THE EPITAXIAL GROWTH OF Ge ON Si(100) USING Te AS A SURFACTANT

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ABSTRACT

The epitaxial growth of Ge on Si using Te as a surfactant has been studied with high resolution photoemission, low energy electron diffraction and cross-sectional transmission electron microscopy. The growth mode of Ge on Si changed from Stranski-Krastanov (S-K) to layer-by-layer mode when 1/4 ML Te atoms were on the surface. During the growth, Te atoms segregated to the top of the surface. If the growth temperature is too high (above ~450°C), the Te coverage was less than that necessary to keep the layer-by-layer growth , and the growth mode of Ge on Si is still S-K.

I: INTRODUCTION

The growth of high quality epitaxial Si-Ge films has recently attracted much attention. The driving force mainly comes from the potential application of Si-Ge alloy and Si-Ge strain layer structures in new generation semiconductor devices, such as high speed electronic and optoelectronic devices [1,2]. It is also of fundamental importance to understand the epitaxial growth process in general; including the interplay among the surface, interface free energy and lattice strain relief. It is well known that the growth mode of Ge on the Si(100) surface is of the Stranski-Krastanov type (i.e. a few uniform layers followed by island formation). Recently, it has been demonstrated that when the growth front is terminated by a specific third species, the surfactant, the growth mode of Ge on Si can be dramatically changed. Three dimensional (island) growth can be converted into two-dimentional (layer) growth with the use of surfactant atoms. A number of atoms, such as As, Sb, and Te, have been used as surfactants. [3-9]

Although the surfactant assistant Si and Ge epitaxial growth process is under active investigation, the growth mechanism is not well understood. We have studied the growth mechanism at atomic scale for Ge on Si growth with Sb as a surfactant. We found that the Sb atoms saturate the dangling bonds on the Si surfaces and move to the growth front during the Ge growth.[7,8] However, Te is a Group VI element with six valence electrons, while Sb is a group V element with five valence electrons. The surface reconstruction and electronic structure of the Te/Si surface is different from that of Sb/Si. In this work, we investigated the heteroepitaxial growth of Ge on Si(100) using Te as a surfactant under different growth conditions. High resolution core level photoemission, angle resolved photoemission, low energy electron diffraction (LEED) and transmission electron microscopy (TEM) were utilized to characterize the growth process and the grown epitaxial structures. The goal of this work was to understand the effect of the surface on the growth process and the growth mechanism at an atomic scale for surfactant-assisted epitaxial growth.

II. EXPERIMENT

The photoemission experiments were performed in an ultra-high vacuum chamber with a Vacuum Generators (VG) ADES-400 angle-resolved spectrometer at the Stanford Synchrotron Radiation Laboratory. The growth of Ge and Si was conducted in the same chamber. The