Symposium: Simulation, modeling, and design tools for nanofabrication

Title: Mechanical Modeling of Polymeric Stamp During Large-Area Electrochemical Metal-Assisted Chemical Imprinting

Authors: Emmanuel Dasinor, Aliaksandr Sharstniou, Bruno Azeredo

Abstract

The patterning of semiconductors with complex 3D hierarchical structures having sub-100 nm resolution is propelling a new generation of optical metasurfaces for applications in optoelectronic interconnects and hyperspectral imaging. These complex architectures are now manufacturable with the advent of electrochemical Metal-assisted Chemical Imprinting (Mac-Imprint). Recently, the novel class of flexible stamps made of Au-coated mesoporous polymeric membrane (i.e., porous Polyvinylidene fluoride (PVDF) and a solid polyimide film), combined with pressure-based actuation systems, ushered in an era of conformal micromachining on both planar and curvilinear inorganic semiconductor substrates. This innovation approach overcomes the limitations of conventional plate-to-plate configuration such as their limited contact pressure control due to the rigidity of both stamp and substrate, as well as the need to pre-machine solution storage reservoirs in either stamp or substrate. The inherent flexibility and stretchability of the flexible catalytic stamp requires a comprehensive numerical analysis to elucidate the changes in the morphology as it undergoes mechanical deformation during pressurization. Herein, this paper seeks to computationally elucidate the mechanical stability of the stamp and the impact of the induced interfacial biaxial stresses and strains on pre-patterns upon contact with silicon. The validation of the numerical model was achieved through empirical calculations of the average induced contact strain using optical digital image correlation (DIC) technique. Remarkably, without any fitting parameter, both results show a good correlation when juxtaposed. This approach provides simulation-based prediction and guidance in optimizing the experimental setup and Mac-Imprint parameters in order to achieve a high-fidelity imprint with desired pattern' dimensions, and functionality.