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Nanomechanical Architecture of Strained Bi-layer Thin Films: From Design Principles to Fabrication

FENG LIU, University of Utah

Controlled and consistent fabrication of different classes and shapes of nanostructures (as opposed to simply stochastic self-assembly) will be a requirement if nanotechnology expects to achieve its promised impact on society. We illustrate by both theory and computation the design principles of an emerging nanofabrication approach based on the *nanomechanical architecture* of strained bi-layer thin films, which are further confirmed by experiments through fabrication of a variety of nanostructures, including nanotubes, nanorings, nanodrills, and nanocoils. This approach demonstrates the possibility of fabricating nanostructures with an unprecedented level of control over their size, geometry, and uniformity, based on *a priori* designs. It possesses also an unparallel level of versatility for making nanostructures with combinations of different materials. By combined multi-scale modeling and simulations from first-principles calculation, to molecular dynamics simulation, and to continuum mechanics modeling, we demonstrate how mechanical bending of nanoscale thin films differs from that of macroscopic thin films. For example, we show that surface stress will even play a more dominant role than misfit strain in bending a film that is down a few monolayers thick. *This work is supported by DOE and NSF.