Nanoscale Pattern Formation Produced by Ion Bombardment of a Rotating Solid Surface: Nonlinear Effects

R. Mark Bradley

Departments of Physics and Mathematics, Colorado State University, Fort Collins, CO 80523, USA

Abstract

We study the nanoscale patterns that form on the surface of a rotating sample of an elemental material that is bombarded with a broad noble gas ion beam for angles of incidence θ just above the critical angle for pattern formation θ_c. The pattern formation depends crucially on the ion energy E. In the high energy regime in which there is substantial sputtering, the equation of motion for the solid surface is the Kuramoto-Sivashinsky equation and the surface exhibits spatio-temporal chaos. In simulations carried out in the low energy regime in which sputtering is negligible, on the other hand, we find disordered arrays of nanoscale mounds (nanodots) that coarsen in time. Finally, for values of E just above the sputter yield threshold, nanodot arrays with an extraordinary degree of hexagonal order emerge for a range of parameter values, even though there is a broad band of linearly unstable wavelengths. The order is due in part to the dependence of the surface velocity on the Gaussian curvature. This finding might prove to be useful in applications in which highly ordered nanoscale patterns are needed.