Perovskite interfaces for solar cells investigated with photoelectron spectroscopy

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Lead halide perovskites have drastically changed the solar cell research field due to their ease of synthesis and high power conversion efficiencies, which now reach over 25%. Improving stability and understanding degradation pathways in these devices is of high importance for their further development and potential commercialisation. X-ray based techniques such as photoelectron spectroscopy (PES) are powerful tools for obtaining chemical and electronic structure information of material surfaces as well as interfaces. By combining measurements with visible illumination and/or dosing of atmospheric gasses, photo-induced reactions and therefore the stability of materials can be studied in-situ. However, the X-rays themselves used for measurement can also cause changes in the perovskite materials. In this presentation, I will show how we were able to establish the mechanism and kinetics of X-ray induced changes in perovskite materials [1]. When taking these effects into account, it is possible to investigate the electronic and chemical structure of perovskite surfaces and interfaces by photoelectron spectroscopy. By studying clean surfaces of perovskite single crystals, it was possible to establish the electronic structure of pure perovskites [2]. Furthermore, I will show results of studies of the interface formation and interface degradation of a perovskite active layer with metals such as silver [3] and copper. Reactions with these metals can lead to a degradation of the perovskite materials. Finally, I will discuss how hard X-ray photoelectron spectroscopy can be used for operando measurements of the interfaces in complete perovskite devices. Such measurements make it possible to study the electric fields at the back contact of a solar cell under bias and illumination.

References:

1 Svanström et al. *PCCP* **23**, 12479-12489, (2021).
2 Garcia-Fernandez et al. submitted.
3 Svanström et al., *ACS Appl. Mater. Interfaces* **12**, 7212-7221 (2020).