SMART SURFACES FABRICATED BASED ON SHAPE MEMORY POLYMER

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1 INTRODUCTION

Natural surfaces with unique properties are rarely smooth and always featuring structures. For example, the lotus leaves demonstrate excellent self-cleaning properties [1] and the butterfly wings ensure a stable and safe flight [2] due to the micrometer to nanometer scale structures. Inspired by the smart surfaces from nature, various surface patterns from single to hierarchical structures are imitated to maximize the functions. Smart surface with tunable properties are significantly important for many applications such as drug delivery, microfluidic devices and antiicing.[3] The property of smart surface is closely related with the chemical composition of surface materials and the topological structure of surfaces. Compared with the chemical composition which is the instinct of materials and hard to change, the control over the surface morphology enables more tunable change of the surface properties.

Shape memory polymers (SMP) are one kind of smart materials that can keep temporary shape stable for a long time and recover to permanent shape upon exposure to an external stimulus, such as light, heat and pH change.[4] To design smart surfaces by using their shape memory effect (SME) should be of great interest. With the shape recovery by controlling the temperature or time, the surface structures can be tuned effectively so that the properties of surface can be regulated.

2 RESULTS AND DISCUSSION

2.1 Continuous Tunable Wettability of Smart Surface

For the existing smart surface there are two issues deserving to be tackled. First, the controlled wettability necessitates continuous input of external stimuli. Second, the traditional control of wettability is polarized. A continuous adjustment of the surface wettability is usually absent, which limits the application range of such smart surfaces. The novel strategy is to fabricate smart surfaces with tunable wettability by using surface patterned crosslinked polycyclooctene (*c*PCO) films. [5] Via controlling the shape recovery process, the roughness of such patterned surfaces can be controlled and results in the change of contact angle (CA).

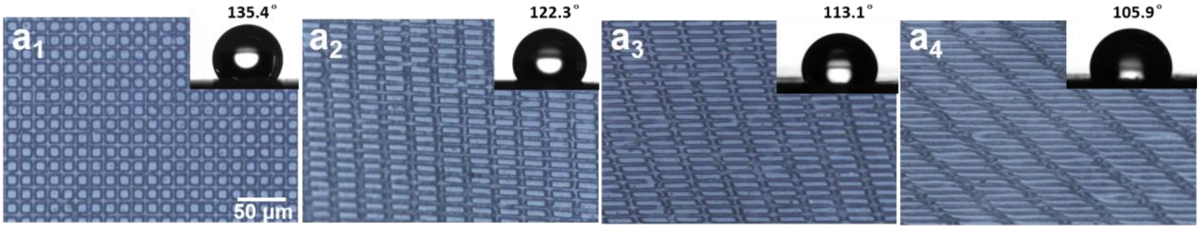

Figure 1: Microscopic images and CA measurement images (in the upper right corner) of samples with various strain of 0% (a_1), 80% (a_2), 200% (a_3), and 450% (a_4).

The figure 1 shows the deformation of patterns during the uniaxial stretching of the surface patterned *c*PCO and the corresponding change of CA. Elongation along the stretching direction and compression in the perpendicular direction can be seen. For the high stretching strain of 450%, shear in the ca. 45 ° direction can be observed. Since the geometrical change of the patterned *c*PCO during the strain recovery brings about a change of the surface roughness, the surface wettability can also be tuned by controlling the recovery temperature or time.

2.2 Fabrication of Surface Patterns Based on the Instability

The new strategy of making use of surface instability to generate patterns has attracted increasing attention due to its simplicity and low cost compared with other conventional methods such as template synthesis, lithography, plasma etching, and phase separation.[6] The underlying mechanism lies in the strain mismatch between a stiff film and an elastomeric supporting substrate. By optimizing physical and microstructural properties of stiff films and substrate, the surface patterning by strain engineering offers new dimensions of design. While these surface designs have substantially been advanced state-of-the-art, it is still an open question how to obtain hierarchically patterned surfaces with a low-cost, scalable, and more importantly, controllable manner for broad industrial applications.

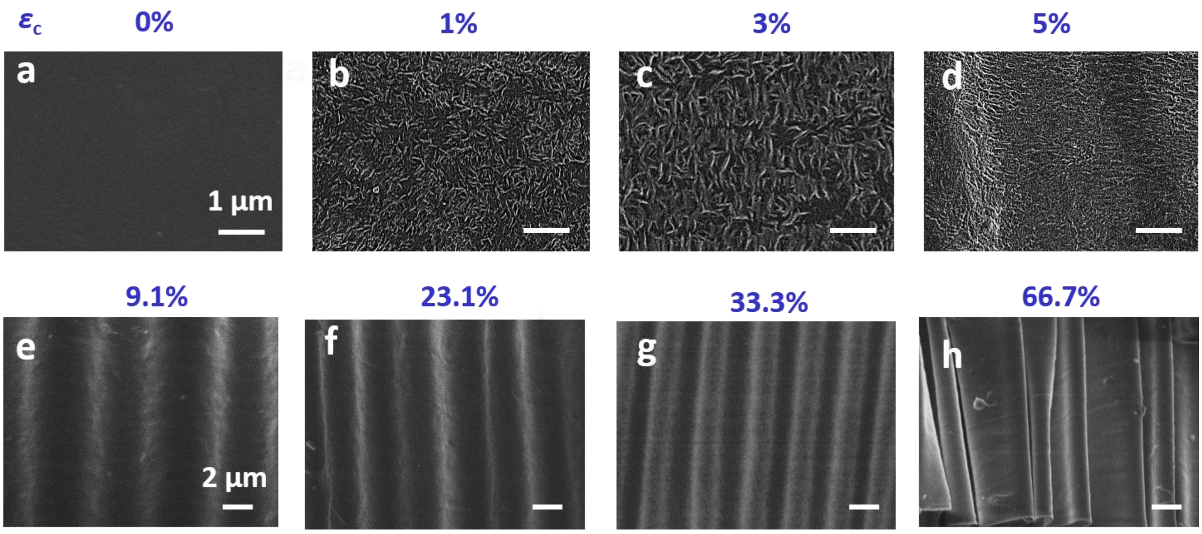

Figure 2: SEM images of patterns obtained with different compressive strain, 0% (a), 1% (b), 3% (c), 5% (d), 9.1% (e), 23.1% (f), 33.3% (g) and 66.7% (h).

In this work, crosslinked polyethylene substrate is used as the underlying substrate for its excellent shape memory effects, thus multi-scale patterns from nanometer to micrometer can be realized via precisely tune the recovery process .[7] More complicated nanostructures can be obtained via the orthogonally biaxial control of shape recovery, coinciding well with the simulation results of Fourier spectral method. Besides, the as-constructed patterned surface demonstrates efficient antibacterial properties, which is related to the increased specific area and surface roughness. This work could shed some lights on the fundamental aspects and real applications of the hierarchical surface patterns.

3 CONCLUSIONS

In conclusion, fabricating smart surfaces with the shape memory polymer can endow the surface with novel properties, especially the dynamic properties. They demonstrate a great controllability and adjustability, which shed new light on development of smart surfaces and benefit their real applications.

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