Chapter 7. Step Structures on Semiconductor Surfaces: Thermodynamics, Kinetics and Influence on Heteroepitaxy

Sponsor

Joint Services Electronics Program (Contract DAAL03-89-C-0001)

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In this program high resolution x-ray reflectivity and diffraction experiments are employed to study the structure and phase behavior of semiconductor surfaces and thin films.

Project Goals

Our project goals are to study:

1. The thermodynamic stability of semiconductor surfaces.
2. The growth of insulators and semiconductors on semiconductor substrates.
3. The kinetics of steps on semiconductor surfaces.

We have been employing the MIT-IBM x-ray beamlines at the National Synchrotron Light Source at Brookhaven National Laboratory to achieve these goals. In addition, we have had access to a rotating anode source at MIT. During the past year, we completed construction of a similar facility here that has a vacuum chamber suitable for studying semiconductor surfaces. Our in-house facility is now operational.

In addition, we have demonstrated the applicability of x-ray techniques to these surface problems through experimentation. Figure 1 shows a series of diffraction profiles obtained from a wafer of silicon in air with a surface misaligned from the (100) direction by 4 degrees. The shift of the peak position for data further from the Bragg peak (which corresponds to the center profile) is a direct consequence of this misalignment. This shows that we are able to probe details associated with the surface with a relatively straightforward measurement. In fact, the

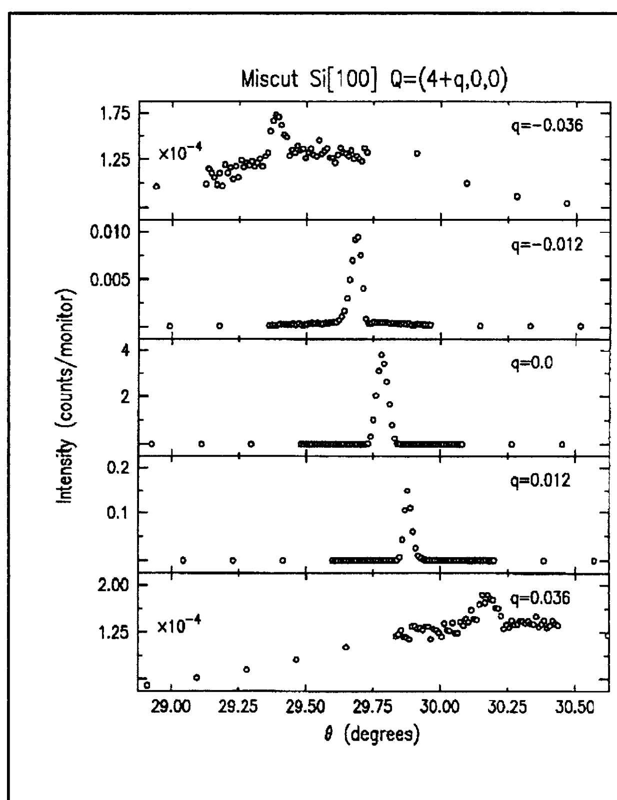

Figure 1. Scans through the reflectivity of a silicon surface misaligned from the (100) direction by 4 degrees in the neighborhood of the (400) Bragg peak (center profile).

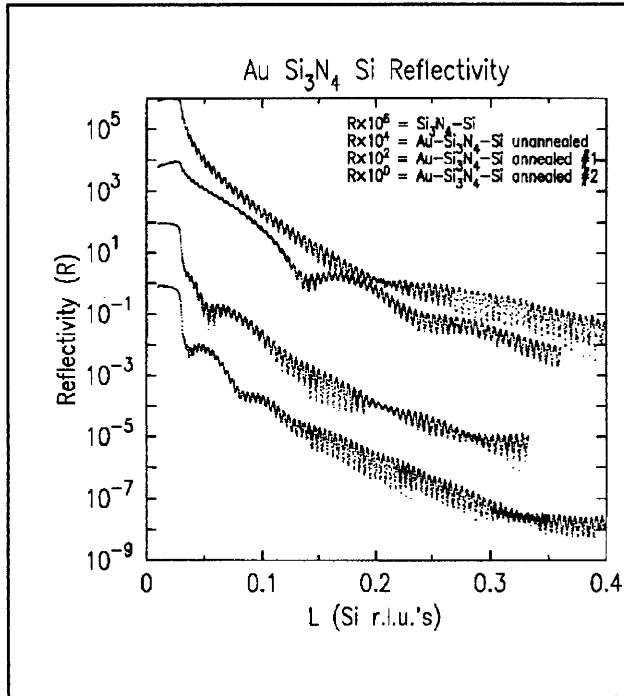

Figure 2. X-ray reflectivity of Si-SiN-Au wafers. Different profiles correspond to different annealing times.

dependence of the shift as a function of the displacement from the Bragg condition reveals details of the step structures on the Si(100) surface required by the misalignment.

Figure 2 shows the results of experiments conducted in collaboration with Professor Carl V. Thompson. These profiles show the x-ray reflectivity of gold films grown on a silicon-nitrate substrate. The rapid oscillation corresponds to the silicon nitride film, which is 1000 Å thick. The much longer period of oscillation corresponds to the thickness of the gold film. The different profiles shown were annealed at high temperatures for differing periods of time and, as a result, the initially uniform gold film becomes discontinuous with larger crystals growing at the expense of smaller ones. The change in the period of the long period oscillation corresponds to this change in morphology. Currently, we are attempting to describe these profiles quantitatively with simple models of the morphology of the gold.