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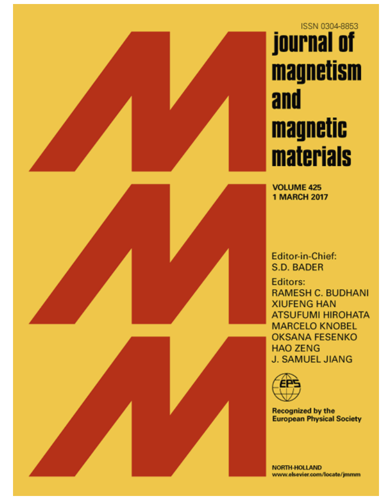

Thermoelectric effects of resonant magnetic tunnel junctions

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Thermoelectric effects of resonant magnetic tunnel junctions

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Abstract

Thermoelectric effects of CoFeB/MgO/InP/MgO/CoFeB double-barrier magnetic tunnel junctions (DBMTJs) are presented in the linear response regime. The nonequilibrium Green's function (NEGF) formalism is used within the effective mass approximation. There are descriptions of temperature and angular dependence for thermoelectric properties. The results show an enhancement in the DBMTJs thermoelectric compared to single-barrier MTJs due to the resonant tunneling effect through the DBMTJs. It is also found that the Seebeck coefficients may be increase in asymmetric DBMTJs. Effects of the temperature and magnetization alignments on the spin-dependent Seebeck coefficients are also described. Finally, the Seebeck coefficients are investigated considering the Rashba spin-orbit coupling at the insulator/semiconductor interfaces.

Keywords: Thermoelectric effects; double-barrier MTJs; Indium Phosphide (InP); resonant tunneling effect;

1. Introduction

Thermoelectricity -electricity made by a temperature difference- has attracted huge attention due to device applications [1] for instance magnetic memory technologies as heat-assisted magnetic recording [2].

Thermoelectric (TE) effects in nano-structures have shown an enhancement compared to those in bulk structures because of the localized states and phonon scattering [3, 4]. The pragmatic significance of the TE effects becomes apparent from the chance of converting waste heat into electricity. Therefore, the significant figure of merit is the metric of thermoelectric performance generated from a temperature difference.

The energy conversion efficiency of the TE materials is explained by the dimensionless figure of merit as $ZT = S^2GT/(\kappa_e + \kappa_p)$, where S denote the Seebeck coefficients, G the electrical conductance, T the average temperature and $\kappa_e(\kappa_p)$ the electronic (phononic) contribution to the thermal conductance. Although the electrical conductance arises only from electrons, the thermal conductance also contains a contribution from phonons as it describes the vibrations of the atoms consisting of the solid lattice. Many of theoretical and experimental works have been done to improve the TE figure of merit by new materials [5, 6] such as nanowires [7, 8], quantum wells [9, 10] and superlattices [11, 12]. In some experiments [13-15], a high figure of merit is related to suppress of phononic contribution.

Magneto-thermoelectric and interfacial transport of ferromagnetic-paramagnetic systems are studied by Johnson and Silsbee about thirty years ago [16]. The non-equilibrium phenomena connected with interaction of spins and heat currents in magnetic nano-structures is investigated by the field of spin caloritronics [17, 18].