論 文 の 内 容 の 要 旨

論文題目　Study of Thermal Oxidation Mechanism of Germanium
（ゲルマニウムの熱酸化機構に関する研究）

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The control of the thermal oxidation is important for semiconductor device fabrication. For Si, thermal oxidation can be well described by the Deal-Grove model. Ge has similar characteristics with Si, and their oxides are comparable concerning the crystal and electronic structures. Therefore, Ge oxidation has been considered to follow the Deal-Grove model without suspicion. Recent researches have revealed some different aspects between Ge and Si oxidation, however, the kinetics of Ge oxidation is still uncertain. The objective of this study is to provide more direct evidence for the non Deal-Grove of Ge oxidation, and to build up a new kinetic model.

In chapter 3, isotope tracer experiments were carried out to compare Si and Ge oxidation process, and a direct evidence has been obtained, which proved that Deal-Grove model is not valid for Ge oxidation. Then the diffusion species were clarified by double oxide layer stack annealing experiments. O_2 interstitial diffusion was found to be limited in GeO_2. Oxygen vacancies are critical for Ge oxidation, which are generated by the interfacial reaction. Ge can be oxidized by GeO_2. A possible model for Ge oxidation was proposed based on oxygen vacancy diffusion under atmospheric pressure. In thick oxide limit the Ge oxidation rate follows parabolic law.

In chapter 4, Ge oxidation under high pressure was investigated. High pressure oxidation can achieve high quality Ge/GeO_2 stacks. A better understanding of Ge oxidation kinetics under high pressure is a key issue. An inverse pressure dependence of oxidation rate was observed in Ge oxidation under high pressure. It is mainly due to the suppression effect of high pressure on oxygen vacancy formation in the oxide. Isotope tracer study was conducted to investigate what

happens in Ge oxidation under high pressure. Atomic O interstitial diffusion was found in high pressure oxidation process. Even though its contribution to the whole Ge oxidation is small, atomic O interstitial diffusion is helpful to passivate the dangling bonds at the interface.

Finally, in chapter 5, the pressure and temperature dependence of oxygen vacancy and O interstitial diffusion was investigated by isotope tracer experiment. It was found that high temperature and low pressure accelerate oxygen vacancy formation, while O interstitial diffusion becomes important under high pressure. Based on these results, a kinetic model for Ge oxidation was proposed by considering two competing diffusion processes. For thick oxide limit, a parabolic law is obtained for the Ge oxidation rate.