Halide Perovskite Thin Films Characterisation by Force Microscopy Techniques

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In the past decade, hybrid halide perovskite solar cells emerged in the field of photovoltaics starting at a modest power conversion efficiency of less than 4%, which has now increased to over 24%. Halide perovskites, used as the light absorber, exhibit outstanding photovoltaic properties (e.g. tuning of the bandgap by compositional engineering, high absorption coefficient and steep absorption edge), which in combination with solution processed multijunction device layouts can overcome efficiency limits of current silicon based solar cells. For instance, incorporation of perovskite top-cell over silicon bottom-cell in a double-junction (tandem) arrangement is predicted to reach energy conversion efficiencies exceeding 30%. Nonetheless, to achieve this goal, a better understanding of the perovskite's fundamental optoelectronic properties is required, especially regarding charge carrier dynamics, device stability, energy band alignment.

In this contribution, we will present our recent results using surface characterisation techniques, in particular Kelvin Probe Force Microscopy (KPFM), to analyse these properties of halide perovskite thin films on silicon substrates. Using a conductive tip, KPFM can track the contact potential difference (CPD) between the tip and the sample, which reflects the difference in their work function. At a given and constant work function of the tip, the local work function of the sample's surface can be imaged with a high resolution, while simultaneously showing the surface topography at the nanoscale (Fig. 1).

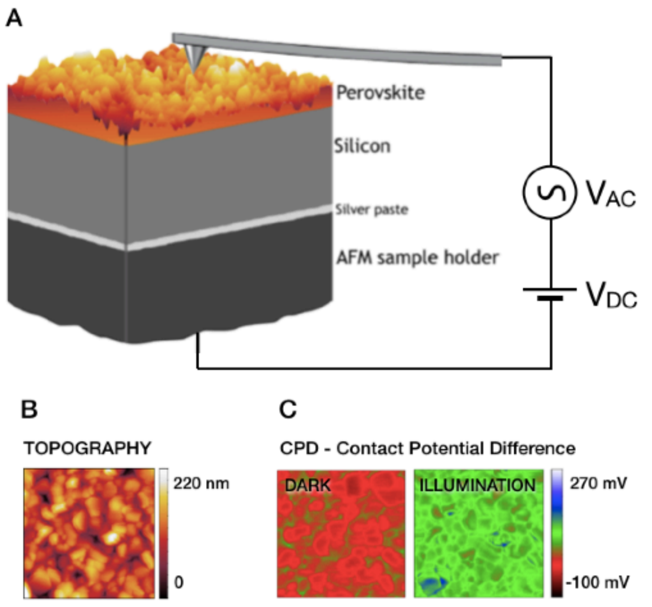

Fig. 1 KPFM measurement set up – (A) The sample is placed on the AFM holder, which is electrically biased. The AFM tip scanning the surface of the sample allows to (B) simultaneously record the topography (3x3µm) of the sample and (C) the contact potential difference map (3x3µm), which can be obtained under different illumination conditions.

The method is non-destructive and does not require complicated sample preparation, can be operated in controlled conditions, as well as in ambient at room temperature, enabling to observe the evolution of the perovskite's surface properties under environmental conditions. By subsequently performing the experiment upon illumination and substracting the CPD signal in the dark from that under illumination one can also image the surface photovoltage. This provides a unique way to reconstruct the perovskite surface and at the same time study its properties, like electronic states, energy band bending and charge trapping.

Keywords: Halide Perovskites; Kelvin Probe Force Microscopy; Surface Photovoltage; Photovoltaic Devices