Generation of femtosecond spin-current pulses at Fe/MgO interface by quasi-static voltage

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The generation of short spin-current pulses is essential for fast spintronic devices. So far, spin current pulses are generated by femtosecond laser pulses which drive spins from a ferromagnetic metal layer. This transient spin current may be used to emit terahertz electromagnetic pulse through inverse spin-Hall effect [1]. However, the need for miniaturization, simplicity and energy efficiency favours electric field control of spintronic devices over optic control. We demonstrate theoretically that the voltage-driven instability of the electronic structure at the Fe/MgO interface results in the generation of the femtosecond spin-current pulse. We show by numeric simulations that spin-dependent screening at dielectric-ferromagnetic metal interface contributes to the spin-polarized current generation in the system subjected to the ac voltage [2]. Then, we show that spin current driven by spin-dependent screening may be used to modulate spin-wave amplitude in bilayer ferromagnetic system [3]. Finally, we combine ab initio calculations of electronic density of states at MgO/Fe interface with continuous model for charge transport. We show that the voltage-driven electron charge accumulation at MgO/Fe interface leads to the Stoner instability because of the electronic interface resonant states. This instability manifests itself in the spin-current and spin accumulation femtosecond pulses which are present because of the contribution of the dynamic spin-dependent potential to the spin-polarized current.

References:

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