Using block copolymers as infiltration sites for development of future nanoelectronic devices: Achievements, barriers, and opportunities

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Using block copolymers as infiltration sites for development of future nanoelectronic devices: achievements, barriers, and opportunities

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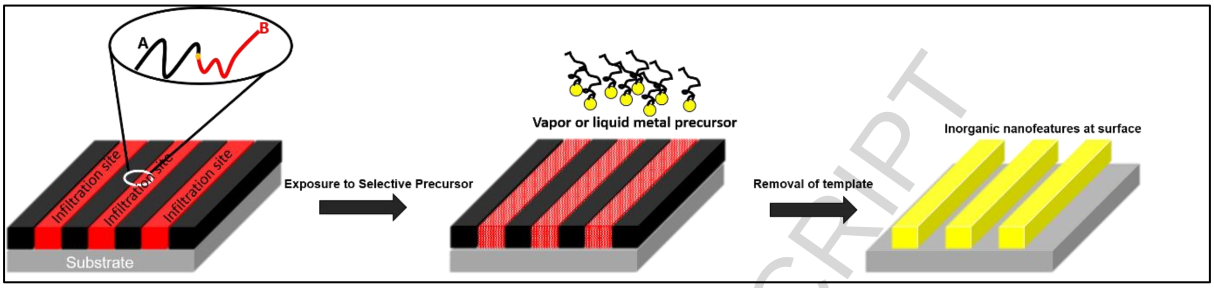

Abstract

Creating inorganic nanostructures for development of nanoelectronic device components is a highly active research area. The ability for manipulation of the chemistry of materials, as well as their shape, size and placement enables scientists and engineers to propose technologically advanced devices. Recent techniques can now realize astounding control of metallic and oxide structures by insertion of metal molecules from gas phase or solution mediated processes into self-assembled block copolymer templates targeting distinct nanodomains as infiltration sites. Inorganic nanofeatures such as metals, oxides including a range of functional perovskites and related structures, have broad energy, photonic, catalytic and environmental nanotechnology applications; however, the objective in this perspective is to highlight salient achievements that block copolymers possess as infiltration sites specifically for nanoelectronic device manufacture. We briefly outline background semiconductor patterning followed by the basic theory of block copolymers for general readers. The subsequent section of this piece highlights gas/vapor and wet chemical approaches for the selective inclusion of functional inorganic materials in block copolymer nanodomains. The piece concisely describes advanced experimental achievements in the early part, while discussion then centres on the barriers that may prevent translation of such research in an industrial manufacturing environment. These barriers comprise both commercial and technical aspects. We present evaluations on each barrier in a forward-looking manner to accelerate overall progression. Finally, we discuss nanoelectronic opportunities that are possible from the synergy of block copolymers and infiltration techniques for future research endeavours. We envisage that this perspective serves to highlight the excellent progress in the field and allows readers to comprehend the hurdles for integration in high volume manufacturing and, thus, may lead to new studies to translate discovery to manufacturing.

Overview

From its inception over 50 years ago, patterning of reduced silicon structures has been the fulcrum of semiconductor manufacturing, sustaining the evolution of Moore's Law.[1],[2] Producing smaller transistor features to prolong Moore's Law has predominantly been achieved through lithographic means, where a design or feature developed on light sensitive films (resists) are transferred using etching into the wafer substrate.[3] Owing to well documented diffraction limits that hinder device pattern resolution attainability and, thus,