Coherent and incoherent dynamics of electrons at surfaces and interfaces probed by time-resolved two-photon photoemission

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Time-resolved two-photon photoelectron spectroscopy (2PPE) has been proven to be an ideal tool for the investigation of electron dynamics at solid surfaces. In most studies the incoherent population dynamics of electronic surface states at clean or adsorbate covered surfaces as well as of bulk states in a near surface region have been investigated. In my talk I will discuss two new developements for the application of 2PPE to the study of coherent and incoherent dynamics of excited electrons at surfaces as well as at interfaces.

In the first part, I will show for the system Ar/Cu(100) how in favourable cases the incoherent population dynamics of electronic states located at the interface between a metal and an insultator can be investigated by 2PPE, despite the fact that these states are buried under films as thick as 20 nm. Time-resolved experiments as a function of layer thickness and parallel momentum reveal two distinct decay channels: elastic tunneling through the Ar film and inelastic decay by electron-hole-pair excitation in the metal which can be divided into interband decay to bulk states and, for finite parallel momentum, intraband relaxation of electrons towards the band minimum.

In the second part, I will demonstrate how the coherent dynamics of electrons can be studied by the optical generation of a lateral current at a surface. The current is generated by electronic excitation using two phase-locked ultrashort laser pulses with different frequencies. The direction of this coherent dc-current can be controlled by the relative phase between the excitation pulses. Detection of the current by time- and angle-resolved photoemission allows the study of elastic and inelastic scattering of the excited electrons in the time-domain. The application of interferometric techniques gives access to the dynamics of the polarization which is induced by the primary excitation.