# Mapping CPD with a NC-AFM using Resonance Frequency Shift Versus Sample Bias Voltage Curves

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It has been demonstrated that the contact potential difference (CPD) for a Si(111)7×7 surface can be obtained by plotting the resonance frequency shift of a cantilever versus sample bias voltage (f-V) using an ultra high vacuum non-contact atomic force microscope (UHV NC-AFM)[1]. f-V image mapping enables CPD maps of a surface without using scanning Kelvin probe microscopy (SKPM). In the current case, CPD maps were obtained by both SKPM and f-V curve techniques on the same atomically resolved area of a Si(111)7×7 surface.

The present experiment was carried out using a UHV NC-AFM (JEOL JSPM-4500A)[2]. The sample was p-type Si(111) and a sub-monolayer of Au was deposited after confirming the 7×7 structure. A commercial conductive Si cantilever was used. The measurement of the f-V data was performed at each pixel in a 128x128 array. The CPD between the tip and sample is the negative of the sample bias at the minima in the f-V curve at each pixel

  Fig. 1 shows the same 10 nm$^2$ images of CPD data by the SKPM (a) and calculated from f-V data (b). It can be observed from both images that the CPD of most adatoms are lower than either the corner holes or Au clusters. The range of CPD values of Fig. 1b is larger than those of Fig. 1a. The minimum value of the CPD for the adatoms in Fig. 1b was obtained on the left side of the position of the adatoms in topography image. This suggests that the f-V measurement position determined by the topography image is slightly shifted. The shift is considered to be due to creep in the scanner and/or electronic. This means that the start position shifts slightly across the adatom during f-V data collection. This will also result in a change in the tip-sample separation during f-V data collection as the feedback loop is turned off during this time. Fig. 2 shows extracted f-V curves for the adatom from both the left side and directly on top of the adatom. The frequency shift for negative biases in the f-V curve at the left of the adatom was larger than that on the adatom. The CPD value calculated from fitting curve at left of adatom is -0.192V, while that on the adatom is –0.091V.
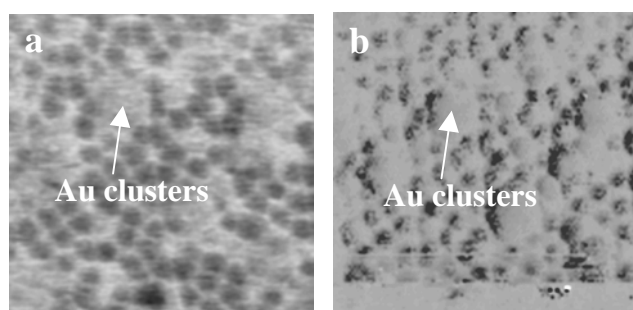


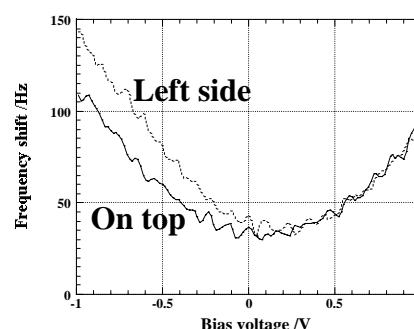Fig. 1  CPD data by the SKPM (a) and from f-V data (b).    Fig. 2  Extracted f-V curves

[1] S. Kitamura, K. Suzuki and M. Iwatsuki: Appl. Surf. Sci. 140 (1999) 265.
[2] S. Kitamura, K. Suzuki and M. Iwatsuki: JEOL News, 32E (1995) 42.