Highly tunable spin Hall magnetoresistance in room-temperature magnetoelectric multiferroic, $Sr_3Co_2Fe_{24}O_{41}$|Pt hybrids

Aditya A. Wagh,[1] Priyanka Garg,[1] Kingshuk Mallick,[1] Suja Elizabeth,[1] and P. S. Anil Kumar[1]

[1] *Department of Physics, Indian Institute of Science, Bangalore, India*

In this study, we investigate the spin transport properties of a room-temperature magnetoelectric multiferroic polycrystalline $Sr_3Co_2Fe_{24}O_{41}$|Pt heterostructure with a highly tunable transverse conical magnetic phase that results in static and dynamic magnetoelectric coupling[1,2]. By measuring the angular dependence of spin Hall magnetoresistance (SMR) at constant magnetic fields (H) ranging from 50 to 100 kOe, we observe negative SMR below a critical field of H $\approx$ 2.5 kOe, with a negative gradient in the H-evolution of normalized SMR ($\frac{\Delta R}{R} \times 100\%$). As the field is increased, a positive slope of $\frac{\Delta R}{R} \times 100\%$ vs. H is observed, and at higher fields around 14 kOe, a crossover from negative to positive SMR is observed. We employ a simple model to estimate the equilibrium magnetic configuration and compute the SMR modulation at various values of H. We propose that the tilting of the cone is dominant and responsible for the observed nature of SMR below 2.5 kOe, while the closing of the cone-angle is pronounced at higher fields and causes a reversal in the sign of the SMR from negative to positive. Importantly, our SMR experiments reveal that a change in the helicity with a reversal of the magnetic field has no influence on the observed SMR. We also measure a longitudinal spin Seebeck effect (LSSE) signal of $\approx$ 500 nV at 280 K under the application of a thermal gradient (ΔT = 23 K) and a field of 60 kOe. The observed LSSE signal, which originates from pure magnon spin current, exhibits an H-dependent behavior similar to that of the magnetization of $Sr_3Co_2Fe_{24}O_{41}$. Our detailed spin transport studies on the polycrystalline $Sr_3Co_2Fe_{24}O_{41}$|Pt heterostructure demonstrate the high tunability of the amplitude and sign of the SMR, highlighting its potential for novel spintronic devices, such as SMR-based spin valves[3] and voltage-controlled spin transport devices.

References:

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