Highly-Sensitive Ultraviolet Photoelectron Yield Spectroscopy: A versatile technique for materials analytics

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Abstract (plain Text, max. 2000 Characters): UV based Photoelectron spectroscopy (PES), is used to investigate the density of occupied states (DOS) of the energetically shallow states of metals, semiconductors, and their interfaces. Conventionally, the incident photon energy (Eph) is kept constant, mostly using He-I emission (hv = 21.2 eV, He-UPS), while the count rate of photoelectrons is measured as a function of their kinetic energy, In most cases, the S/N ratio for He-UPS is not sufficient to reliably determine defect densities and their distribution in the band gap of semiconductors.

Here, we present a much less common PES technique, Constant Final State Yield Spectroscopy (CFSYS)[1]: Eph is varied and the electron analyzer detects photoelectrons at a constant kinetic energy, i.e. a fixed final state. We use near-UV excitation from a Xenon white-light source coupled and a double grating monochromator yielding Eph ≈ 4-7 eV. This can result in a 3-4 orders of magnitude higher dynamic as compared to He-I UPS, allowing for the direct measurement of very low defect densities.[1]

We present several recent examples demonstrating the applicability and advantages of CFSYS, for a) detection of defect distributions, e.g. in solar cell absorbers such as Lead-Halide Perovskites,[2,3] b) considering surface photovoltage in highly photoactive absorbers, and c) resolving interface energetics of hetero interfaces.[4]. To further develop this technique towards even greater sensitivity and using higher excitation photon energies, thus enabling e.g. valence band spectroscopy in wide gap semiconductors, it is envisaged to leverage know-how from VUV/EUV metrology and other applications.

[1] Korte, L., and M. Schmidt DOI: 10.1016/j.jnoncrysol.2007.09.010

[2] Levine, Igal, et al. DOI: 10.1021/acs.jpcc.0c11627

[3] Menzel, Dorothee, et al. DOI: 10.1021/acsami.1c10171

[4] Menzel, Dorothee, et al. DOI: 10.1002/aenm.202201109