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Growth of SiGe Layer on Si(100) Substrate Using Disilane Gas and Thermally Evaporated Ge in Gas-Source MBE

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Recent progress has resulted in low temperature growth of the high quality Si and SiGe in gas-source MBE, UHV-CVD and conventional APCVD using high purity gas, load-lock to reduce oxygen and water partial pressure in growth environment. In these studies, the hydrogen and chlorine were found to be effectively used as surfactants for suppression of 3D islanding and segregation. However, it is difficult to observe the direct effect of hydrogen surfactant on Ge islanding and segregation in these growth techniques because of complications in gas kinetics affecting adsorption, decomposition and desorption process. Combining a Si gas source and an elementary Ge source in growth provides a simpler approach for understanding the hydrogen surfactant effect.

In this study, the SiGe growth on Si(100) substrate using disilane gas as the Si source and thermally evaporated Ge as the Ge source was studied. The growth study of SiGe layer was conducted with various disilane flow rates(1~5 sccm) and various Ge fluxes at the range of 500 ^{o}C-700 ^{o}C growth temperature in the gas source MBE system. The qualities of SiGe layers such as surface morphology, composition, crystallinity, and abruptness of the interface were investigated using the *in-situ* RHEED, HRXRD, RBS, SIMS and XTEM. The *in-situ* RHEED observation indicated that SiGe layers under the critical thickness grew easily by two-dimensional growth. An x-ray analysis using (400) HRXRD rocking curve, taken with Cu$K\alpha$ radiation showed that a sharp x-ray diffraction with a narrow FWHM and Pendullosung was obtained for a 100-nm-thick $Si_{0.9}Ge_{0.1}$ film grown at relatively high growth temperature 650 ^{o}C. The observation of Pendullosung is indicative of high crystalline quality and smooth growth front. An x-ray rocking curve simulation based on the dynamical theory of x-ray diffraction was carried out with the addition of a layer having a the graded Ge composition between the substrate and the SiGe film for evaluating the transition width. No significant change in the rocking curve until the layer thickness reached 30 Å was observed. it is likely that the abruptness is the result of the hydrogen surfactant effect even though the hydrogen desorption temperature is much lower(~ 400 ^{o}C) than growth temperature. Detailed analysis on hydrogen surfactant effects will be presented .

Fig.1 Illustration of two dimensional growth of SiGe layer under simultaneously exposure of disilane and Ge. The RHEED pattern was taken with <110> azimuth beam angle after 10 min. growth (equivalent to 100nm thick) at 650 ^{o}C growth temperature. The flow rate of disilane is 3 sccm and the Ge flux is 0.2 ML/sec.

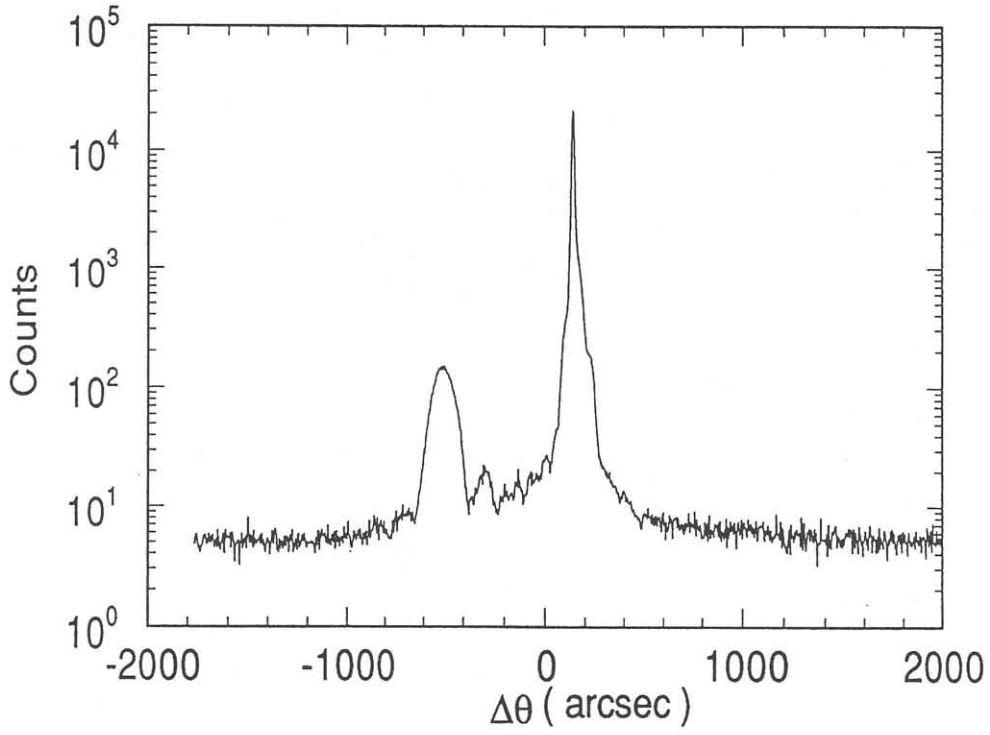

Fig.2 (004) X-ray rocking curve data from a SiGe film grown at 650 °C. The thickness and composition of the SiGe layer are 100 nm and 10 %, respectively.