In-situ Observation of Surface Kinetics during MBE Growth using Synchrotron X-ray Diffraction

Wolfgang Braun, *Paul-Drude Institute for Solid State Electronics, Berlin, Germany.* E-mail: braun@pdi-berlin.de

The weak interaction of x-rays with matter offers the advantage of not disturbing the system under investigation and in most cases allows us to analyze the results using kinematical scattering theory. Both properties make x-ray diffraction an almost ideal tool to study crystal growth in situ and in real time.

To obtain the necessary sensitivity to study surfaces and interfaces that consist of a very limited number of scatterers, high primary beam intensities usually available at synchrotrons are required. Using a dedicated beamline at BESSY in Berlin, we study the surface kinetics of various III-V materials during deposition and the subsequent recovery under standard molecular-beam epitaxy conditions.

Following the diffraction oscillations during layer-by-layer homoepitaxy on GaAs(001) and the closely related InAs and GaSb surfaces, we can analyze the coverage of the different levels that constitute the growth front. After deposition, the system reduces to a two-level system. This initial, fast recovery is followed by a slower recovery phase in which the two-level structure laterally coarsens until the big terraces of the pre-growth state are recovered.

Despite their similarity in crystal structure, the three materials systems exhibit strong differences in their deposition and recovery kinetics, which are obviously related to the detailed atomistic processes taking place at the reconstructed surface during deposition.

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