Tailoring the Self-Assembly of Ordered and Hyperuniform Nanostructures by Solid-State Dewetting

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Solid-state dewetting (SSD) is a process whereby thin solid films break, retract, and agglomerate. In crystalline thin films, it occurs at relatively high temperatures via surface diffusion. Although detrimental during the processing of planar architectures, it provides a kinetic pathway between very different morphologies, from simple film-like arrangements to pierced films, connected filaments, nanowires, and islands [1]. This presentation outlines different solid-state dewetting scenarios and their exploitation for the bottom-up fabrication of nanostructures. The main phenomenology of SSD and a convenient phase field modeling of surface diffusion, enabling large-scale three-dimensional simulations of the dewetting process, are first illustrated [2]. Specific processes are then discussed, such as the self-assembly of complex Si nano-architectures and ultra-long nanowires via solid-state dewetting of pre-patterned, single-crystalline, silicon-on-insulator thin films [2,3]. Representative applications are also presented [4]. Moreover, a spinodal-like solid-state dewetting regime for mono-crystalline SiGe layers deposited on silicon-on-insulator substrates triggered by elasticity is illustrated [5]. This process results in disordered arrangements of nanostructures featuring an (effectively) hyperuniform character, i.e., with (almost complete) suppression of long-wavelength fluctuation, like periodic arrangements, while not having any Bragg peak in diffraction, like in a liquid. Finally, extensions and future perspectives are discussed. This includes the study of polycrystalline thin films with the aid of phase field simulations and the emergence of hyperuniformity in other systems [6].

References: [1] C. V. Thompson, *Annu. Rev. Mater. Res.* 42, 399 (2012); [2] M. Naffouti et al. *Sci. Adv.* 3, eaao1472 (2017); [3] M. Bollani et al, *Nat. Commun.* 10, 5632 (2019): [4] N. Granchi et al., *Opt. Express* 31, 9007 (2023); [5] M. Salvalaglio et al. *Phys. Rev. Lett.* 125, 126101 (2020); [6] J.-B. Claude et al, *Phys. Scr.* 98 115953, (2023).