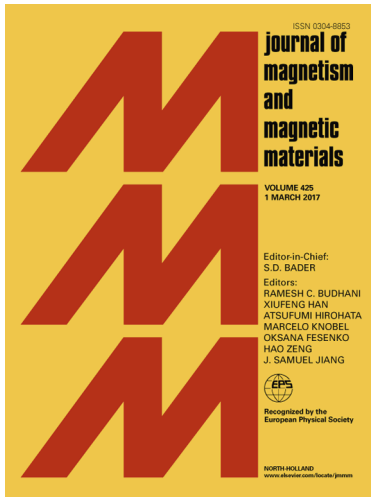

Magnetoelectric effects in a layered ferromagnet-electrostrictor heterostructure

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Magnetoelectric effects in a layered ferromagnet-electrostrictor heterostructure

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Abstract. Magnetoelectric (ME) effects in a heterostructure consisting of mechanically coupled layers of amorphous ferromagnet FeBSiC and electrostrictive lead magnesium niobate - lead titanate (PMN-PT) ceramics are observed and investigated. Magnetoelectric characteristics of the structure strongly differ from those of the ferromagnetic-piezoelectric one. The FeBSiC-PMN-PT structure did not show the direct ME effect under excitation with an alternating magnetic field. For the converse ME effect, when the structure was excited with alternating electric fields, the frequency doubling and mixing of electric fields frequencies were observed. Nonlinear ME effects arise due to the nonlinear electrostrictive strain vs electric field dependence. Efficiency of nonlinear ME conversion is proportional to the piezomagnetic coefficient of the ferromagnetic layer, nonlinear electrostriction coefficient of the electrostrictive layer, and amplitudes of the excitation fields. A theory for nonlinear ME effects in the ferromagnet-electrostrictor heterostructures was developed.

Keywords: magnetoelectric effect, composite heterostructure, magnetostriction, electrostriction, frequency doubling, frequency mixing.

1. Introduction

Magnetoelectric (ME) effects in composite structures consisting of mechanically coupled ferromagnetic (PM) and piezoelectric (PE) layers have been intensively studied in recent years due to prospects of their application for design of high-sensitivity magnetic field sensors, data storage elements, tunable microwave devices, and magnetic energy harvesters [1-3]. The ME effects are manifested as a change in the structure polarization P under the action of a magnetic field H (direct effect) or a change in the structure magnetization M (or an induced anisotropy field) under the action of an electric field E (converse effect). The ME effects arise due to combination of magnetostriction of the FM layer and piezoelectricity of the PE layer through mechanical coupling between the layers [4].