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Complex dewetting of ultrathin silicon films for large-scale nanoarchitectures

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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. 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. The solid state dewetting initiated at the edges of the patterns controllably creates the ordering of Nano Crystals (NCs) with ad hoc placement and periodicity. 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 microscopy and scanning electron microscopy. 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. We also investigate the influence of adding a Ge flux during the dewetting. Finally, we show the feasibility to perform ultra-long Si nanowires on SiO₂ and also core-shell structures by adding SiGe fluxes with different compositions.

Biography

Dr Abdennacer Benali has his expertise in Molecular Beam Epitaxy for both III-V and IV-IV semiconductors. He worked on III-V nanowires for photovoltaics where he acquired a strong knowledge in the material elaboration field. He also worked on the dewetting of Si and SiGe layers on SOI substrates. He made strong collaboration with laboratories all over Europe during his different projects.

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