Seminar

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Institute for Plasma Research

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Title: Dynamical Evolution of Self-organized Nanostructures Produced by Unconventional Ion Beam Irradiation Techniques

Speaker: Dr. K M Rakhi
Indian Institute of Technology Ropar, Punjab

Date: 27th January 2025 (Monday)

Time: 03.30 PM

Venue: Seminar Hall, IPR

Abstract

Ion beam irradiation (IBI) serve as facile tool for fabricate nanopatterns on surfaces via physical self-assembly induced by bombardment of solid targets with energetic ions [1]. For near-normal incidence ion beam, nanodot patterns form [1], while nanoripple and triangular patterns emerge under oblique incidence angle conditions [1]. By adjusting the physical space parameters such as ion beam energy (E), ion flux (f), ion fluence (F, the product of f times the total irradiation time), ion species and ion incidence angle, the scales of these patterns can be effectively controlled. These nanopatterns play a critical role in advancing nanotechnology, but a deeper understanding of their formation and behavior is still necessary [2].

In this talk, we present a detailed exploration into the effects of low-energy (IBI) on silicon (Si) surfaces, with a particular focus on the formation of self-organized of nanotriangular structures. Our study explores how various physical parameters influence the development of these patterns, emphasizing the significance of surface physics in their formation. Our findings indicate that even subtle changes in surface topography can significantly alter the nanoscale properties of the material, which differ from bulk behavior. We examine how different irradiation conditions contribute to the growth of nanotriangular structures on Si surfaces.

A central theme of this research is the evolution of nanopatterns on solid substrates under unconventional ion beam configurations [3], in contrast to conventional methods [1]. These unconventional techniques include intermittent sputtering sequences to investigate surface relaxation, azimuthally swinging geometries at varying speeds to study morphological transitions [4], and swinging geometries to analyse coarsening phenomena and hierarchical surface formation [5]. The potential to improve pattern order through these methods is also explored.

In the intermittent sputtering method, Ar+ ions are used at oblique angles with relaxation periods between irradiation intervals, leading to nanoripple formation and hierarchical triangular structures at lower energies. Our results show that ripple ordering peaks at intermediate sputtering intervals, with triangular structure areas varying with these intervals, consistent with numerical simulations. These findings suggest that intermittent sputtering is a promising technique for tailoring ion-beam nanostructured surfaces. We also explore changes in Si surface morphology induced by 500 eV Ar+ ion sputtering at a 67° incidence angle, utilizing a novel substrate-swinging approach. By adjusting azimuthal angles and rotation speeds, we identify four distinct morphologies: ripples with and without triangular structures, smooth surfaces, and disordered ripple patterns. Notably, we observe that ripple wave vector orientations shift at specific azimuthal angles, providing valuable insights into surface evolution under unconventional sputtering conditions and contributing to our understanding of surface patterning applications.

In conclusion, the findings presented in this research provide significant contributions to the understanding of nanopattern formation and ion-solid interactions. This study highlights the potential of unconventional ion beam techniques to enhance surface ordering, improve pattern quality, and reduce surface defect density.

Keywords: Surface nanopatterning, Low-energy ion beam irradiation, Unconventional methods, Power spectral density, 2D slope distribution, Autocorrelation function, Atomic force microscopy.

References:
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