NewTimes – New Trends in Materials Science and Engineering
1st International Virtual Conference
14-18 June 2021

SESSION: New trends in surface science and coatings

Preference: ORAL presentation

A novel nanoindentation protocol to characterize surface free energy of superhydrophobic nanopatterned materials

E. M. Rossi[1], P. Sudharshan Phani[2], R. Guillemet[3], Julie Cholet[4], Doriane Jussey[5], W.C. Oliver[6], M. Sebastiani[1]*

[1] Università degli studi Roma Tre, Engineering Department, Via della Vasca Navale 79, 00146 Rome (Italy).
[2] International Advanced Research Centre for Powder Metallurgy & New Materials (ARCI), Hyderabad, Telangana 500005, India.
[3] Thales Research & Technology, avenue Augustin Fresnel, 91767 Palaiseau Cedex, France.
[4] KLA Corporation, 105 Meco Ln, Oak Ridge, TN 37830, USA.

Surface Free Energy (SFE) represents a relevant design parameter to produce materials and devices with finely controlled interfacial performances. The non-destructive measurement of SFE in nanopatterned superhydrophobic hard surfaces is a challenge in both research and industry since, in most cases, time-consuming contact angle measurements are not feasible.
In this framework, a novel nanoindentation-based method has been established for the measurement of the pull-off adhesive forces by carefully controlling environmental and instrumentation issues, through the enhancement of the hardware capabilities of a commercially available nanoindenter and the development of a novel testing protocol, implementing adhesion-accounting contact mechanics models [1, 2].
A set of reference surfaces was selected for validation: (i) highly energetic, new, and atomically flat surfaces from cleavage of the silicate sheet based structure of muscovite mica; (ii) Double-Sided Polished germanium <100> crystals. The latter yielded the pristine substrates for the development of superhydrophobic surfaces, tackled via both patterning and fluorinate silane coating (silanization). Those processes performances were independently studied and, ultimately, their interplayed role was investigated on both nanopatterned and silanized germanium substrates. Contact angle measurements were performed on all the investigated surfaces to provide comparative results.
The novel method is found to effectively measure SFE over five orders of magnitude, covering the hydrophilic to the superhydrophobic surfaces. The potential applications include fast non-destructive mapping of SFE values over heterogeneous surfaces with spatially controlled wettability.

[1] B. V. Derjaguin, V. M. Muller, and Y. P. Toporov: Effect of contact deformation on the adhesion of elastic solids. J. Colloid Interface Sci. 53(2), 314 (1975).
[2] D. Tabor: Surface forces and surface interactions. J. Colloid Interface Sci. 58(1), 2 (1977).

Acknowledgements: The authors gratefully acknowledge partial financial support from the European Commission, European project Oyster, grant agreement n. 760827.

Corresponding Author e-mail: marco.sebastiani@uniroma3.it
*lead presenter: e-mail: edoardo.rossi@uniroma3.it

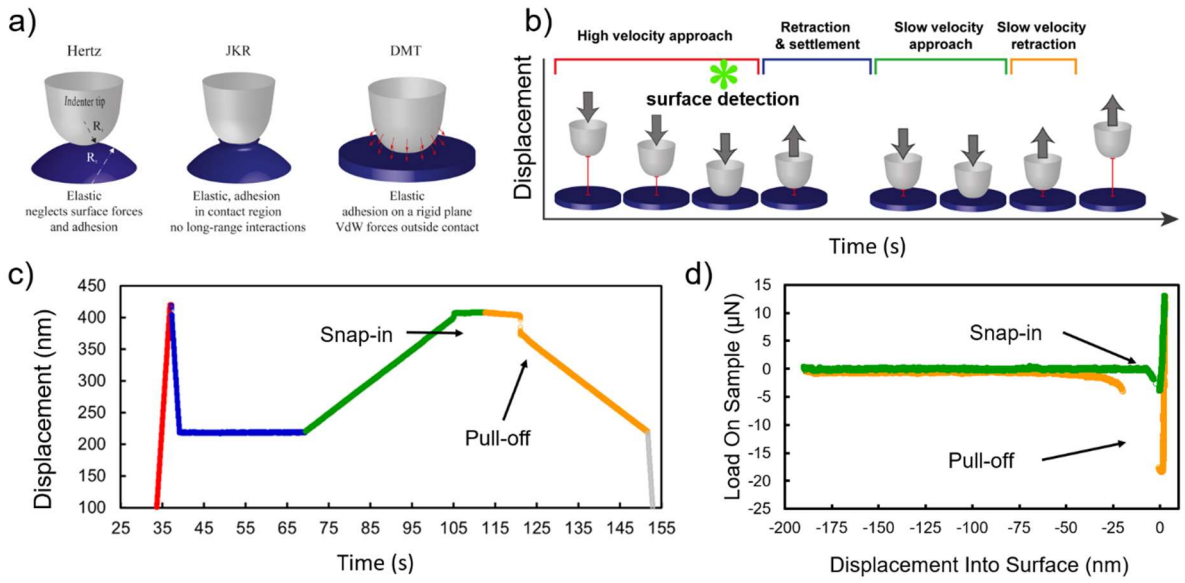

Figure 1 . a) Contact mechanics models for the assessment of the SFE at the micro- and nano-scale. b) Schematic of the developed method. c) indenter displacement – time graph with the highlighted segments of the procedure and d) the corresponding Load On Sample – Displacement Into Surface signal.