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Nonequilibrium patterns in nanocomposite films and fluids

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Carbon and silicon impact a broad range of technologies from structural composites to microelectronics. Working at the nanoscale in the colloidal domain, we leverage soft matter to simplify processing and improve the performance of these materials. Our approach, which exploits concepts firmly rooted in polymer science, has potentially profound implications for a number of emerging technologies. Two specific examples will be discussed. In the first, thin films of purified single-wall carbon nanotubes are deposited on elastomer substrates for applications in flexible electronics. By adapting approaches developed to study the elasticity of thin polymer films, we infer the mechanics of the nanotube coatings from the pattern of wrinkles and folds that emerges under compression, and we relate this response to the electronic and optical properties of the films. In the second example, patterns of phase separation in drying nanocrystal-polymer mixtures are explored in the context of achieving homogeneous coatings. The results are interpreted using equilibrium theories of colloid-polymer mixtures coupled with lattice-Boltzmann simulations of drying complex fluids. I will conclude by discussing some examples of how ideas from both of these scenarios are being merged for new applications.