response to tunnel magnetoresistance - tunnel magnetotransmission. Unlike the optical response to colossal magnetoresistance, existing near the Curie temperature only, the tunnel magnetotransmission increases at $T \to 0$ K, has a complex hysteresis behavior with the change of sign of the effect, and saturates in magnetic fields above 1 kOe. The observed tunnel magnetotransmission has been interpreted within the magnetorefractive effect theory developed for granular films.

1. Introduction.

Numerous works have been devoted to identification of the physical mechanisms of optical response to colossal magnetoresistance (CMR) in doped manganites (see, for example, [1,2] and references therein). Such response can be considered as magnetoreflection and magnetotransmission effects which take place in the CMR manganites in the infrared spectral range near the Curie temperature (T_C). Apart from CMR in granular manganite-based systems there exists the specific low-temperature magnetoresistance (MR) which is due to scattering and tunneling of spin- polarized charge carriers thorough grain boundaries – the so-called tunnel magnetoresistance (TMR) [3]. Noticeable TMR values were observed in manganite films with an equivalent (variant) structure [4]. Such structure can be formed during growth of manganite films on the $ZrO_2(Y_2O_3)$ single crystalline substrates and can be considered as consisting of a set of identical crystallites – structural domains of equal size with fixed number and concentration of coherent high-angular boundaries within the film volume. This is the main structural difference from polycrystalline films. The variant structure leads to formation of highly conductive ferromagnetic nanosized grains (crystallites) separated by lowly conductive grain boundaries. As a result an additional contribution to MR associated with TMR appeares [4-7]. Taking into account different temperature dependences of CMR(T) and TMR(T) it is easy to separate their contributions to the total MR(T) dependence by choosing the manganite composition with high T_C, for example, the $La_{2/3}Ba_{1/3}MnO_3$, and wide temperature range of interest. Though the TMR in manganites is well-known, however, there is clear lack of evidences for optical response to tunnel magnetoresistance. Earlier the optical response to TMR was considered theoretically for granular allows [8] and metallic superlattices [9,10]. As far as we know the few experimental attempts [11,12] to reveal an optical response to TMR in manganites have not been successful. The main problem of these attempts is in the absence of low-temperature optical measurements (close to zero Kelvin) and high absorbance of manganites in a ferromagnetic state. In this work, we have made a comparative analysis of experimental data on optical properties and electrical resistance for the thin $La_{0.67}Ba_{0.33}MnO_3$ films in the presence and absence of the variant structure in the wide temperature range. As a result, the contribution of optical response to TMR in magnetotransmission of unpolarized light was revealed.

2. Materials and methods

Epitaxial films of the $La_{0.67}Ba_{0.33}MnO_3$ composition with the thickness of d = 80 nm were grown on the single-crystal $SrTiO_3$ (001) (the cubic lattice constant a_0 = 3.905 Å), hereafter denoted as LBMO/STO, and