Principles of KPFM and applications

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Kelvin Probe Force Microscopy (KPFM) is a technique aiming at the detection and compensation of electrostatic forces arising between a nanoprobe (the tip of the microscope) and a surface (hereafter referred to as the electrodes) when they are biased. The origin of these forces differs upon the distance between the electrodes [1]. At large distance (>1nm), electrostatic forces can be quantitatively connected to the Contact Potential Difference (CPD) between the electrodes, i.e. the difference between their work functions. Thus the technique gives a quantitative CPD map of the surface on the local scale [2]. When measured closer to the surface (in the range of 0.5-1 nm), short-range electrostatic forces start to get involved in the imaging process. Then, a KPFM image with atomic-scale resolution can be achieved [3]. However, in this situation, the origin of the KPFM signal rather reflects atomic-scale properties of the surface, among which its local polarizability. The ability for the technique to provide access to the CPD and other properties down to the atomic-scale makes KPFM widely used in surface science nowadays. In the 1990's, the KPFM technique has been successfully coupled with noncontact-AFM [1]. The possibility to perform joint experiments where structural and electronic properties become accessible in a row made the couple KPFM/nc-AFM attractive and intensively developed and used in numerous research labs.

The goal of this lecture will be to discuss experimental (technical implementation, modes, time constants considerations, artefacts…) and theoretical aspects (long-/short-range electrostatic forces) of the KPFM technique when coupled with nc-AFM and to illustrate these by means of examples taken from recent literature.

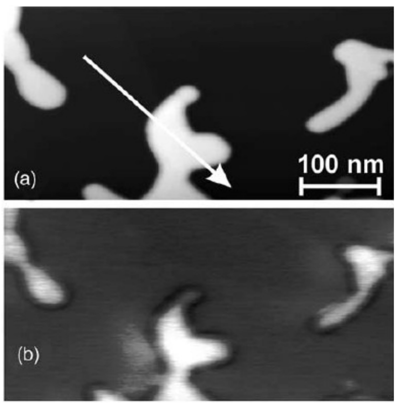

Figure 1: Nc-AFM (a-) and KPFM (CPD, b-) images of an HOPG substrate including Au islands [2].

References

[1] M. Nonnenmacher, et al. *Appl. Phys. Lett.* 58 (1991) 2921
[2] T. Glatzel et al. *Appl. Surf. Sci.* **210** (2003) 84.
[3] K. Okamoto *et al.*, Appl. Surf. Sci. **210** (2003) 128.