High-performance, heteroepitaxial, nanolaminate device layers on single-crystal-like, artificial substrates and controlled self-assembly of anostructures within device layers for wide-ranging electrical and electronic applications

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For many energy and electronic applications, single-crystal-like materials offer the best performance. However, in almost all cases, fabrication of single-crystal form of the relevant material is too expensive. In addition, for many applications, very long or wide materials are required a regime not accessible by conventional single-crystal growth. This necessitates the use of artificially fabricated, large-area, single-crystal-like substrates suitable for heteroepitaxial growth of the relevant advanced material for the electronic or energy application in question. In this talk, details of the fabrication of such substrates will be provided. Heteroepitaxial growth of nanolaminate multilayers and devices on such substrates using a variety of deposition techniques such as pulsed laser ablation, sputtering, e-beam evaporation, MBE, MOCVD, and chemical solution deposition will be reported upon. Application areas that have been demonstrated via the use of such artificial substrates include – oxide high-temperature superconductors, semiconductor materials (Si, Ge, GaAs, CdTe, Cu_2O), ferroelectrics ($BaTiO_3$), multiferroics ($BiFeO_3$), etc. In addition, strain-driven self-assembly of second phase nanomaterials at nanoscale spacings has been demonstrated within device layers. Control of heteroepitaxy in lattice-mismatched systems and the effects of strain on self-assembly will be discussed. Such heteroepitaxial device layers on large-area, single-crystal-like artificial substrates are quite promising for a range of electrical and electronic applications.