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Order Through Instability: Patterning with Polymers and Nanoparticles

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Nature provides wonderful inspiration and justification for the development of hierarchical structures in synthetic materials. The balance in structure provides balance in performance and properties, while consuming minimal resources (e.g. energy, materials) during development. A ubiquitous trait in the development or processing of these Natural structures, consistent with the use of minimal resources, is the use of instabilities to guide the shape and building of hierarchical elements. In this paper, an overview is presented of recent efforts in our group to use elastic and fluid instabilities to build hierarchical structures. The physics of developing morphology, or arrangement, for wrinkles and folds in polymer thin films will be discussed, focusing on the impact of geometric constraint, origin of stress, and polymer architecture. Similar strategies, combined with tailored nanoparticle chemistry, are used to develop hierarchical assemblies of quantum dots. The resulting process and structures, in general, always rely upon a unique balance of geometry and materials properties and are designed with an eye toward scaling and application in products ranging from responsive optics to flexible electronics.