Electrochemical Nanoimprinting of Silicon: A Direct Patterning Approach

Aliaksandr Sharstniou[a], Stanislau Niauzorau[a], Bruno Azeredo[a*]
[a]The Polytechnic School, Arizona State University, 6075 S. Innovation Way West, Mesa, AZ, USA 85212-2180;

ABSTRACT

Soft-lithography and nanoimprinting lithography have been critical in manufacturing 3D features with sub-20 nm resolution onto polymeric materials. However, methods for transferring 3D polymeric patterns (i.e. template) into silicon have relied upon the etch selectivity of the mask pattern during reactive ion etching, which in turn limits aspect-ratio, introduces shape distortions and introduces surface roughness via scalloping effects.

To tackle this problem, this paper demonstrates an electrochemical nanoimprinting process for single-crystal semiconductors for directly etching 3D features into silicon wafers without the need for templates or lithographical steps. It is shown that stamps made of porous catalysts used in the imprinting process allows for better morphology control of the imprinted silicon which is attributed to increased pathways for diffusion of chemical species during imprinting. This process delivers low-defect density, and large-area patterning (>1 cm2) in a single imprinting operation. Further, it outperforms the resolution and scalability of leading serial (e.g. FIB, electron beam) and parallel (e.g. gray-scale lithography) methods altogether, allowing for fast replication of patterns onto hard materials from a soft or polymeric mold. This technique bypasses the need for dry etching and is potentially compatible with roll-to-roll platforms, amorphous and poly silicon and III-V semiconductors. In turn, it may pave the way for mold replication onto hard molds and the manufacturing of complex objects for infrared optics.

Keywords: nanoimprinting, electrochemical imprinting, MACE, metal-assisted chemical etching, silicon photonics, microfabrication, microengineering.

*bruno.azeredo@asu.edu