SPECIAL PHYSICAL MATHEMATICS SEMINAR

MATHEMATICAL MODELING OF SELF-ORGANIZED NANOSCALE POROUS STRUCTURES IN ANODIC ALUMINUM OXIDE

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ABSTRACT:

A theory of the spontaneous formation of nanoscale porous structures in aluminum oxide film growing during aluminum anodization is presented. The main elements of this theory are the Butler-Volmer relation describing the exponential dependence of the current on the overpotential and the dependence of the activation energies of the interfacial reactions on the Laplace pressure and elastic stress. Two cases are considered, distinguished by whether the elastic stress dependence is significant or not.

A linear stability analysis, in the case when the elastic stress is negligible, shows the presence of a long-wave instability resulting from the competition between the destabilizing effect of the electric field-assisted dissolution reactions and the stabilizing influence of the Laplace pressure due to surface energy. A weakly nonlinear analysis near the instability threshold reveals that the nonlinear dynamics of the interface perturbations is governed by the Kuramoto-Sivashinsky equation. The spatio-temporally chaotic solutions of this equation can explain the formation of spatially irregular pore arrays that are observed in experiments.

The inclusion of the elastic stress dependence transforms the long-wave instability to a short-wave instability. A weakly nonlinear analysis of the short-wave instability shows that it leads to the growth of spatially regular, hexagonally ordered pore arrays, as observed experimentally.

FRIDAY, OCTOBER 7, 2005
1:00 PM
Building 2, Room 255

Refreshments at 2:15 PM in Building 2, Room 349.

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