CSU PHYSICS COLLOQUIUM

Nanoscale Surface Patterning by Non-Equilibrium
Self-Assembly of Ion-Induced Vacancies and Ad-Atoms

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Colorado State University
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Refreshments at 3:45 PM
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Abstract

Various self-organized nanoscale surface patterns can be produced by low- and medium-energy ion beam irradiation [1], depending on the irradiation conditions. Hexagonally ordered dot or pit patterns, checkerboard patterns, as well as periodic ripple patterns oriented perpendicular or parallel to the ion beam direction are formed spontaneously during the continuous surface erosion by ion sputtering. On amorphous surfaces, the formation of these patterns results from an interplay of different roughening mechanisms, e.g. curvature dependent sputtering, ballistic mass redistribution, or altered surface stoichiometry on binary materials, and smoothing mechanisms, e.g. surface diffusion or surface viscous flow.

An additional surface instability arises above the recrystallization temperature of the material. In this case, ion induced bulk defects are dynamically annealed and amorphization is prevented. The diffusion of ion-induced vacancies and ad-atoms on the crystalline surface is now affected by the Ehrlich-Schwoebel (ES) barrier, i.e. an additional diffusion barrier to cross terrace steps. Vacancies and ad-atoms are trapped on terraces and can nucleate to form new extended pits or terraces, respectively [2].

For the mathematical description of the pattern formation and evolution in the reverse epitaxy regime, a continuum equation can be used which combines the ballistic effects of ion irradiation and effective diffusion currents due to the ES barrier on the crystalline surface. By comparison with experimental studies of pattern formation on Ge and GaAs surfaces at different angles and temperatures, we will show that the pattern evolution is determined by the surface instability due to the ES barrier, surface diffusion, and ballistic effects of ion irradiation.

Bio

Stefan Facsko, born in Timisoara, Romania, studied physics at the RWTH Aachen, Germany, from 1986 to 1993. He continued with his PhD at the same university at the Institute of Semiconductor Technology, lead by Prof. Heinrich Kurz, where he defended his thesis „Particle Emission from Semiconductor Surfaces Induced by Ion Beams and Ultra-short Laser Pulse: Applications in Nanotechnology and Analytics“ in 2001. In 2003 he changed to the Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany, and became a junior research group leader for „Highly Charged Ions“ in the Institute of Ion Beam Physics and Materials Research. Later he became also group leader of „Ion Induced Nanostructures“ and „Ion Beam Analysis“. Since 2013 he is the scientific head of the Ion Beam Center at the Helmholtz-Zentrum Dresden-Rossendorf and „Research Fellow“ of HZDR He has more than 100 publications in refereed journals and 5 patents.