PHYSICAL MATHEMATICS SEMINAR

NANOSCALE RIPPLED SURFACES SPONTANEOUSLY FORMED USING ION BEAMS

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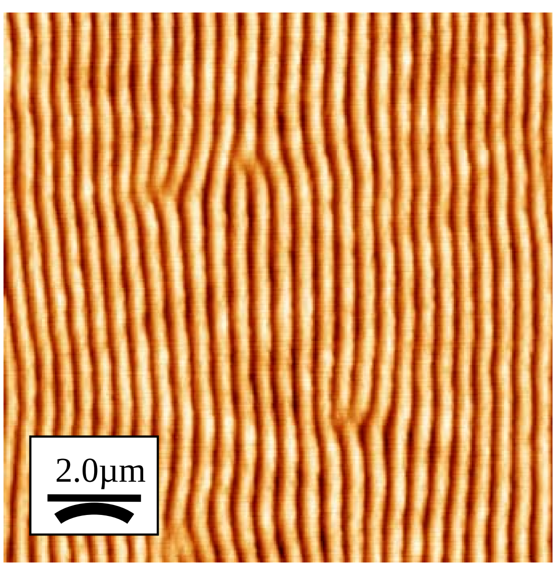
ABSTRACT:

Microlithography is by far the most common way to create arrays of grooves and patterns on surfaces, but is not the only method that may be used. We have been studying a bottom-up fabrication method to create smooth undulating ripple arrays on semiconductor surfaces using one-step processing with nothing more than a low energy ion beam and a heated substrate. This technique, so-called “sputter rippling”, takes advantages of a surface instability seen during ion etching in which an ion beam serving to roughen and etch a surface is placed in competition with thermally activated surface diffusion serving to smoothen the same surface. Under the right conditions, the physics of the competition serve to amplify a surface feature of a characteristic wavelength, leading to the observation of a regular surface morphology.

Sputter rippling has received attention as a prototypical pattern forming instability, and the mathematics of the instability are straightforward to elucidate, at least for a linear stability analysis of the very initial stages of growth. We have been studying sputter ripple evolution on Si(111) surfaces, a surface on which extremely regular ripples may be formed, and in this talk we critically compare the behavior of this experimental system to that predicted by the idealized linear stability model of sputter rippling. In short, though the linear stability model seems to be applicable in the very initial stages of growth, frankly, the model breaks down by the time of any appreciable morphological evolution.



AFM of sputter ripples formed on Si(111)

With the deviations from the linear stability model in mind, we will discuss rich opportunities to describe ripple pattern formation in the so-called non-linear regime, where we have observed many new and usual features of surface morphological evolution during sputter rippling not currently predicted by theory. Some of these features are morphological transitions from 1-d to 2-d ripples, and then subsequent transitions back to 1-d ripples, and the coarsening of ripples. Influences of the dynamics of discrete surface steps, assumptions about the nature of ion-surface interactions, and the limits of pattern regularity will be discussed.

TUESDAY, APRIL 26, 2005
2:30 PM
Building 2, Room 338

Refreshments at 3:30 PM in Building 2, Room 349.

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