Temperature Scaling of Contact Ageing Rates

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Silica junctions are found in a huge variety of technical and natural interfaces, ranging from MEMS to seismic faults[1–5]. Recent experiments[3] have demonstrated a logarithmic increase of the static friction required to break one of them with the contact time, and related this phenomenon (so-called ”contact ageing”) to a gradual formation of chemical bonds in the contact [6–8]. Considering that the bond formation is a thermally activated process, then one way to put at test the aforementioned fundamental assumption in tribology is provided by investigating the temperature dependence of the static friction in Silica contacts. Here, this is done by means of atomic force microscopy in ultra-high vacuum complemented by large scale all-atom molecular dynamics simulations. Quite unexpectedly, we observe that the temperature affects the static friction and the contact stiffness in contrasting ways. In the latter we observe that it increases faster with increasing temperature, consistent with the commonly accepted wisdom of temperature activated contact aging stemming from temperature enhanced bond formation in Silica junctions as corroborated by our simulations. As for the static friction we observe that it behaves in the opposite manner, i.e. the higher the temperature the slower it increases. This observation unambiguously exposes a paradoxical result that a faster contact aging does not necessarily leads to a faster increase of static friction. Therefore, static friction is not generally a good measure of the bonds formed at the interface of an amorphous dry contact but instead the contact stiffness seems to provide a better measurement for contact ageing.

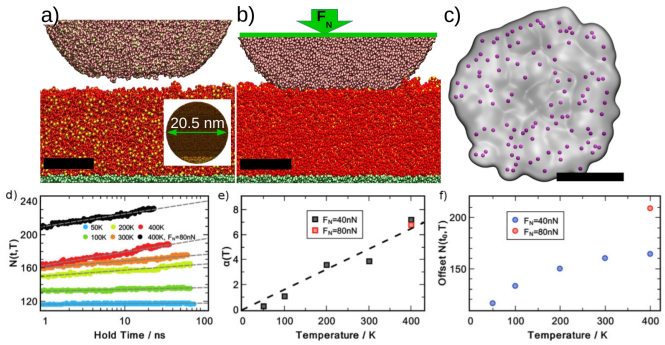

Figure: MD simulations of SiO 2 contact ageing under an applied normal load.

References:

1. Evstigneev, M. et al. Journal of Physics: Condensed Matter 20, 354001 (2008).
2. Gosvami, N. N. et al. Physical Review Letters 107, 144303 (2011).
3. Li, Q., et al. Nature 480, 233–236 (2011).
4. Dieterich, J. H. et al. Pure and applied geophysics 143, 283–302 (1994).
5. Marone, C. Review of Earth and Planetary Sciences 26, 643–696 (1998).
6. Liu, Y. et al. Physical Review Letters 109, 186102 (2012).
7. Li, A., et al. Tribology Letters 56, 481–490 (2014).
8. Tian, K. et al. Physical Review Letters 118 (2017).