LEEM of Surfaces During Irradiation with Energetic Ions

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The interaction of energetic ions with crystals creates macroscopic phenomena of compelling scientific and technical interest. These span growth, erosion, implantation, island nucleation, pattern formation, bulk irradiation damage, etc. In order to investigate the evolution of surface structure, and the behavior of surface sinks during irradiation with a beam of energetic ions, we use atomic step edges as contour lines that define surface topology. Here we report results for a range of beam intensities and ion impact energies. At low beam energy < 50 eV, these concern step flow from hyperthermal epitaxial growth, and nucleation on terraces driven by excess adatoms. At intermediate energies ~ 1 keV we observe erosion, with surface pattern formation, and terraces driven by excess advacancies to nucleate advacancy islands. At high energies ~ 5 keV the surface sinks are driven by the bulk and surface thermal point defects created by surface thermal spikes and nanoexplosions.

The investigations have been made possible by incorporation of an ion beam source into the same vacuum enclosure as a LEEM. To this end we have successfully combined an NEC SNICS II negative ion accelerator with a Tromp LEEM. In the flight path of the ion beam, a 90° spherical deflector directs the beam through the sector field, along the axis of the LEEM, through the objective lens, and onto the sample surface. With a 15-20 keV accelerator voltage, and a LEEM operating at 15 keV, the ion impact energy can be tuned through the range 0-5 keV. Ion beam intensities > 10^{14}/cm^{2}s are achieved, depending on beam species. The base pressure of the sample volume remains in the 10^{-11} torr range. Initial experiments have studied Si^- on Si(001) and Pt^- on Pt(111).