# Characterization of Reaction Layers Between Metals and Organic Thin Films with Hard X-ray Photoelectron Spectroscopy (HAXPES)

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In organic electronics applications, interfaces between metal contacts and organic semiconductors are ubiquitous. These interfaces are, however, not ideal in the sense that there is a sharp and abrupt transition between the metallic phase and the organic material. Instead, both materials are separated by an interphase region which is formed by chemical reactions between the metal and the organic semiconductor.
In order to characterize and, eventually, gain precise control over this interphase region we deposited metals (Ca, Co and Fe; thickness ~ 5nm) in an ultrahigh vacuum environment onto tetrapyrrole and oligothiophene films (thickness > 25 nm). In these systems, the organic molecules undergo well defined chemical reactions with the metals, which allows to distinguish between reacted and unreacted molecules with X-ray photoelectron spectroscopy (XPS). Because interphase regions can extend significantly into the organic bulk material, we enhanced the depth resolution in our experiments by applying hard X-ray photoelectron spectroscopy (HAXPES) with photon energies between 2 and 7 keV. With this method, we were able to estimate the concentration profiles of reacted and unreacted species in the interphase region and determine the depths up to which the reaction zones penetrate the organic layers. Furthermore, we systematically varied process conditions, such as temperature and metal deposition rate, to influence the reaction rates and gain control over the interphase region.