Multiple Auger processes in Graphene

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Resonant decay processes of graphene systems have been studied by resonant photoemission (resPES) and X-ray absorption spectroscopy (XAS). The π*-resonance is sensitive for structural details (defects, substrate distance and screening) and is used to identify the degree of localization of the lowest unoccupied states in the conduction band.

The influence of the substrate and interlayer coupling manifests itself in the appearance of different multiple Auger decays at the π*-resonance. Its appearance and spectral intensity is a measure for the magnitude of perturbation of the π-cloud in graphene.

In HOPG, as a reference system for many layer graphene with strong layer interaction, we find remarkable difference in the profile of the Auger decay between π* and σ*–band, which we attribute to an additional multiple-Auger in the π-system with a three-hole (3h) final state [1]. For graphene flakes the 3h decay is replaced by a characteristic Auger-gain (-4h) and Auger-loss (+4h) process at the π*-resonance.

A prerequisite for the appearance of this decay mechanism is the existence of localized excitonic states, which cause the appearance of the multiple Auger decay. We can distinguish between inter-layer (3h) and intra-layer excitons (±4h).

Through monolayer graphene – metal substrate interaction this characteristic Auger decay vanishes. Instead we observe a characteristic pre-edge structure at 284.5eV photon energy in the total electron yield XAS spectra [2].

We will show that the pre-edge peak reported for graphene on metal substrates is not due to doping but due to a low energy Auger decay.

In consequence it is necessary to avoid metallic substrates in order to study the pristine free carrier properties of graphene.

[1] M. Richter, D. Friedrich, D. Schmeißer, Physica E (2013), accepted.
[2] M. Richter, I. Paloumpa, D. Friedrich, D. Schmeißer, ECS Trans. (2013), accepted.