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Ultrafast Transport of Laser-Excited Spin-Polarized Carriers in Metallic Multilayers[1]

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The ultrafast spin dynamics induced by a transport of spin polarized carriers is a hot topic motivated by the fundamental interest in magnetic excitations and applications like spintronics and data storage. To understand underlying elementary processes typically occurring on femtosecond time scales, we have developed a time-of-flight-like approach that probes the spin dynamics induced by hot carriers (HC) and demonstrated a *spin polarized* HC transport through an epitaxial Au/Fe/MgO(001) structure. Using a back pump-front probe configuration, we establish that HC induced in Fe by the pump laser pulse can form a nearly *ballistic* spin current (SC) in Au. Optical second harmonic (SH) generated at the Au surface by the probe pulse monitors the transient surface HC density and spin polarization (SP). Since HC with different SP are excited in Fe to different final energies and consequently have different lifetimes in Au, the HC pulse has steep leading part formed by ballistic HC with the negative SP and shallow trial part formed by diffusive HC with the positive SP. This leads to the SC sign change within the 1 ps overall SC pulse duration. We also make a step towards understanding the origin of laser-induced ultrafast demagnetization overcoming the limited ability of conventional pump-probe schemes to distinguish photon-, electron-, and phonon-mediated effects. Comparing the SH response of Fe to the direct optical excitation with that to the excitation by hot carriers generated in Au, we rule out coherent effects of the pump pulse electromagnetic field and show that the HC-induced spin dynamics is responsible for the ultrafast demagnetization.

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