Morphologies and coarsening of quantum nanoislands on annealed metal surfaces

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Abstract

A low temperature (<140K) deposition of certain ultrathin (20ML or less) metal films on a metal or a semiconductor, followed by the annealing at a moderate temperature (300-400K), results in nanoislands with an atomically flat top surface, steep edges, and a quantized, "magic" height. A detailed understanding of the kinetic pathways to form such island morphologies remains incomplete, in particular questions abound about the nature of the upward mass transport. Such transport is necessary to form multilayer islands, but it is inhibited at low temperature. We developed an advanced model, based on a surface diffusion equation with the built-in electronic and stress effects, that enables the computation of the evolving nanoisland morphologies for a large set (20-30) of Pb or Ag nanoislands that form from the film surface roughness shortly after the start of the annealing. The results of a large-scale computations with varying surface roughness reveal the complicated spectra of a metastable and stable "magic" heights, the surface diffusion pathways that lead to a truncated pyramid-like nanoisland morphologies, and the coarsening rules that underlie the morphological evolution resulting in the "survival of the fittest" among the nanoislands of different heights and sizes. Also we clarified the impacts of the charge spillage at the metal-substrate interface on morphologies, metastability, and coarsening. Our model not only compares favorably to the existing experimental results, it also advances understanding of a metal nanoisland growth.

Biography of Presenter

Mikhail Khenner got his PhD degree in 1999 from the Universite Aix-Marseille II in Marseille, France. He did postdoctoral studies in Tel Aviv University and University of Delaware. He works in WKU since 2009, where he is now the Associate Professor of Applied Mathematics. He is the author and co-author of over forty publications in the fields of modeling crystal growth, thin films, pattern formation and self-assembly. He was invited to present his research at various national and international conferences in materials science and mathematical modeling. He is the member of the Society for Industrial and Applied Mathematics (SIAM), SIAM Activity Group on Mathematical Aspects of Materials Science, and the Kentucky Academy of Science. He routinely collaborates on research projects with applied mathematicians, materials scientists, and engineers.