

## An STM study of molecular-beam epitaxy growth of GaAs

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Scanning tunneling microscopy (STM) studies have been performed on GaAs homoepitaxial films deposited by molecular beam epitaxy. The surface evolution of the growing film is quenched and direct comparison between STM images and reflection high-energy electron diffraction (RHEED) data is made. Growth was performed under standard conditions on an (001) sample with a substrate temperature of 555°C and a nominal sample miscut of 0.1°.

Large scale images of films ranging in thickness from 0.25 to 1450 biatomic layers have been studied [1]. All surface features show anisotropy with the major axis along the  $[110]$  direction. The local viscinality of the sample is found to vary widely over the surface. After growth interruption and surface recovery, large scale step bunching is observed. With the initiation of growth we find that there is a strong correspondence between the surface step density and the RHEED specular intensity. The overall absolute value of the step density is a sensitive function of the details of the growth procedure. However, a cyclic temporal variation in the step density giving rise to RHEED oscillations is found under a variety of growth conditions [2]. There appears to be an asymmetry in the sensitivity of RHEED to islands versus holes on the surface. Our data suggest that 100 Å islands are more sensitively detected by RHEED than are 100 Å holes.

We find that the decay of RHEED oscillations is not associated with an increase in surface roughness but with the development of ramified islands and terrace edges. During the evolution of the surface there is a gradual coarsening of the features. This process leads to a loss in correlation of the growth over the coherence length of the RHEED beam and thus a decay in oscillation intensity. To quantify the morphology we have measured the rms roughness, surface step density, and height–height correlation functions. For a thickness of 1450 layers the rms roughness of the layer is  $\sim 2$  Å in a 2000 Å square area. A comparison with predictions from scaling models of MBE growth will be made.

If the films are annealed under high vacuum conditions, the surface is observed to transform to a  $2 \times 6$  reconstruction. This transformation is associated with a loss of As from the surface. Concomitant with this microscopic change is an evolution of the terrace morphology. Under these Ga rich conditions, a novel step edge instability is observed. Possible explanations will be presented.

- [1] J. Sudijono, M.D. Johnson, M.B. Elowitz, C.W. Snyder and B.G. Orr, *Surface Sci.* 280 (1993) 247.
- [2] J. Sudijono, M.D. Johnson, C.W. Snyder, M.B. Elowitz and B.G. Orr, *Phys. Rev. Letters* 69 (1992) 2811.