3B/2003G296

Si 2p core-level spectra for oxynitride on Si(100) with plasma-excited N_2O

Yoshiharu ENTA*, Katsunori SUTO, Hiroo KATO, Yasuo SAKISAKA
Faculty of Science and Technology, Hirosaki University, Hirosaki 036-8561, Japan

Introduction

Silicon oxynitride as a gate insulator of a highly integrated metal-oxide-semiconductor device has prominent property in suppressing boron diffusion from the polysilicon gate electrode and improving hot carrier residence. In this study, initial stage of oxynitridation of Si(100) with plasma-excited N_2O was investigated by Si 2p core-level spectra. The interfacial roughness was discussed from the temperature dependence of suboxide components.

Experimental

Prior to loading into the UHV chamber, the Si(100) wafer was cleaned by standard RCA method, and then annealed at 1000°C by direct current resistive heating in vacuum. The photon energy was set at 135 eV, where the overall instrumental energy resolution is estimated to be less than 200 meV. N_2O gas with a purity of 99.999% was excited by Penning discharge plasma source before exposing the sample. Oxynitridation was carried out at the substrate temperatures of RT - 800°C and at the N_2O pressure of 5×10^{-4} Pa.

Results and Discussion

All of the obtained Si 2p core-level spectra were successfully fitted with five components, one bulk and four oxynitride components, as well as those of the oxide. The typical result is shown in Fig.1. The four oxynitride components could correspond to the number of oxygen or nitrogen bonded to a silicon atom. Since the chemical shift of Si 2p bonding with nitrogen is smaller than that bonding with oxygen, each chemical shift is slightly smaller than that of the oxide film[1]. These chemical shifts gradually decrease as temperature increases as shown in Fig. 2. This is due to the increment of the nitrogen concentration in the film with temperature increasing. In fact, Auger electron spectroscopic measurements support this explanation. Fig. 3 shows a temperature dependence of thicknesses of Si^{1+}, Si^{2+} and Si^{4+}. While the Si^{4+} is almost constant, Si^{1+} and Si^{2+}, which are associated with the interfacial roughness, decrease with temperature. This suggests more smooth interface at higher temperature, being in agreement with the result of rapid thermal oxynitridation in N_2O[2].

References

[1] Y. Enta et al., Phys. Rev. B57, 6294 (1998).
[2] M. L. Green et al., Appl. Phys. Lett. 65, 848 (1994).

*enta@cc.hirosaki-u.ac.jp

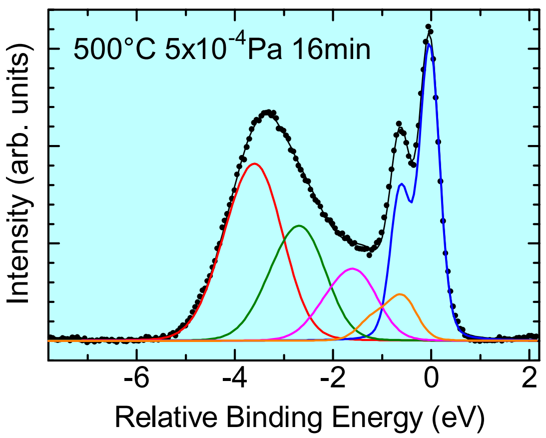

Fig. 1 Si 2p core-level spectrum of oxynitride on Si(100). Solid lines show peak-fitting result.

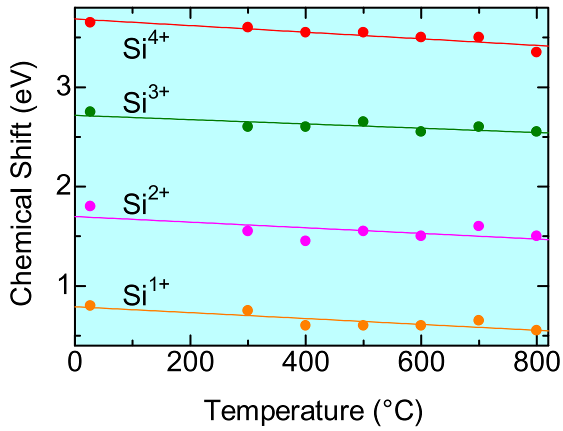

Fig. 2 Temperature dependence of chemical shifts of Si^{1+}, Si^{2+}, Si^{3+}, and Si^{4+} components.

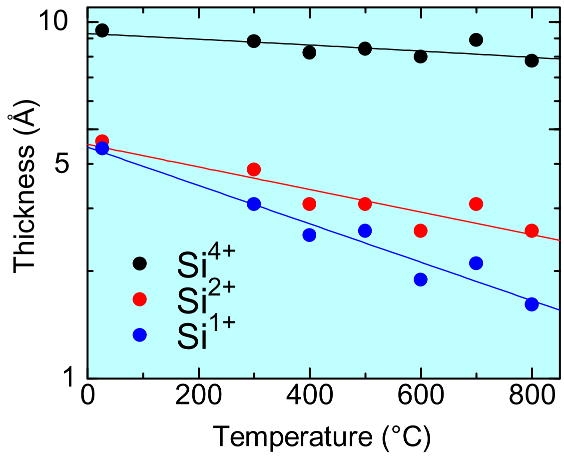

Fig. 3 Temperature dependence of suboxide components.