HOW ROUGHNESS AFFECTS ADHESION, OR, WHY DOES FOOD WRAP CLING AGAIN?

Martin H. Müser* and Anle Wang
*martin.mueser@uni-saarland.de
Lehrstuhl für Materialsimulation, Universität des Saarlandes
Campus C6 3, 66123 Saarbrücken, Germany

KEYWORDS
Contact mechanics; adhesion; computer simulation

ABSTRACT

Thin elastic layers, such as food wrap or Gecko feet, easily stick to most rough counterfaces, while semi-infinite solids usually don't. One potential explanation for this phenomenon is that the large compliancy of thin structures automatically leads to a large, real contact area when being squeezed against a counterface. However, true contact between adhesionless solids is determined by the pressure, the elastic properties, and the roughness at the smallest wavelengths, i.e., that on nanometer scales or below. This is a thousand times smaller than the thickness of common plastic foil. In other words, even thin structures are essentially semi-infinite relative to those scales that determine the true contact area of adhesionless solids. Yet, every-day experience tells us that thin objects stick much better to counterfaces than thick ones made up of the same material. Computer simulations based on the Green's function molecular dynamics method [1] helped us to reveal why this is so.

As shown in Fig. 1, reducing the thickness of an elastomer below the roll-off wavelength of the height profile of its randomly rough counterface leads to the phenomenon of contact splitting [2], whereby mesoscale contact patches break up into smaller patches of similar contact area but with much increased contact line length. These are the zones where adhesion predominantly acts once it is "switched on". Results can also be rationalized in terms of Persson's contact mechanics theory for adhesive bodies [3].

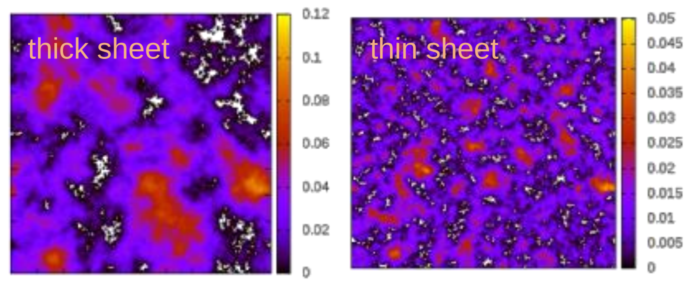

Fig.1 Gap topography of a thick sheet (left) and a thin sheet (right) that is pressed against a randomly rough substrate. White marks the area of contact, where the gap is zero, while colors indicate the gap height, expressed in microns. The gap is smallest for dark colors.

ACKNOWLEDGMENTS

We thank the DFG for financial support.

REFERENCES

[1] Campana C. and Müser M. H., "Practical Green's function approach for the simulation of elastic, semi-infinite solids," Phys. Rev. B, 74, 2006, 075420.
[2] Kamperman M., Kroner E., del Campo A., McMeeking R.M., and Arzt E., "Functional adhesive surfaces with "Gecko" effect: The concept of contact splitting", Adv. Eng. Mater., 12, 5, 2010, 335-348.
[3] Carbone G., Mangialardi L., and Persson B.N.J., "Adhesion between a thin elastic plate and a randomly rough substrate", Phys. Rev. B 70, 12, 2010, 125407.