

Reconfigurable photonic crystals enabled by pressure-responsive shape-memory polymers

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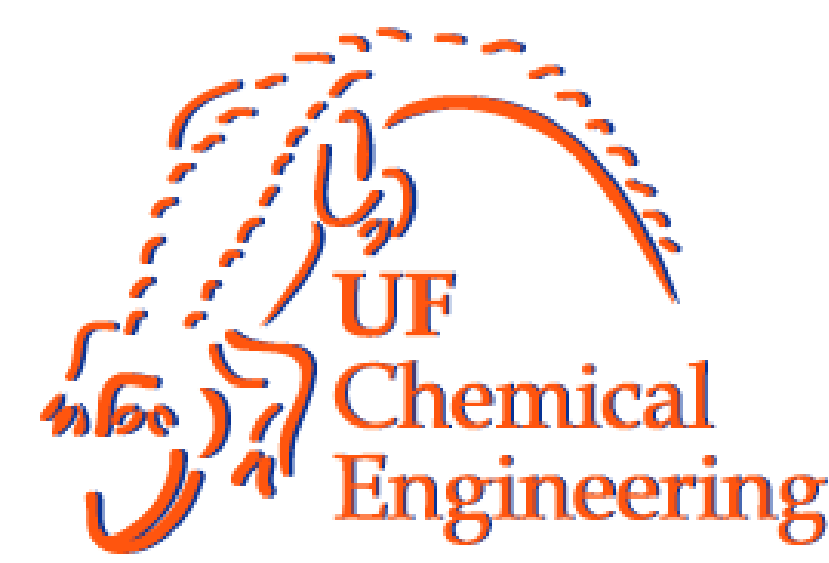
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Here we report a series of SMPs that enable unusual ‘cold’ programming and instantaneous shape recovery triggered by applying a contact pressure at ambient conditions. Moreover, the interdisciplinary integration of scientific principles drawn from two disparate fields—the fast growing photonic crystal and shape-memory polymer technologies—enables fabrication of reconfigurable photonic crystals and simultaneously provides a simple and sensitive optical technique for investigating the intriguing shape-memory effects at nanoscale.

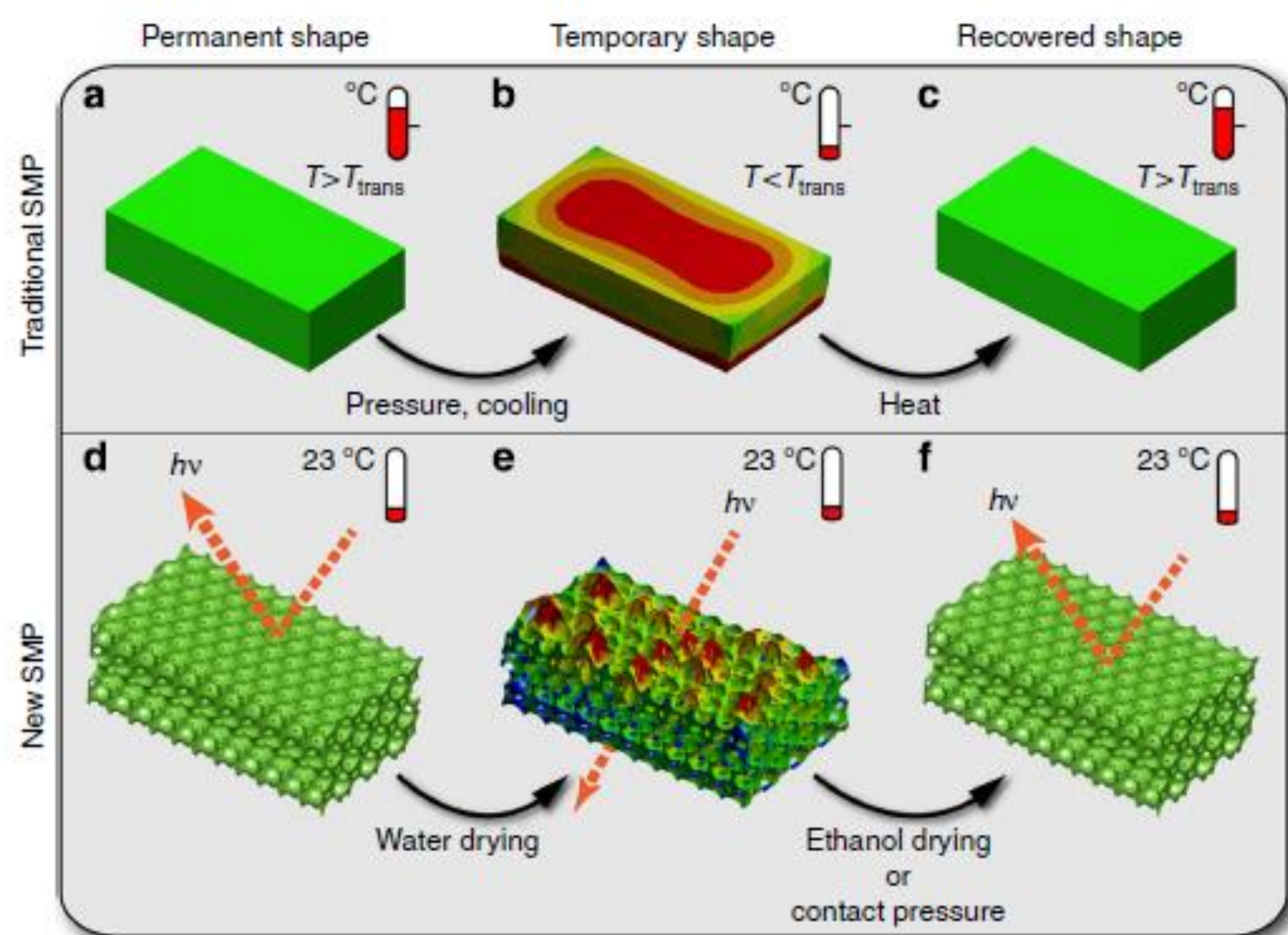


Figure 2.

Structures and Properties of the new SMPs.

(a) Molecular structures of ETPTA ($x+y+z=20$) and PEGDA ($x=12$) oligomers.

(b) Differential scanning calorimetry plot of a macroporous ETPTA-co-PEGDA copolymer with 1:3 ratio.

(c) Typical force–depth indentation curve used to measure elastic properties of SMP.

(d) Average Young’s moduli for PEGDA, ETPTA-co-PEGDA copolymer with 1:3 ratio and ETPTA polymers.

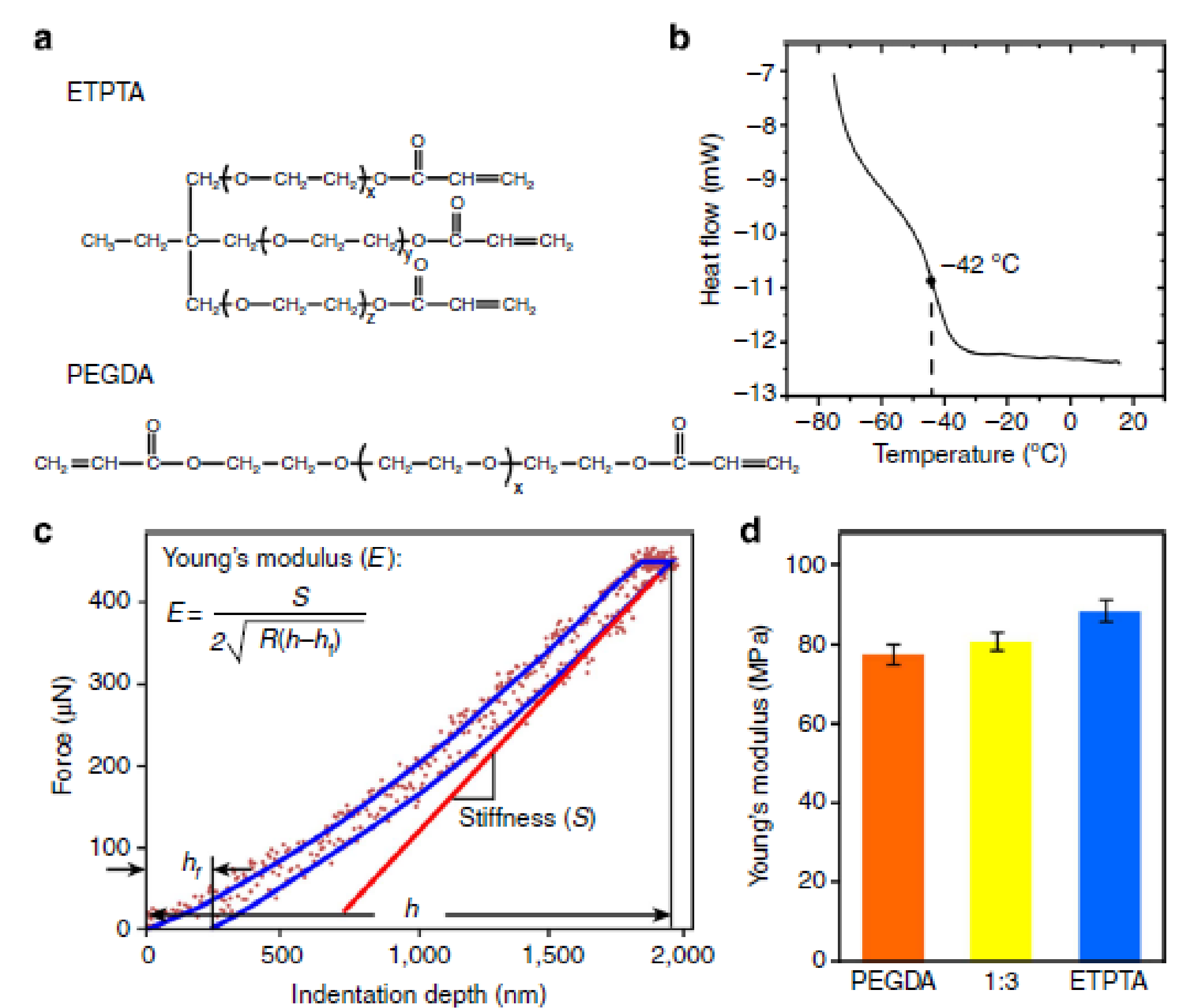


Figure 4.

Difference in topography and PBGs.

(a,c) 3D AFM image and the height profile scanned across the profile line for a water-dried SMP sample consisting of 280nm macropores. (b,d) 3D AFM image and the height profile for the same sample dried out of ethanol.

(e) Cross-sectional SEM image of the sample in b. (f) Normal-incidence optical reflection spectra compares the PBG properties of the macroporous samples dried out of water and ethanol.

The scalar-wave approximation-simulated spectrum assuming a perfect macroporous crystalline lattice is also shown to compare with the experimental results.

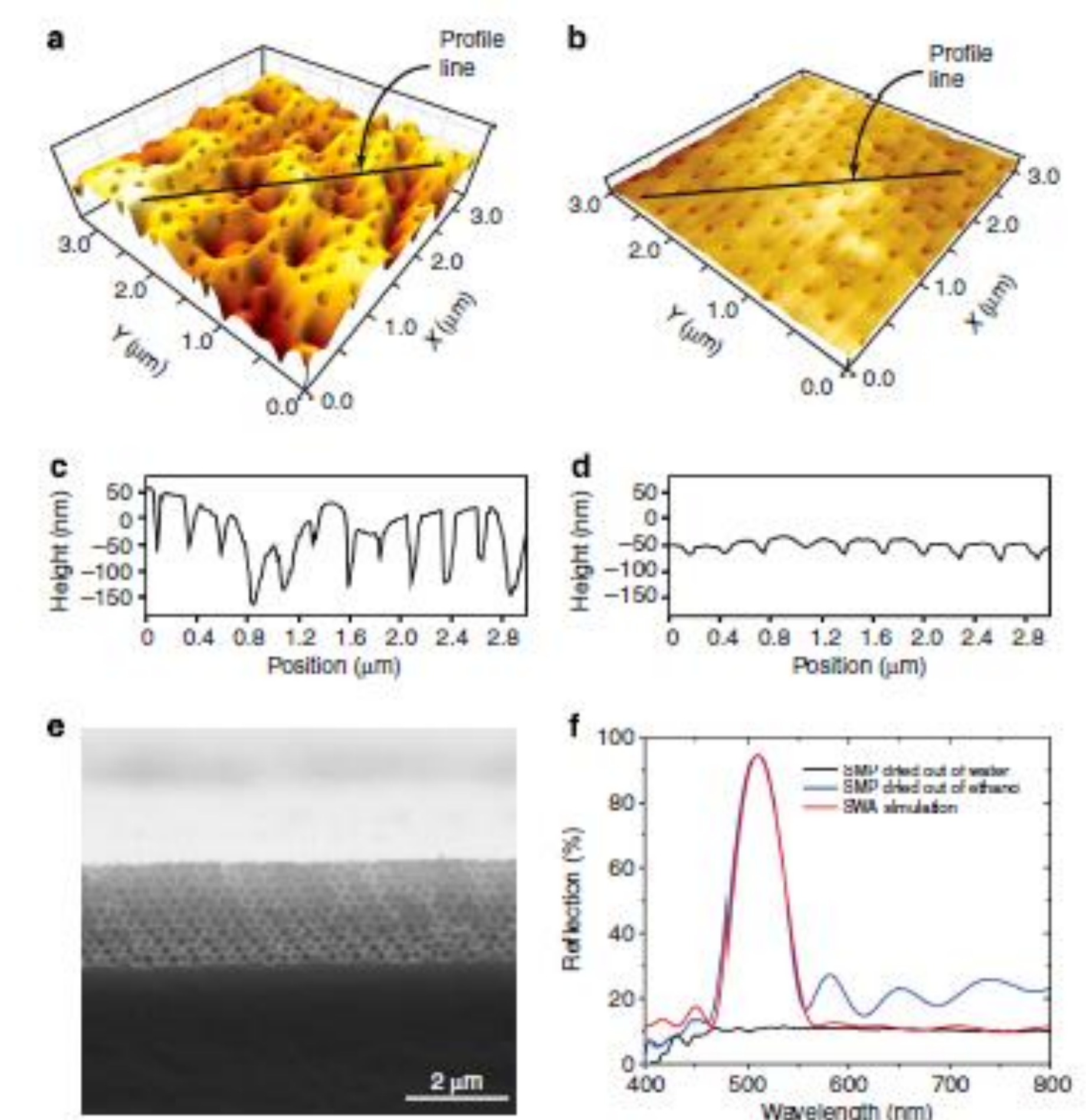


Figure 5.

Pressure-dependent macropore recovery.

Pressure-dependent macropore recovery.

(a) Normal-incidence optical reflection spectra obtained from a porous SMP membrane consisting of 280nm macropores under different pressures. The same sample dried out of ethanol was ‘Full Recovered’. (b) Normalized absolute reflection amplitude of a recovered SMP sample was used as an indicator of the nanoscopic SMP strain-recovery rate @ different pressures. (c), (d) Cross-sectional SEM images of a porous SMP membrane recovered by 7.13 and 27.9 kPa pressures.

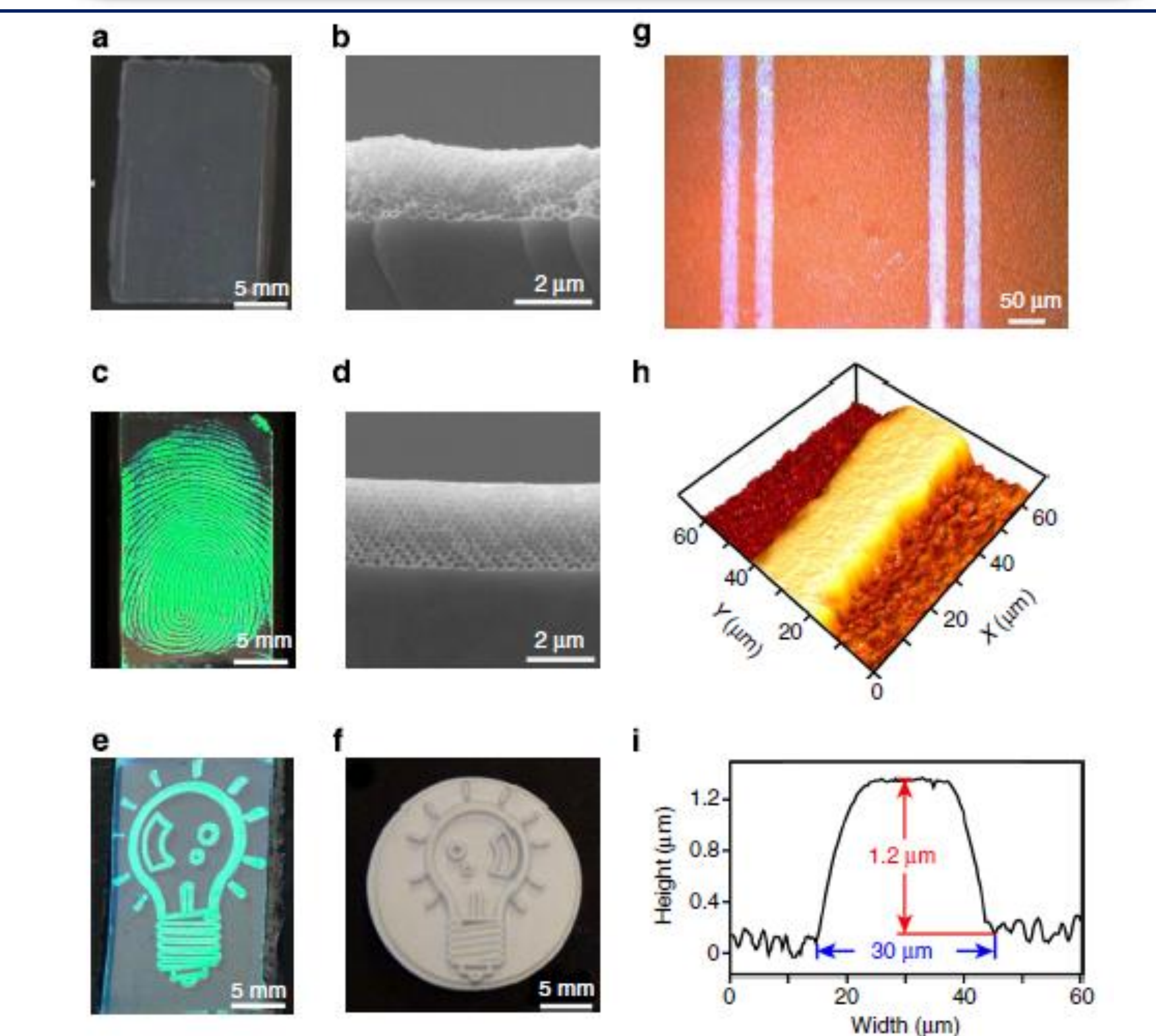
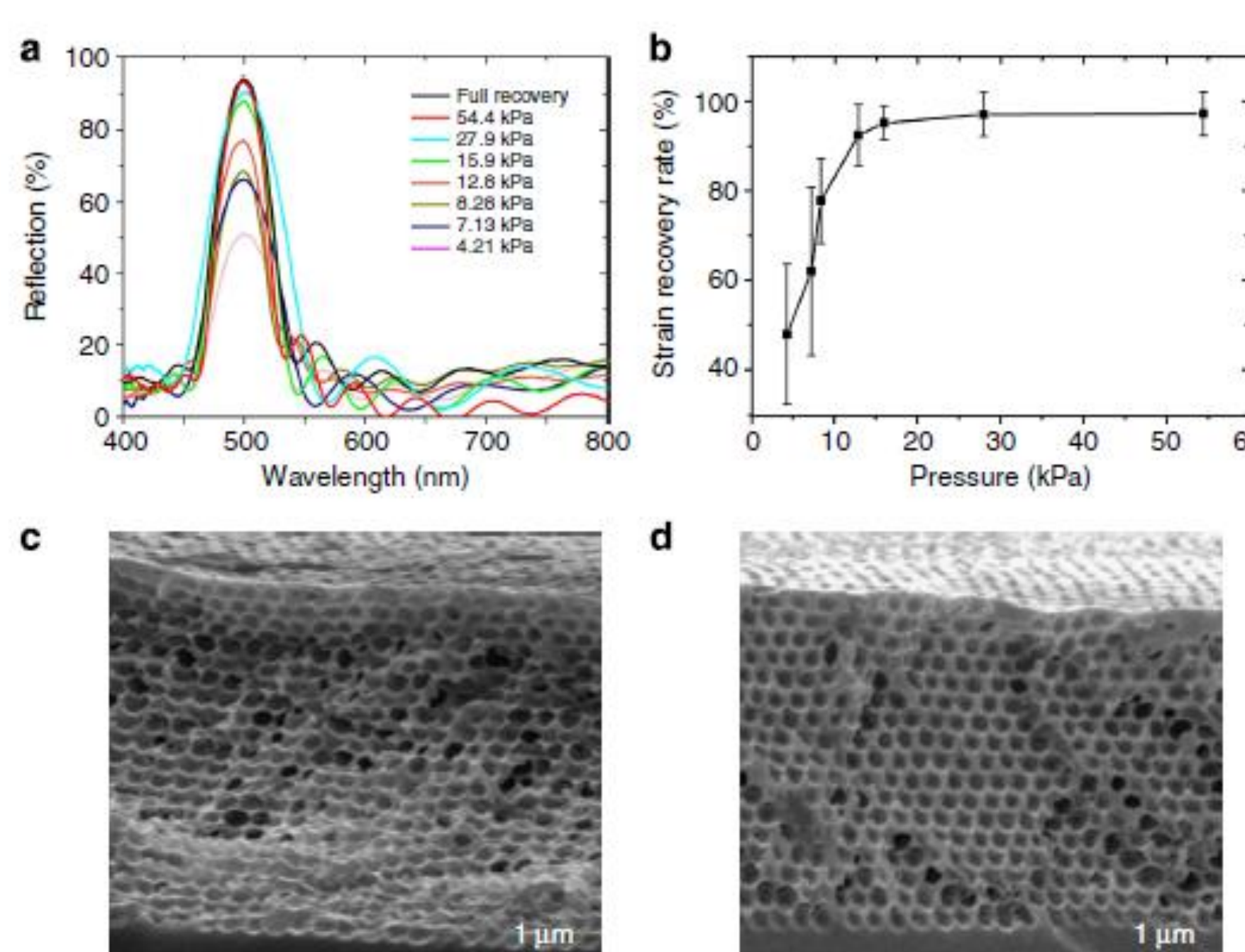


Figure 3.

Arbitrary photonic crystal patterns printed on the new SMP membranes.

(a) Photograph of a translucent macroporous SMP film with disordered macropores. (b) Cross-sectional SEM image of the macroporous sample in a with deformed macropores. (c) Photograph of a green-coloured fingerprint pressed on the sample in a. (d) Cross-sectional SEM image of an iridescent region in c with 3D ordered macropores $\varnothing 300\text{nm}$. (e) Photograph of an iridescent ‘light bulb’ pattern printed on a translucent macroporous SMP. (f) Photograph of the rubber stamp used in generating the ‘light bulb’ pattern in e. (g) Optical microscopic image of micropatterned pairs of double lines on a macroporous SMP membrane. (h) And (i) 3-D AFM image and the height profile of a section of a line in g.

Acknowledgements

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Main References

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