Olzat Toktarbaiuly

Electromigration of atoms on vicinal surfaces at high temperatures

Step bunching of vicinal Si(111), W(110) and Al_2O_3(0001) are discussed and an experimental setup built to anneal the samples in a controlled electric field under UHV conditions is described.

Atomic steps’ dynamics on vicinal surfaces and the phenomenon of step bunching have long been of great scientific interest. In particular, this is true for key surfaces such as Si(111) which is widely used in the semiconductor industry.

Antiband instability on vicinal Si(111) was studied and theoretical description of antiband formation via the evolution of the atomic step’s shape is provided. Conditions for the onset of antiband instability in the diffusion limited regime were derived theoretically. The effect of changing the electromigration field on antiband instability on Si(111) was investigated and compared to the theoretical model. The experiment strongly supports the validity of theoretical model and indicates the significance of accounting for the factor of critical electric field in theoretical models of step bunching and antiband instabilities.

For the first time, step bunching on W(110) was observed and the resultant surface morphology due to the step bunching process was examined by scanning probe microscopy. Step bunching occurs on vicinal tungsten surfaces at electric fields applied perpendicular to the step direction. An electric field of 25 mV/cm applied in step-up direction was found to be sufficient to induce electromigration of tungsten atoms and step bunching on vicinal W(110) at 1500 ˚C. Experimental results show that higher electric fields result in higher step bunches on vicinal W(110) surfaces.

We have observed that it is possible to achieve electromigration induced step bunching for the insulating oxide surface Al_2O_3(0001).