Improving the understanding of the KPFM technique through analyses of InP multilayers with associated modelling

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Significant achievements in material and solar cell devices engineering have resulted in great progress in the development of photovoltaic (PV) technologies over the past decade. As a result, solar cells have become extremely complex devices, often constituted by many layers and interfaces (e.g., multijunction devices). The study and the comprehension of the mechanisms that take place at the interfaces is crucial to work towards further improvement of the efficiency. In this regard, Kelvin probe force microscopy (KPFM) is a surface probe technique that enables nanometer-scale imaging of the surface potential or work function of the sample [1]. Consequently, KPFM has been intensively used to characterize the dopant profiles of Si based materials and devices [2]. Nonetheless, several factors can influence the KPFM measurements, namely the surface states, and the experimental measurement environment including the AFM probe operating conditions [3]. For these reasons, many publications concerning KPFM are limited to a qualitative interpretation of data. To have access to a guantitative comprehension of KPFM measurements, we have prepared a dedicated structured sample with alternating layers of S and Fe doped InP layers, whose dopants densities were previously determined by secondary-ion mass spectrometry (SIMS), 2×10¹⁹ and 9×10¹⁶ cm⁻³, respectively. We have performed KPFM measurements and shown that we can spatially resolve 20 nm thick InP layers, and notably when performed under illumination which is well known to reduce the surface band-bending [4]. Finally, we have used KPFM modeling to get the best approximation of the experimental values by adjusting the probe diameter, the measurement working distance and the surface state density in InP [5]

InP:Fe Scan direction InP:S

Figure 1: a) SEM image of the surface of the sample, the image was edited to enhance the height contrast of the layers; b) map of CPD (contact potential difference, which is the difference of electrostatic potential between the tip and the sample surface) before and after irradiating the sample surface with white light; c) experimental vertical profile of the CPD map.





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