Nanoindentation protocol to characterize surface free energy of micro and nano-structured titanium

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The unique combination of high tensile strength, flexibility, lightness and corrosion resistance makes titanium a material of choice for a variety of applications, ranging from aerospace to regenerative medicine. To further improve the performance of the material by controlling its surface properties, etching treatments to modify the roughness, or coatings with active materials such as antioxidant or antibacterial agents are often used [1]. The ability to engineer and control surface free energy and wettability of functional materials is critical for their successful application and knowledge of the chemical-physical properties of surfaces is of fundamental importance for the design of a system with predictable, reliable, and reproducible performance. This need becomes even more pressing when micro- and nano-scale systems are considered.
Surface energy and wettability are generally determined by contact angle measurements [2]. In some cases, however, this technique is inapplicable, for example due to the limited amount of surface available or to the use of a nonplanar substrate. Furthermore, surface irregularities can affect the measurement in an unpredictable way, preventing the distinction of the morphological contribution from that of chemical reactivity. Nanoindentation tests, based on mechanical contact methodologies, can represent an interesting alternative as they are independent of the roughness parameters. In this work, the effect of different etching treatments on titanium surface properties was evaluated relating contact angles and nanoindentation measurements. General morphology and samples roughness was also investigated and related to the calculated surface free energy.

[1] Sotgiu, G., Orsini, M., Porcelli, F., de Santis, S., Petrucci, E. Chemical Engineering Transactions, 86, 1417–1422 (2021)
[2] S. De Santis, G. Sotgiu, F. Porcelli, M. Marsotto, G., M. Orsini. Nanomaterials 11, 445-458 (2021).