Generation of Terahertz Transients from $Co_2Fe_{0.4}Mn_{0.6}Si$ Heusler alloy/ Heavy-Metal Bilayers

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The detailed understanding of the spin-to-charge conversion process has been gaining importance due to intended applications for high speed spin-based electronic devices. It has been shown recently, that spin-to-charge conversion via the inverse spin-Hall effect (ISHE) can be employed for the generation of electro-magnetic transients showing frequency content extending up to the Terahertz (THz) frequencies [1]. In the present work we generated pulses of THz radiation by optical excitation of $Co_2Fe_{0.4}Mn_{0.6}Si$ (CFMS)/Heavy Metal (HM) bilayers. CFMS is a half-metal with a band gap in one spin channel and hence shows, in the ideal case, a 100% spin polarization at the Fermi level, which is expected to result in substantial enhancement of interfacial spin current polarization [2]. We compared the efficiency of THz transients for four CFMS/HM bilayers, where HM stands for either Pt, Ta, Cr or Al. Our results show the highest THz amplitude for the CFMS/Pt bilayer. Furthermore, we demonstrate the tunability of the THz amplitude by an external magnetic field and observe the opposite THz polarity for reversed field directions. We ascribe the generation process to the ISHE [3]. In order to investigate the role of the interface in THz generation efficiency, we measured spin-mixing conductances, characterizing the CFMS/HM barrier spin transparency using a ferromagnetic resonance (FMR) experiment and compared it with the THz peak amplitudes. Our measurements show that, although the efficiency of THz generation is mostly governed by spin-orbit coupling, the barrier transparency, as well as spin diffusion length and spin current density play an important role.

References:

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