Supplementary Information for "Time-Dependent Electrical Contact Resistance at the Nanoscale"

Mohammad R. Vazirisereshk,[1] Saima A. Sumaiya,[1] Rimei Chen,[1] Mehmet Z. Baykara,[1] and Ashlie Martini[1,*]

[1] *Department of Mechanical Engineering, University of California Merced, 5200 N. Lake Road, Merced, CA, 95343, USA*

(Dated: April 4, 2021)

Fig. S1 summarizes the contact area evolution with time obtained from the C-AFM experiments with diamond and Pt tips at different temperatures. The data in Fig. S1a and b were obtained sequentially with the same conductive diamond tip. The fact that we observe a gradual increase in contact area in both cases reflects good repeatability in our experiments, while differences in the rate of increase can be tentatively attributed to subtle changes in the atomic structure of tip apexes in each experimental run.

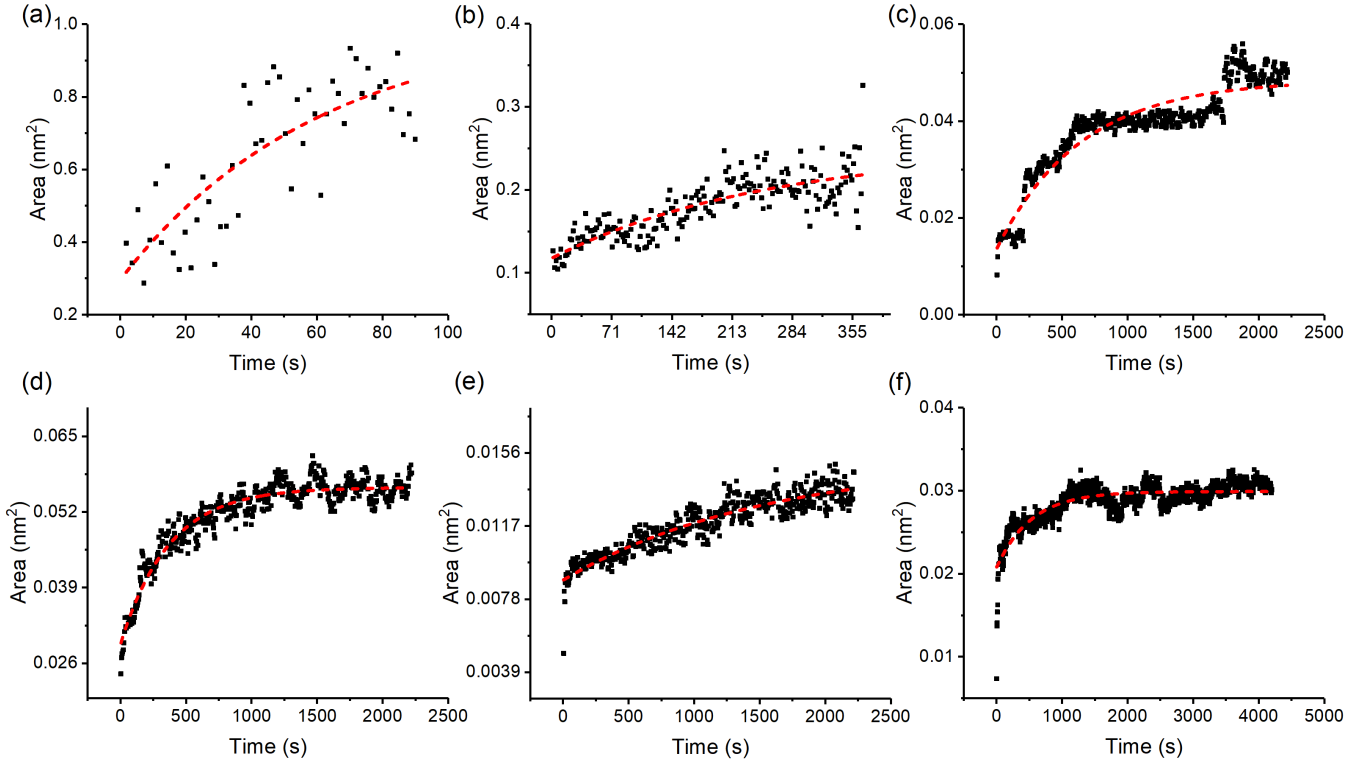

FIG. S1: Contact area obtained from measured resistance data via C-AFM experiments with different tip materials and temperatures: (a) and (b) diamond at 311 K, (c) and (d) Pt at 323 K, (e) Pt at 311 K and (f) Pt at 305 K. The dashed lines are fits to Eq.1.

TABLE S1: Constants obtained by fitting the experimental data in Fig. S1 to Eq.1.

Tip Material, Temperature	A_0 (nm^2)	α	τ (s)
Diamond, 311 K	0.296	2.41	61.3
Diamond, 311 K	0.118	1.12	255.0
Pt, 323 K	0.014	2.58	641.2
Pt, 323 K	0.029	0.93	366.5
Pt, 311 K	0.009	0.72	1528.8
Pt, 305 K	0.021	0.44	529.1

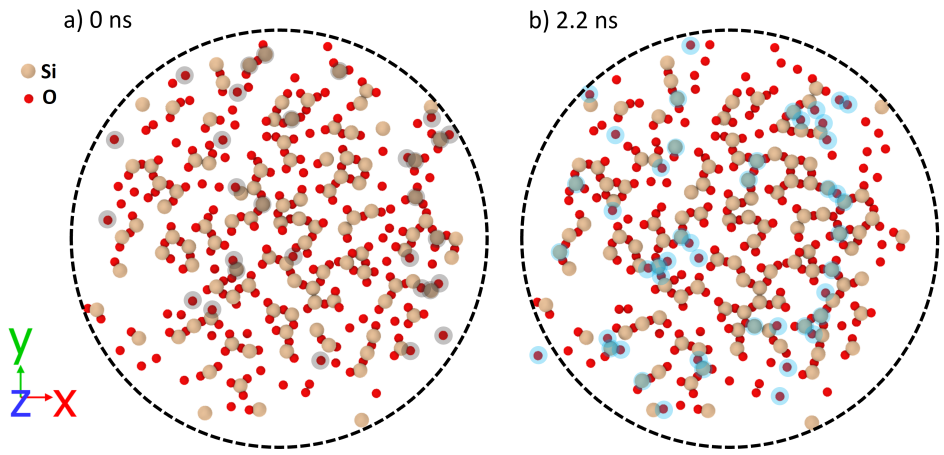

FIG. S2: Contact area evolution with time. Top view of the contact at (a) 0 ns and (b) 2.2 ns. The grey circles in (a) highlight the atoms that are not present in the contact at (b). Similarly, the blue circles in (b) represent the new atoms that migrated to the contact during the simulation and are not present in (a). The dashed circles approximate the perimeter of the contact area and are the same size in (a) and (b), indicating the atoms mostly migrate into the center of the contact.

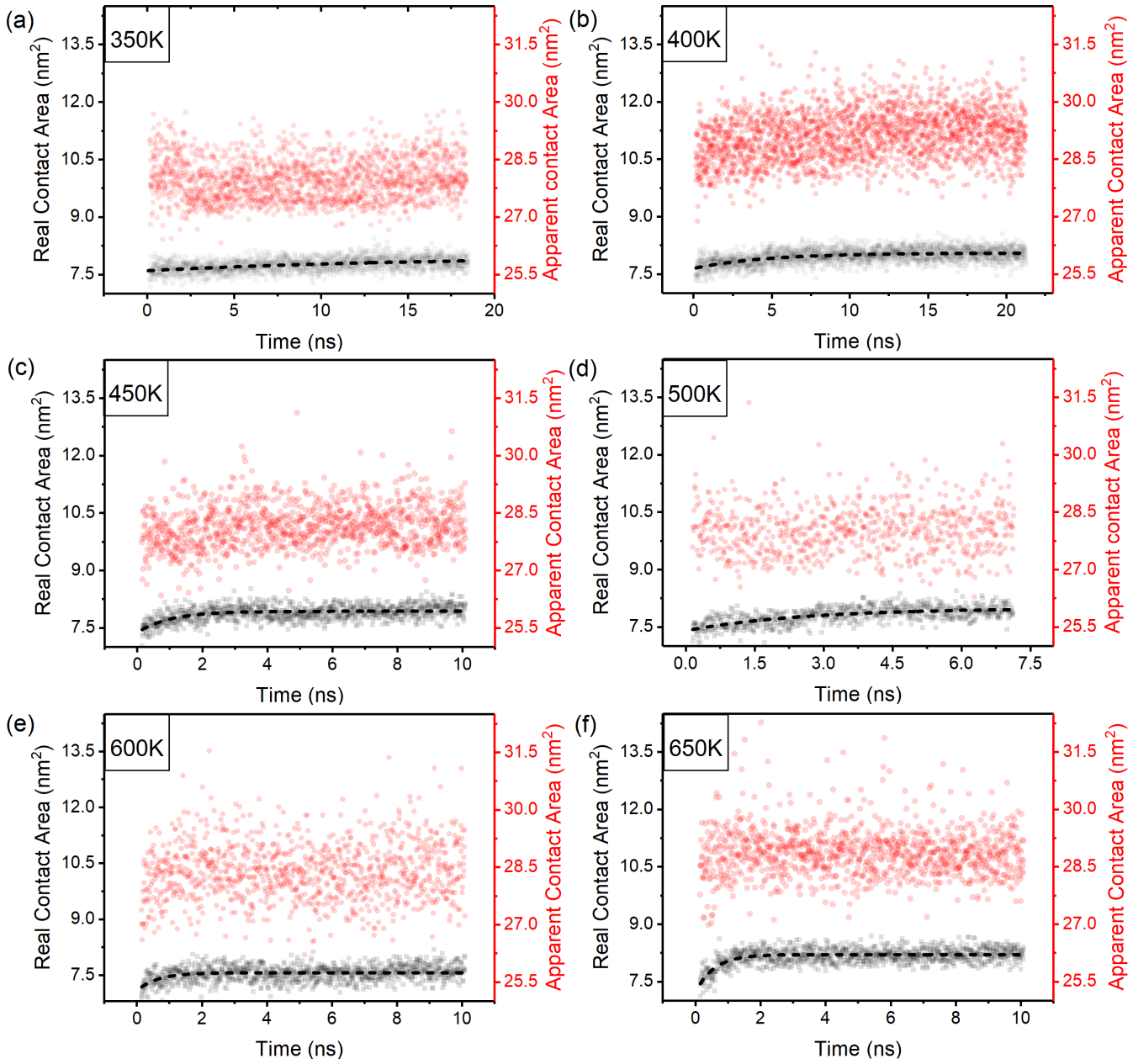

FIG. S3: (a-f) Real (black, left y-axis) and apparent (red, right y-axis) contact area as a function of time from MD simulations at 350 K, 400 K, 450 K, 500 K, 600 K and 650 K. The black dashed lines are fits of the real contact area to Eq.1.

TABLE S2: Constants obtained by fitting simulation data at different temperatures in Fig. S3 to Eq.1.

Temperature (K)	A_0 (nm^2)	α	τ(ns)
350	7.597	0.048	13.5±3.14
400	7.648	0.052	4.6±0.40
450	7.377	0.075	1.0±0.12
500	7.402	0.080	2.6±0.40
600	7.080	0.074	0.62±0.12
650	7.206	0.138	0.55±0.05

* amartini@ucmerced.edu