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 photoelectron spectroscopy was applied. In our pump-probe experiments front side as well as back side pump excitation was used. By comparing the obtained results, we can separate the contribution of non-local transport effects from local effects, like electron-electron(e-e) and electron-phonon(e-ph) scattering. 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. Here, we report on first experimental results obtained by linear photoelectron spectroscopy using 1.55 eV pump and 6 eV probe photons on an Au/Fe/MgO(001) epitaxial heterosystem. In case of the back side configuration, the pump beam excites hot electrons in the iron layer, which are injected into the gold layer and propagate to the surface, where they are probed by photoelectron emission spectroscopy with 6 eV photons. By looking at the back pump data we can show a positive shift in the time delay of the intensity built-up and maximum in comparison to the front pump data, where the maximum intensity occurs earlier. This we attribute to transport effects during propagation of the hot electrons through the gold layer. In the case of different gold thicknesses, we observe a generally higher relaxation time τ for thicker gold films, this can be explained by the presence of an iron layer with a much faster bulk relaxation time τ, or smaller mean free path for the electrons. The experimentally measured relaxation time τ consists of the different possible decay channels and contains a higher fraction of iron for smaller gold thicknesses due to the mean free path of the electrons in gold. This effect is more pronounced for the back side, than the front side geometry. Furthermore, a slow decaying intensity component after 500 fs, which persists at longer time delays, can be seen and 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. It will highlight the differences between front and back side geometry, showing a delayed peak intensity for back side excitation. 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.

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