Nanomechanical investigation of a porous polymer structure

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Porous materials are of great interest due to their importance and applications in biological tissues and membranes, absorption, filtration, mechanics, acoustics, chemical scaffolding, and electronic materials. Generally, the material properties are considered to be those of the material matrix with the porous regions subtracted away. For instance, super-hydrophobic properties of some porous structures[1] are well explained by Cassie's law[2], which splits the interface between a liquid droplet and the surface into liquid-solid and liquid-air contacts where the macroscopic wetting properties are given by the weighted additive values of these 2 regions. It thus seems logical that porous material properties can be deduced by macroscopic measurements. Here, we investigate this hypothesis by nanomechanical testing of a porous structure.

Two key instrumental methods used to obtain localized nanomechanical information are instrumented nanoindentation and scanning probe microscopy (SPM) or its common variant, Atomic force microscopy (AFM). AFM has the advantage of being able to provide high resolution mapping with the same probe that is also used for the characterization of the local mechanical properties. The ability to measure mechanical response at exact sample locations, in very small volumes and at shallow depths, while monitoring time, depth and force response allows us to probe heterogeneity at the nanoscale, as well as local effects which occur due to vertical polymer confinement[3]. Polymers are particularly amenable to study by AFM since their typical contact stiffness is similar to those of common AFM probes.

Self-organized patterns are of great interest to a number of fields, amongst them polymeric structures. This work applies nanoindentation for investigating the mechanical properties of micro porous polymeric reliefs obtained using the well-known breath figure (BF) method first presented in 1994 by B. Francois *et.al*[4,5] . Measuring the local elastic modulus of these porous reliefs revealed, surprisingly, significant reduction in the elastic modulus near the pores. The results suggest a structure-induced modification of the polymer chains ordering with profound influence on the mechanics.

Reference

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