Ordered Large–Pore Mesoporous Metal Oxide Thin Films with Nanocrystalline Domain Structures: Preparation, Properties, and Applications

Nanocrystalline metal oxides with mesoporous morphologies have been the focus of much research over the past decade, because various physical properties are expected to be altered due to both the high surface area–to–volume ratio and nanoconfinement effects. In this regard, it has been shown that polymer templating strategies are efficient routes to produce such materials. Their formation relies on the solution phase coassembly of molecular sol–gel precursors with a polymeric structure–directing agent. Thin films of such materials can be produced by the same coassembly methods but using an evaporation–induced self–assembly (EISA) process. Because of the high degree of chemical control available, the pore–to–pore distance, wall thickness, and pore symmetry can be varied essentially independently. To date, many important metal oxides have been made by means of EISA and related routes. However, the majority of these sol–gel derived materials exhibit only a semi–crystalline or even amorphous pore wall structure which makes them unsuitable for most applications; the lack of control over crystallization is one of the major weaknesses of this approach. Here, we show the synthesis of various oxide and non–oxide thin films with both ordered cubic networks of open pores averaging 15–20 nm in diameter and tunable nanocrystalline domain sizes by utilizing a novel poly(ethylene–*co*–butylene)–*block*–poly(ethylene oxide) diblock copolymer as the structure–directing agent.