Design, characterization and lithographic application of Si nanocrystals patterns via templated dewetting

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Silicon-based nanocrystals represent a promising resource both for next generation electronic devices and for nano-photonics applications but require precise size, shape and position control [1,2]. However owing to their large surface-area-to-volume ratio, thin semiconductor solid films are often unstable upon annealing. Under the action of surface diffusion the film breaks eventually forming isolated islands. This is one of the main factors impeding the use of ultra-thin silicon films on insulators (UT-SOI) for the further miniaturization of electronic components. Here, with an e-beam lithographic method, we demonstrate the ultimate control of UT-SOI dewetting for the precise formation of complex nano-architectures featuring extremely reduced fluctuations of size, shape and positioning (a few %) over hundreds of repetitions and on large scales [3,4]. The solid state dewetting initiated at the edges of the patterns controllably creates the ordering of nanocrystals (NCs) with ad hoc placement and periodicity [5,6]. The NC size is tuned by varying the nominal thickness of the film while their position results from the association of film retraction from the edges of the lay out and Rayleigh-like instability. Islands formation, organization, positioning and composition are studied by dark-field, atomic force and transmission electron microscopy (Figure 1 and 2). Predictive phase-field simulations of the mass transport mechanism, assess the dominant role of surface diffusion providing a tool for further engineering this hybrid top-down/bottom-up self-assembly method. Finally, we show its potential by fabricating nano-transfer molding for nanoimprinting lithography of titania and silica xerogels on silicon and glass substrates.

[1] M. Aouassa et al, Appl. Phys. Lett. 101, 013117 (2012)
[2] I. Berbezier et al., J. Appl. Phys. 113, 064908 (2013)
[3] M. Naffouti et al, Science Advance, Vol. 3, n°11, eaao1472 (2017)
[4] M.Abbarchi et al., Microelectronic Engineering, Volume 190, Pages 1-6 (2018)
[5] M. Abbarchi et al., ACS Nano 8, 11181 (2014)
[6] N. Meher et al., Small 12, n°. 44, 6115-6123 (2016)