Determination of the Sample-Intrinsic Work Function on a Gold Surface Using Voltage-Pulse Scanning Probe Microscopy

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The work function, defined as the minimum energy required to remove an electron from a material, is a key parameter influencing the performance of optical and electronic devices. Recent advances in nanotechnology have highlighted the need to measure the work function on material surfaces with high spatial resolution. For this purpose, scanning probe microscopy (SPM), including scanning tunneling microscopy (STM) and atomic force microscopy (AFM), has been widely used [1, 2]. However, their observables, such as local barrier height (LBH) and local contact potential difference (LCPD), are affected by unknown work function of the probe and therefore do not directly reflect the sample's intrinsic work function. To address this limitation, we developed "pulse-SPM," a method that allows simultaneous measurement of LBH and LCPD. Our previous work demonstrated its accuracy in determining work function on semiconductor surface. In this study, we further apply our pulse-SPM method to a gold surface, a well-characterized reference material in LBH and LCPD studies, and show that the method also yields reliable results on metals.

Figure 1 illustrates the principle of pulse-SPM. The system integrates a combined STM-AFM setup with a pulse-voltage controller. During operation, a conductive cantilever oscillates at constant amplitude while synchronized voltage pulses are applied to the sample. By sweeping the trigger delay (τ) across the oscillation cycle, the tunneling current (I_{t}) is recorded as a function of τ. Since τ correlates with tip-sample distance z, the $I_{\mathrm{t}}(\tau)$ curve can be converted to $I_{\mathrm{t}}(z)$, as in conventional STM, and LBH is then extracted via tunneling theory. Furthermore, repeating the measurements with the reversed voltage polarity allows determination of LCPD [3, 4]. With both LBH and LCPD acquired, the sample's intrinsic work function can be calculated through basic arithmetic. In the presentation, we present results for the Au(111) surface and discuss the broader applicability of pulse-SPM to metal surfaces.

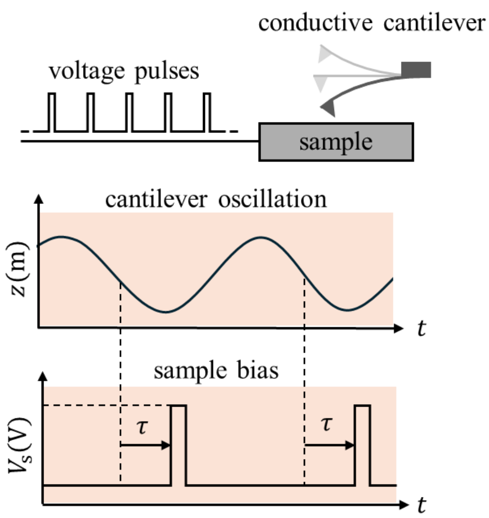

Figure 1. Principle of pulse-SPM.

Reference

[1] L. Olesen, et al., Phys. Rev. Lett. **76**, 9 (1996).
[2] Th. Glatzel et al., Appl. Surf. Sci. **210**, 84 (2003).
[3] E. Inami and Y. Sugimoto, Phys. Rev. Lett. **114**, 246102 (2015).
[4] E. Inami and Y. Sugimoto, Jpn. J. Appl. Phys, **55**, 08NB05 (2016).