

# Strain-Dependent Nanowrinkle Confinement of Block Copolymers

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Here we describe an all-soft, templated assembly of block copolymers (BCPs) with programmable alignment. Using polymeric nanowrinkles as a confining scaffold, poly(styrene)-block-poly(dimethylsiloxane) (PS-*b*-PDMS) BCPs were assembled to be parallel or perpendicular to the wrinkle orientation by manipulating the substrate strain. Self-consistent field theory modeling revealed that wrinkle curvature and surface affinity govern the BCP structural formation. Furthermore, control of BCP alignment was demonstrated for complex wrinkle geometries, various copolymer molecular weights, and functional wrinkle skin layers. This integration of BCP patterning with flexible 3D architectures offers a promising nanolithography approach for next-generation soft electronics.

## Significance and Impact

Strain-dependent BCP assembly is general across different surfaces, meaning our strategy can be used to create highly aligned, densely packed features in functional materials (such as arrays of curved graphene nanoribbons). The polymeric substrate can also be stretched to vary the separation between the line patterns, offering dynamic routes to texture materials. Moreover, these patterns have potential for defect-tolerant applications. Overall, our 3D nanopatterning platform will enable unique properties not previously possible by hard confinements and will open prospects for advancing next-generation flexible devices.

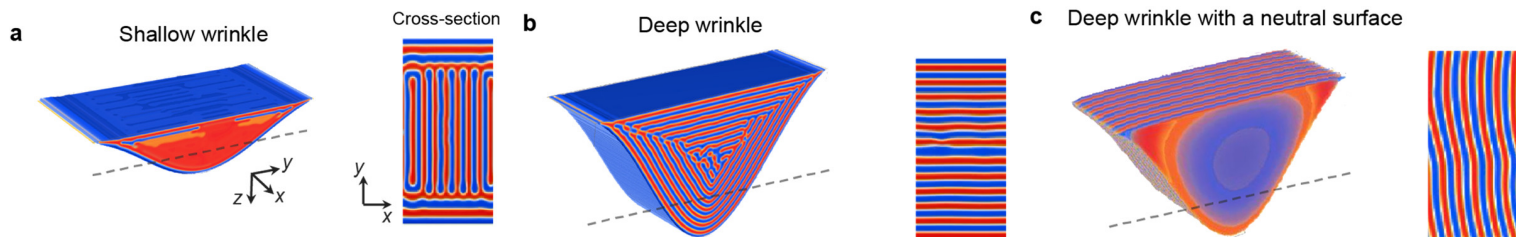


Figure 1. SCFT modeling of BCP alignment in wrinkles highlighting wrinkle curvature and surface affinity. Each data set shows a unit cell of a single wrinkle valley with a corresponding cross-sectional view of the BCP pattern in the  $x$ - $y$  plane (at the dotted line). (a) Shallow wrinkle representing the 10% prestrain case that showed perpendicular BCP alignment. (b) Deep wrinkle representing the 30% prestrain case that demonstrated parallel BCP alignment. (c) Deep wrinkle with no surface preference that gave parallel BCP alignment.