SUPPLEMENTAL MATERIAL

Rougher is more slippery: How adhesive friction decreases with increasing surface roughness due to the suppression of capillary adhesion

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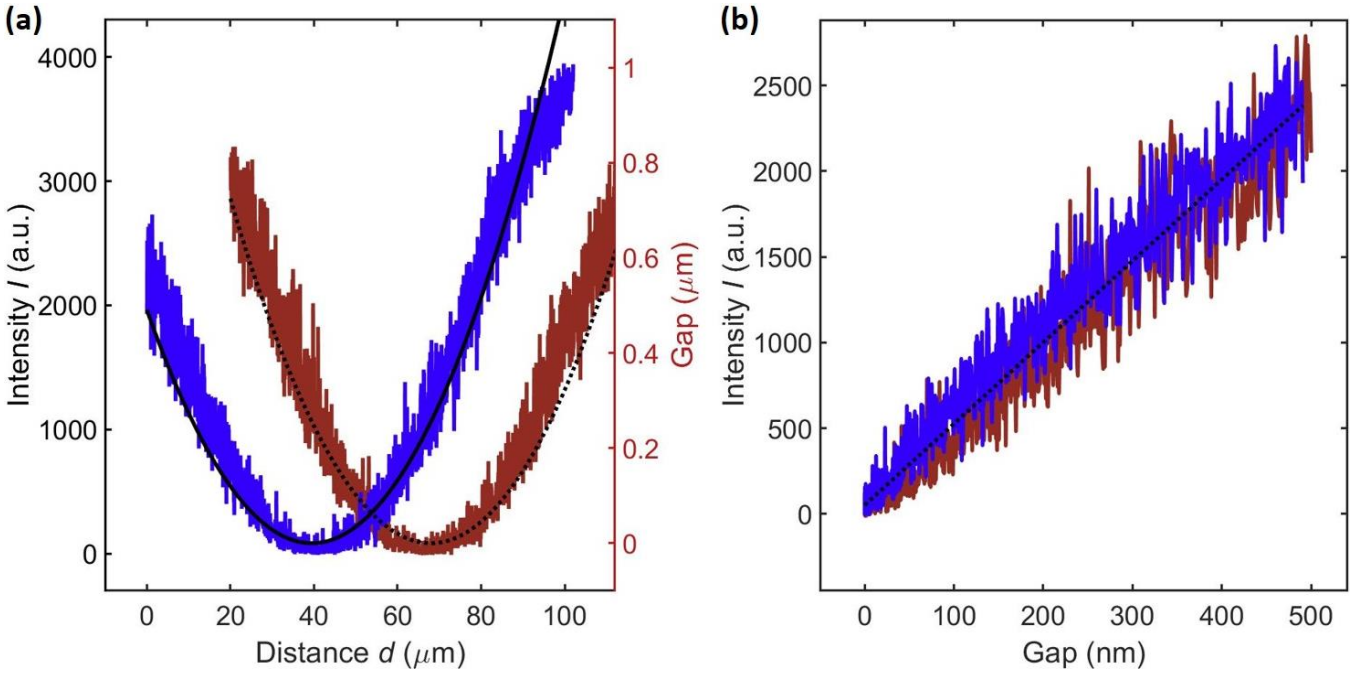

FIG. S1. Fluorescence intensity and local gap. (a) Cross-sectional fluorescence intensity (I) profile taken through the sphere-on-flat contact center in both orthogonal in-plane directions (blue and red curves; the two curves were manually shifted for clarity). Black solid and dotted lines show the expected sphere-on-flat gap based on the sphere diameter and on the assumption that there is no roughness and no deformation. (b) Intensity as a function of the gap size for gaps smaller than 500 nm in both in-plane directions. The potted black line indicates a linear fit to the data.

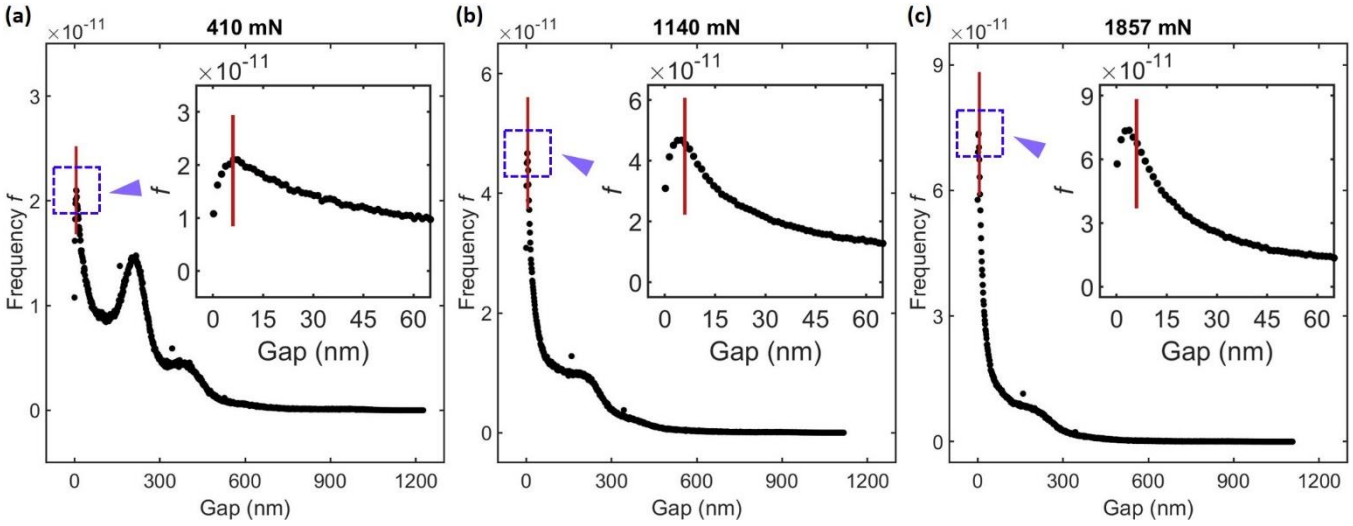

FIG. S2. Fluorescence intensity distribution as a function of the local gap. The fluorescence intensity shows a clear peak at a gap of ~6 nm (red line, inset figures) at each normal force 410 mN (a), 1140 mN (b), and 1857 mN (c). The corresponding gap value at the peak position determines the threshold for the area of real contact in Fig. 2.

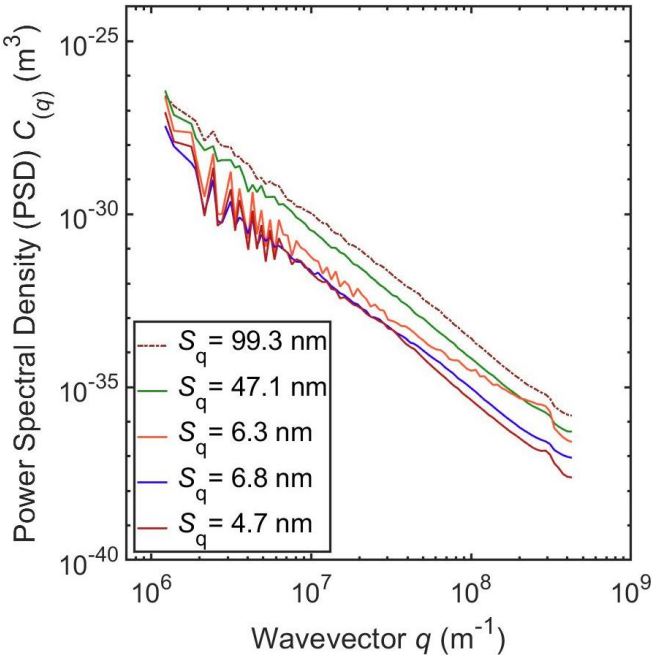

FIG. S3. The power spectral density (PSD) of the surface topography of Si_3N_4 with varying surface roughness. Each curve indicates the average of 3 AFM measurements taken on different locations on the same sphere. The size of the AFM topography is 10 μm × 10 μm with 95.4 nm^2 per pixel resolution.

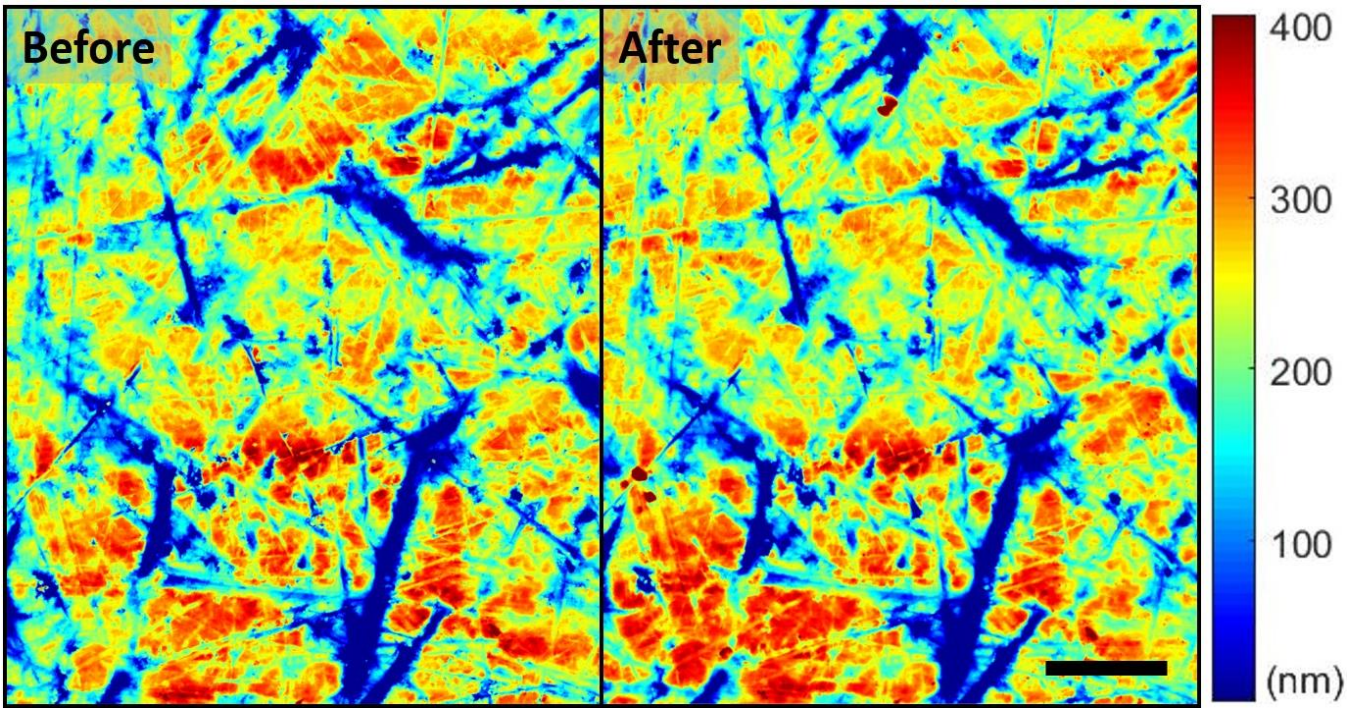

FIG. S4. Si_3N_4 sphere AFM topography before and after contact. A 2 N normal force was applied to the Si_3N_4 sphere against sapphire flat contact. The RMS roughness of the Si_3N_4 sphere is 90 nm. Scale bar, 10 μm.

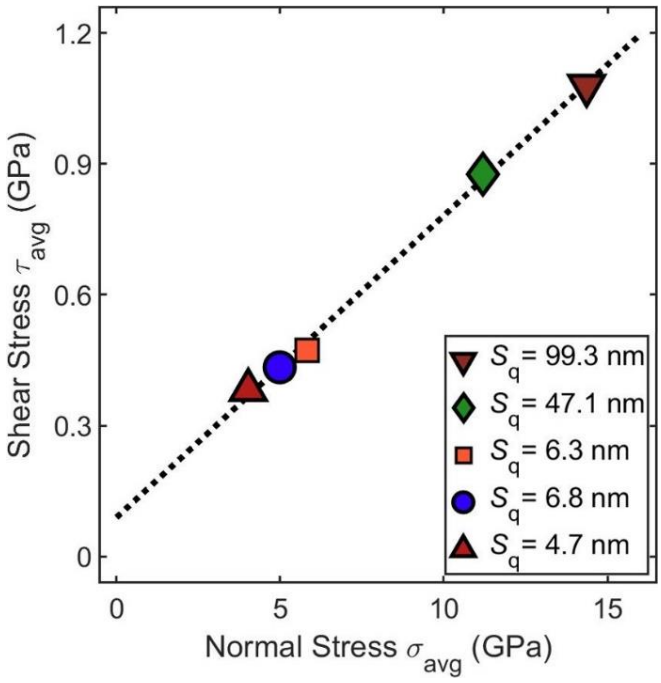

FIG. S5. Shear stress as a function of normal stress. The average shear stress (τ_{avg}) is calculated by multiplying the average normal stress (σ_{avg}), which is the inverse of the slope between the area of real contact as a function of normal force of Si_3N_4 sphere for different surface roughness (Fig. 3(a)), to the average coefficient of friction (inset of Fig. 3(b)).

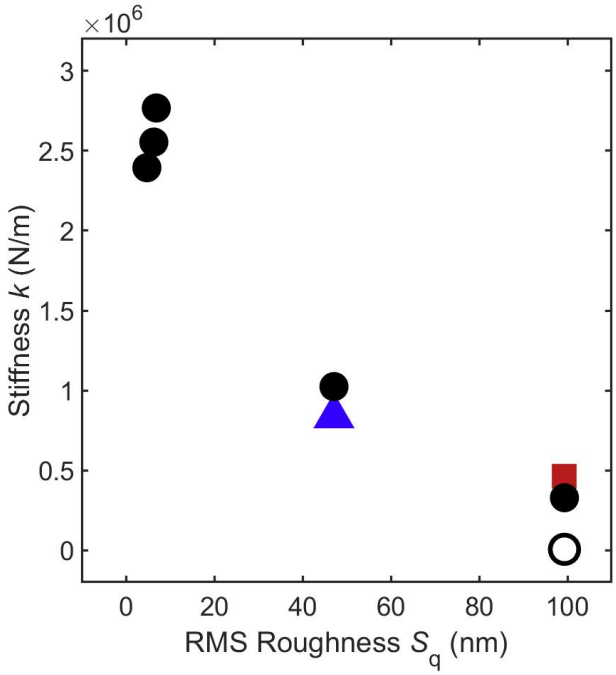

FIG. S6. Normal contact stiffness calculation with and without plasticity. The normal contact stiffness calculation without plasticity was conducted with the roughest Si_3N_4 sphere (S_q = 99.3 nm) as shown with open black circle mark. The lower stiffness without plasticity compared to with plasticity (solid black circle mark) is attributed to the fact that the highest asperity peaks on the sphere surface are provide a low stiffness when they are not plastically flattened.

TABLE SI. Mechanical properties of Si_3N_4 and sapphire.

Material	Young's modulus *E* (GPa)	Poisson's ratio *v*	Hardness *H* (GPa)
Sapphire	335 [1]	0.25 [2]	20 [3]
Si_3N_4	205*	0.25*	23*

*Measured by nanoindentation (TI980, Bruker)

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