ULTRAFAST DYNAMICS OF HOT ELECTRONS AND HOLES BY FEMTOSECOND PHOTOELECTRON SPECTROSCOPY IN AU/FE/MGO(001)

F. Kühne[1], Y. Beyazit[2], D. Diesing[1], P. Zhou[2] and U. Bovensiepen[2]

[1]University of Duisburg-Essen, Faculty of Chemistry, Universitätsstr. 5, 45711 Essen, Germany
[2]University of Duisburg-Essen, Faculty of Physics and Center for Nanointegration Duisburg-Essen (CENIDE) Lotharstr. 1, 47048 Duisburg, Germany
Florian.kuehne@stud-uni.due.de; www.uni-due.de/agbovensiepen

Optically excited electrons and holes are of particular interest in modern solid state physics because they allow a microscopic understanding of the interactions in non-equilibrium states. Excited charge carriers in metals and semiconductors relax on a femto- to picosecond timescale due to electron-electron(e-e) and electron-phonon(e-ph) scattering. Here we want to discern the relaxation by such local inelastic processes and non-local transport. To analyze the ultrafast dynamics of charge carriers, femtosecond time-resolved linear photoelectron spectroscopy was applied. This work is a continuation on previously performed two-photon photoelectron spectroscopy experiments [1] and provides complimentary data above and below the Fermi energy E_F. By comparing results obtained in our pump-probe experiments by front side as well as backside pump excitation, we can separate the contribution of non-local transport effects from local effects, like electron-electron(e-e) and electron-phonon(e-ph) scattering. Here, we report on first experimental results obtained by using 1.55 eV pump and 6 eV probe photons on an Au/Fe/MgO(001) epitaxial heterosystem. In case of the back side pump configuration, hot electrons are excited in the Fe layer, which are injected into the Au layer and propagate to the surface, where they are probed by photoelectron emission spectroscopy with 6 eV photons. In the back pump data, we can observe a positive shift in the time delay of the intensity built-up and maximum in comparison to the front pump data, we attribute this difference to transport effects due to propagation of the hot electrons through the Au layer. We will present an energy and thickness dependent analysis of the propagation and relaxation times τ of electrons and holes above and below E_F, as well as an analysis of the electron-phonon(e-ph) coupling occurring at later times. We observe a higher relaxation time τ for thicker Au films, this can be explained by the presence of an Fe layer exhibiting a much faster bulk relaxation time τ than in Au. For thicker Au films this Fe-Au interface contribution recedes and the relaxation time τ increases. Furthermore, a slow decaying intensity component after 500 fs, which persists at longer time delays up to 2 ps, is assigned to effects of electron-phonon(e-ph) coupling. In this poster the difference of local relaxation and non-local transport mechanisms will be discussed.

This work was funded by the Deutsche Forschungsgemeinschaft through the Collaborative Research Center CRC 1242 (project number 278162697).

[1] Y. Beyazit, J. Beckord, P. Zhou, J. Meyburg, F. Kühne, D. Diesing, M. Ligges, U. Bovensiepen; https://arxiv.org/abs/1910.14309