# SUMMARY OF Ph.D. DISSERTATION

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Title

## Studies on defects and electrical characteristics of strained Si on $Si_{1-x}Ge_x$ substrate

**Abstract**

In the electronic technology supporting present IT society, silicon MOS-FET has become a fundamental device. However, as far as the technology development based on the present scaling rule continues, the limit of performance of LSI will be getting near. The strain has been introduced into the Si substrate as the efficient technology that does not depend on scaling rule, and the improvement of carrier mobility in strained Si has been confirmed. This technique is promising approach because it does not need substantial modification of the present MOS-FET production process and its application will be expansive in various areas.

The $Si_{1-x}Ge_x$ epitaxial growth for lattice expansion on the Si substrate becomes necessary in introducing the wide-ranging strain with the wafer-scale substrate for the growth of a s-Si epitaxial layer. Therefore, the occurrence of crystal defect from the stress will not be avoided at each boundary. In this dissertation, alteration of the crystal characterization, mobility estimation and diffusion behavior of As of the s-Si substrate on $Si_{1-x}Ge_x$ have been investigated with the Ge concentration in $Si_{1-x}Ge_x$ layer.

Chapter 1 is introduction. Background of s-Si is described and motivation for this work is shown.

In chapter 2, the theory of mobility enhancement in s-Si and the mechanism of dislocation are shown.

In chapter 3, the variation of dislocation in s-Si and the surface morphology are shown. The depth variation of threading dislocation density of s-Si/relaxed SiGe/graded SiGe multilayer structure can be evaluated making use of the Dash etching solution, whose environmental load is little. In graded SiGe layer, misfit dislocations occur in the changing region of Ge concentration. The surface roughness of s-Si depends on the Ge concentration in SiGe layer. With thermal treatment, behavior of defect inside the substrate changes significantly in the temperature range above 800 °C.

In chapter 4, the spectra from the surface to the bulk of s-Si/SiGe/Si structure were investigated with Cathodeluminescence (CL) method. D1 and D2 lines originating from the crystal defect and the oxygen were measured along the depth direction in CL spectra. The defects originating from D1 become dominant at the Si substrate. In addition, variation of oxygen concentration in the substrate was confirmed with thermal annealing. It is found that defects originating from D1 are attributed to the interaction with oxygen in the substrate. Therefore, it suggests that D1 line is a luminescence from dislocations of Lomer-Cottrell type.

In chapter 5, in order to estimate the mobility of s-Si, As doping was carried out with the thermal diffusion method due to avoid the implanted damage to the substrate. It is found that the diffusion coefficient of As in s-Si/relaxed SiGe increases with the increase of Ge concentration. This is mainly attributed to the increase in point defect concentration due to the allying effect of SiGe layer. On the other hand, the diffusion of Ge from relaxed SiGe layer does not depend on Ge concentration and almost it is constant. Regarding the mobility in s-Si/SiGe layer, it decreases with the influence of alloy scattering from relaxed SiGe layer as compared with that of standard Si. However, it is confirmed that it increases with the increase of Ge concentration.

Chapter 6 is conclusion, and results of this work are summarized. It is clarified that CL line originating D1 comes from the luminescence from dislocations pf Lomer-Cottrell type and that mobility in s-Si increases with the increase with Ge concentration in SiGe layer.