SUPPORTING INFORMATION

# Surface-Potential Heterogeneity of Reacted Calcite and Rhodochrosite

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Table S1. Confidence levels of KPFM and tapping-mode AFM

| Technique | Sample | Mean $\mu$ | Standard Deviation $\sigma$ | $t = \mu/\sigma$ | Degrees of Freedom | Confidence (%) |
|---|---|---|---|---|---|---|
| KPFM | $CaCO_3$ | 126 mV | 31 mV | 4.06 | 500 | 99.997% |
| | $MnCO_3$ | 271 mV | 14 mV | 19.4 | 100 | 100% |
| Tapping-mode AFM | $CaCO_3$ | 1.1 nm | 0.6 nm | 1.83 | 500 | 96.6% |
| | $MnCO_3$ | 1.3 nm | 0.7 nm | 1.85 | 100 | 96.6% |

* Two-sample *t*-test follows standard procedures outlined in *Introduction to the Practice of Statistics* by Moore and McCabe, W. H. Freeman and Company, New York, 1998

Table S2. F-test results for data shown in Figure 3

| Sample | Dependent Variable | Probability (> F-Test Value)* |
|---|---|---|
| calcite | $h$(nano) | $2.6\times10^{-4}$ |
| | $V'_{null}$(nano) | 0.69 |
| rhodochrosite | $h$(nano) | 0.20 |
| | $V'_{null}$(nano) | $1.2\times10^{-4}$ |
| HOPG | $h$(step) | 0.62 |
| | $V'_{null}$(edge) | 0.16 |

* F-test follows standard procedures outlined in *Introduction to the Practice of Statistics* by Moore and McCabe, W. H. Freeman and Company, New York, 1998

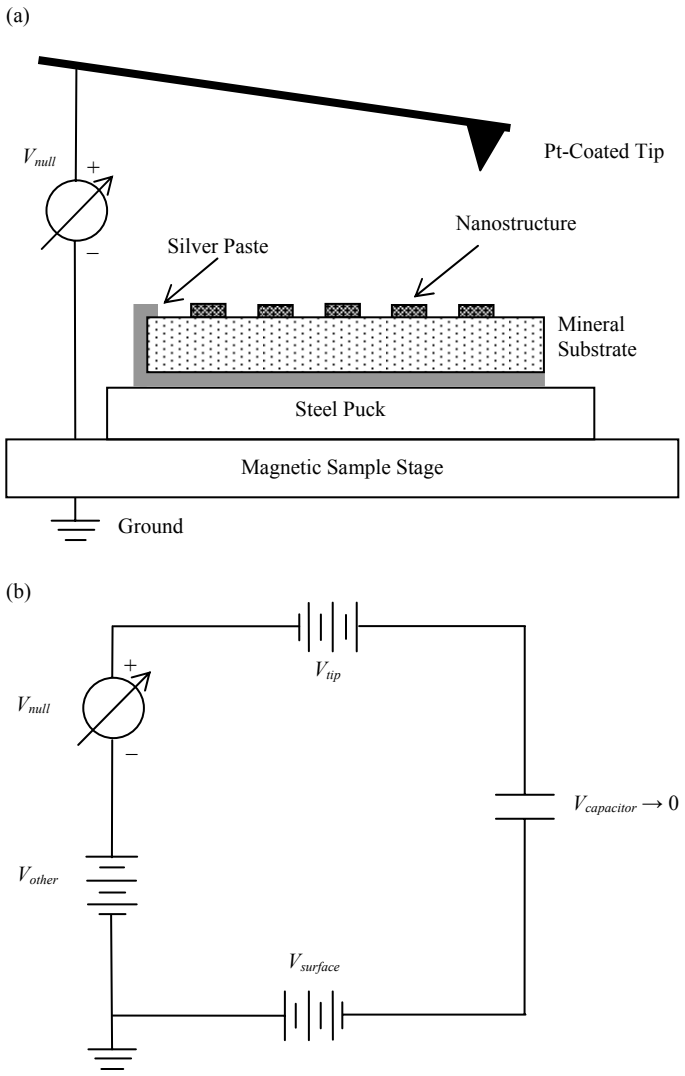


Figure S1. (a) Experimental setup of Kelvin probe force microscope and (b) an equivalent circuit.

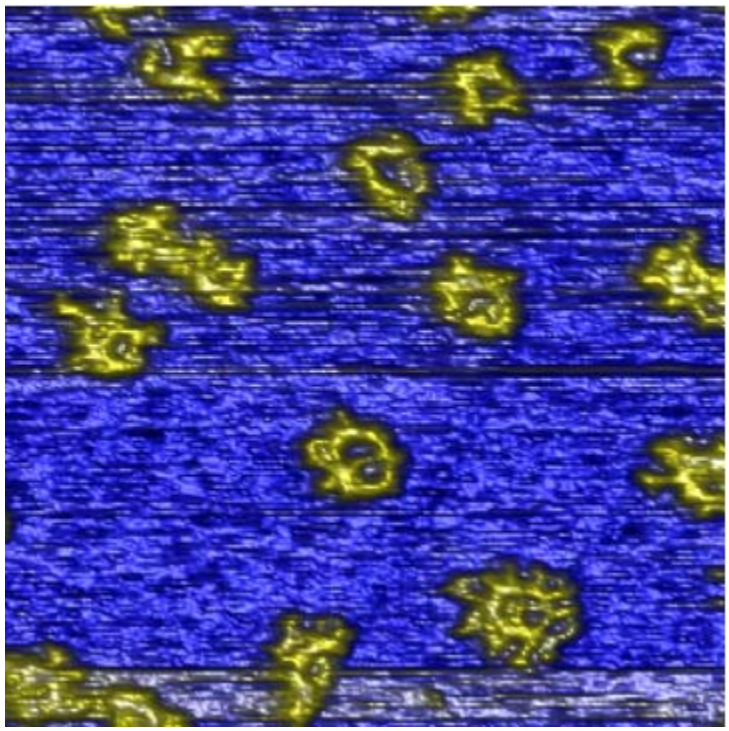

Figure S2. Raw potential image with stripes between raster lines. Image Size: 5 μm × 5 μm. The same area as in Figure 1(a).

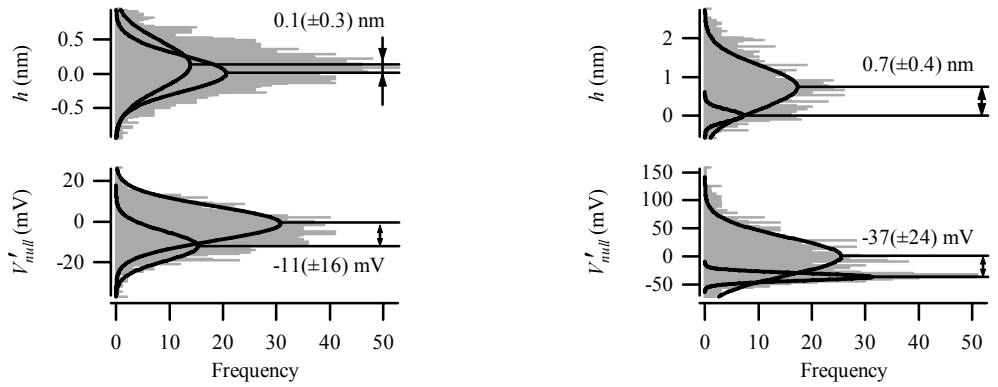


Figure S3. Height and potential histograms of steps and terraces for (left) calcite and (right) rhodochrosite surfaces of Figure 1.

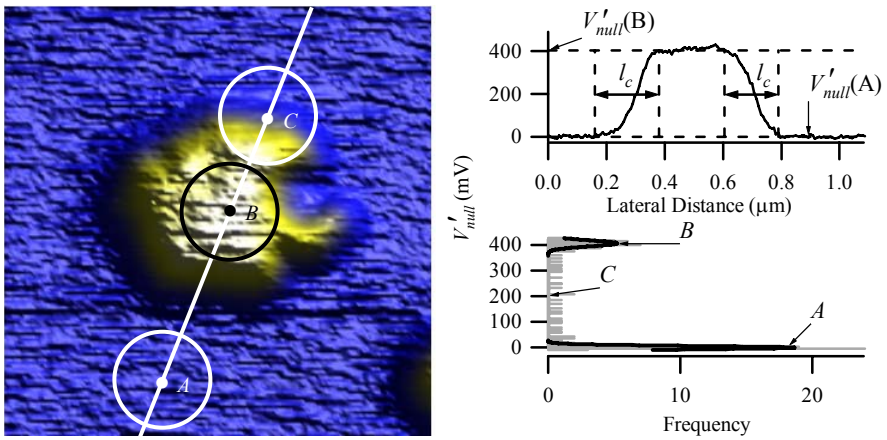


Figure S4. Lateral Resolution of KPFM. (Left) Potential image from Figure 3. (Right) Cross section and histogram used to estimate the lateral resolution of KPFM.

Circles in the potential image shown in Figure S4 represent the areas that contribute to the KPFM measurement when the tip is at three locations A, B, and C. Location A is influenced only by the substrate, location B only by the nanostructure, and location C by both. The cross section, as marked by the white line, is presented on the right-hand side, along with a histogram of this cross section. According to the histogram, $V'_{null}(\mathrm{A}) = -0\pm(10)$ mV and $V'_{null}(\mathrm{B}) = 407\pm(17)$ mV. The intersection of the horizontal lines at $V'_{null}(\mathrm{A})$ and $V'_{null}(\mathrm{B})$ with the cross section provide the lateral size of the transition region as $l_C = 200(\pm 20)$ nm.

The transition region represented by C may be modeled as:

$$V'_{null}(\mathrm{C}) = \alpha V'_{null}(\mathrm{B}) + (1-\alpha)\, V'_{null}(\mathrm{A}) = \alpha V'_{null}(\mathrm{B})$$

where $\alpha$ is the fraction of the contribution made by the substrate and varies linearly along the lateral distance $l_C$. For a qualitative distinction of the nanostructure from the substrate

(i.e., the lateral resolution), the criterion is that $V'_{null}(\mathrm{C})$ be greater than the noise $\xi$ of $V'_{null}(\mathrm{A})$:

$$V'_{null}(\mathrm{C}) = \alpha V'_{null}(\mathrm{B}) > \xi.$$

For $V'_{null}(\mathrm{A})$, we can assume that the noise equals three times the sigma value, i.e., $\xi$ = 3 × 10 mV = 30 mV. Hence:

$$\alpha > \frac{\xi}{V'_{null}(\mathrm{B})} = \frac{30}{407} = 0.074$$

This $\alpha$ value corresponds to $l_C$ × 0.074 = 15 nm, which is the lateral resolution for qualitative measurements. This qualitative resolution is illustrated in Figure S5 for manganese oxide grains removed from nanostructures by tapping the AFM tip with large driving forces. The particular grain shown in the cross sections is about 35 nm in diameter. The size of the grain is delineated using the topography around it as the baseline.

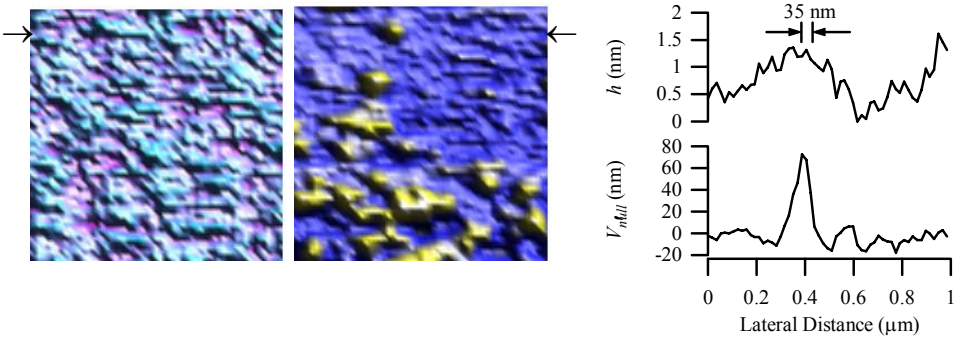


Figure S5. Topography image, potential image, and cross sections of manganese oxide grains. Image size: 1 μm×1 μm.

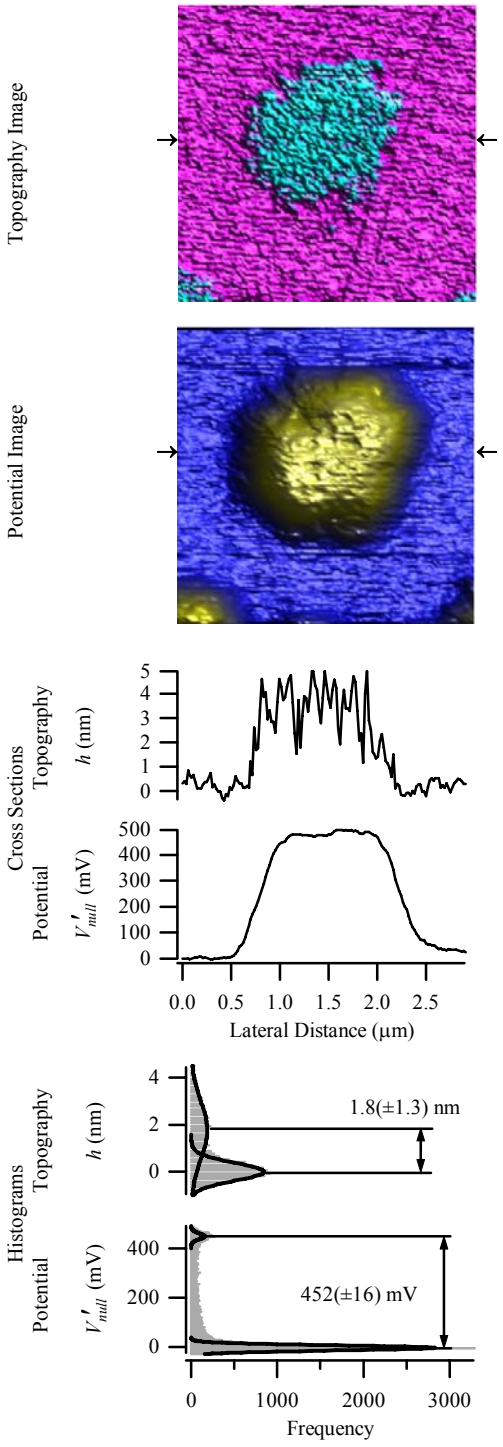


Figure S6. Example of similar results for another reacted rhodochrosite surface. Image Size: 3 μm × 3 μm. Image were obtained at 49% relative humidity.