Temperature and Frequency Dependent Spin Pumping in NbN/Ni81Fe19 Bilayer Thin Films

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A flow of spin angular momentum with no net charge current, called pure spin current, is a key to fabrication of energy efficient spintronic devices. Such no-charge-based devices are in great demand owing to information transfer without Joule heat loss. One way to generate pure spin current is via ferromagnetic resonance spin pumping [1,2] using the dynamic transfer of spin angular momentum from a precessing ferromagnet into an adjacent nonmagnet. The spin current can be detected electrically using the inverse spin hall effect (ISHE) phenomena. Recent spin pumping studies in superconducting spintronics [3,4] have shown that superconductors could be used towards future low-energy computing technologies. It has been reported via ferromagnetic resonance experiments that induced spin currents can be amplified by adding a strong spin-orbit coupled spin sink layers in a superconductor/ferromagnet hybrid structure and will be key for superconducting spintronics. Therefore, this makes essential to study the spin pumping in other superconductor/ferromagnet hybrid structure, where superconductor exhibit higher superconducting transition temperature (T_C), and investigate magnetodynamic properties below and above the (T_C).

We report broadband ferromagnetic resonance spin pumping experiments, for temperatures ranging from 300 K - 4 K and frequencies from 2 GHz - 12 GHz, on NbN/ $Ni_{81}Fe_{19}$ hybrid structures. The NbN thickness was varied from 40 nm - 140 nm, whereas $Ni_{81}Fe_{19}$ was kept at 15 nm. We observed a systematic shift in ferromagnetic resonance fields, amplitude, and linewidths as a function of frequency and temperature. We observed disappearance of the ISHE voltage below the T_C of NbN thin films, indicating the suppression of spin current below the T_C. The spin mixing conductance, spin current density, and estimated spin hall angle values showed strong temperature dependence.

References:

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