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A MEIS Study on Ge Epitaxial Growth on Si(001) with dynamically supplied Atomic Hydrogen

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February 27, 1998

Abstract

It is a difficult and challenging problem to control the growth of epitaxial films. Heteroepitaxy is especially difficult because of the lattice mismatch between substrate and deposited layers. This mismatch leads usually to a three dimensional(3D) island growth. But the use of surfactants such as As, Sb, and Bi can be beneficial in obtaining high quality heteroepitaxial films.

In this study, medium energy ion scattering spectroscopy(MEIS) was used in order to reveal the growth mode of Ge on Si(001) and the strain of deposited film without and with dynamically supplied atomic hydrogen at the growth temperature of 350°C.

It was possible to control the growth mode from layer-by-layer followed by 3D island to layer-by-layer by controlling the hydrogen flux. In the absent of hydrogen, the film grows in the layer-by-layer mode within the critical thickness(about 3ML) and the 3D island formation is followed(Fig1). The 3D island formation is suppressed by introducing hydrogen, resulting in layer-by-layer growth beyond the critical thickness(Fig2). We measured angular shift of blocking dip in order to obtain the structural information on the thin films. In the presence of atomic hydrogen, the blocking dip is shifted toward higher scattering angle about 1°. That means the film is distorted tetragonally and strained therefore(Fig4). In other case, the shift of blocking dip at 3ML is almost same as previous case. But above the critical thickness, the position of blocking dip is similar to that of Si bulk(Fig3). It means the film is relaxed from the first layer.

There is 4.2% lattice mismatch between Ge and Si. That mismatch results in about 2° shift of blocking dip. We measured about 1° shift. This fact could be due to the intermixing of Ge and Si. This experimental results are consistent with Vegard's law which says that the lattice constant of alloys is linear combination of the lattice constants of the pure materials.

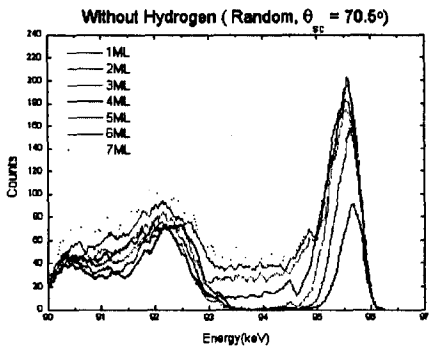

Fig 1

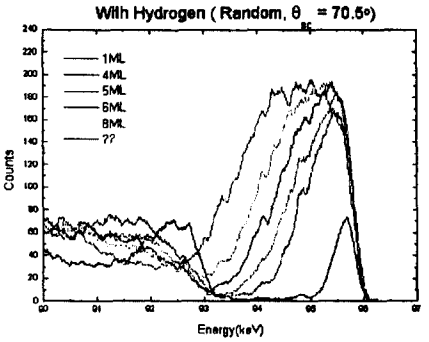

Fig 2

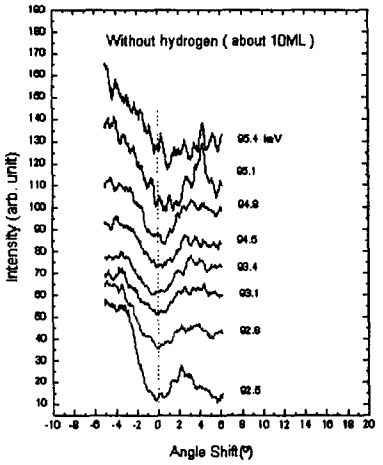

Fig 3

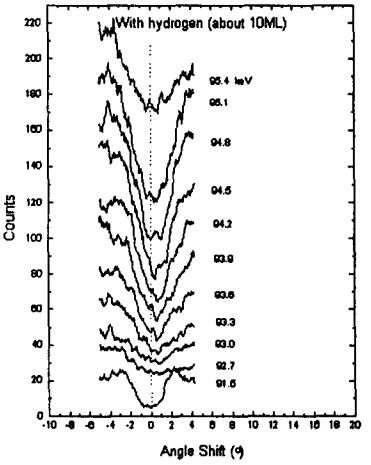

Fig 4