Continuum models of self-organized nanostructuring by low-energy ion beam erosion

Rodolfo Cuerno
Univeridad Carlos III de Madrid

The production of nanopatterns on the surfaces of targets irradiated by ion beams at low and medium energies has developed during the present decade to a salient degree of control over the main pattern features. However, there is still a wide experimental scatter in the type and relevance of various dynamic interfacial properties induced by this technique as a function of system type and parameters. In parallel, diverse theoretical models exist that differ in their capabilities to reproduce such a wide range of experimental features.

We will attempt an overview [1] of the most recent studies of nanoripple and dot production by ion-beam sputtering, with special attention to the comparison between experiments and (continuum) models. Among these we will focus particularly on a recent "hydrodynamic" model that relates to descriptions of pattern formation in macroscopic systems such as aeolian sand dunes. In this model an explicit description is provided for the density of material that diffuses onto the surface, which is coupled with the dynamics of the surface itself. Closed evolution equations for the surface height can be obtained, that generalize the anisotropic Kuramoto-Sivashinshy equation through additional nonlinearities. In general dot or ripple patterns form, that later evolve exhibiting complex nonlinear dynamics. Thus, we observe interrupted coarsening behavior in such a way that for normal incidence domains of hexagonally ordered structures appear, that compare favorably with those obtained in many experiments of nanodot formation by IBS [1]. This short-range ordered pattern coexists with long range disorder and kinetic roughening. In the case of oblique incidence, a ripple pattern is generically obtained. In our model, these ripples also show interrupted coarsening and feature additional nonlinear features, such as non-uniform transverse motion, that again compare well with experimental observations on nanoripples. We discuss the applicability and limitations of our model especially in view of further experimental results on the occurrence of lateral order and pattern coarsening properties.

This work is based on collaborations with Mario Castro, Raúl Gago, Javier Muñoz-García, and Luis Vázquez.

[1] J. Muñoz-García, L. Vázquez, R. Cuerno, J. Sánchez-García, M. Castro, and R. Gago, *Self-organized surface nanopatterning by ion beam sputtering*, to appear in *Lecture Notes on Nanoscale Science and Technology*, edited by Z. Wang (Springer, Heidelberg). arXiv:0706.2625.