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The Analysis of N Component in Thin Oxide Film Thermally Grown by NH_3 Oxidation

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ABSTRACT

The depth profiles of the as-grown and the annealed NH_3 oxide film in NH_3(7.5%)/N_2 ambient at 450℃ are analized . This annealing in the ambient of mixed gases removes the small quantities of N component from the NH_3 oxide film. In AES analysis, the NH_3 oxidation shows the exact stoichiometry of SiO_2 and a sharp slop at SiO_2/Si interface

I. Introduction

The new thermal oxidation methods, which is done by adding NH_3 gases to pure O_2 gases and proposed to promote the material quality of oxide film and the SiO_2/Si interface[1] ,practically enable fabrication process due to its simplicity. As a result so far, it is known that reaction equation of NH_3 oxidation is $4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$[2], and the quantities of oxidizing species[3], O_2 and H_2O, are controlled by concentration of NH_3 gases[4] added during oxidation. But none of the other material analyses for the oxide layer thermally grown by this new method are studied.

In this study, we obtained the depth profile of the as-grown NH_3 oxide film and the annealed NH_3 oxide film in NH_3(7.5%)/N_2 ambiant at 450℃. We analyzed the atomic concentration of this film for the stoichiometry of SiO_2 film and SiO_2/Si interface states using AES(Auger Electron Spectroscopy).

II. Experimentation and Results

Fig.1 shows the depth profile using SIMS(Secondary Ion Mass Spectroscopy) for the oxide film grown by NH_3 oxidation method at 1100℃ for the wafer of (100), p-type, 6-7 $\Omega\cdot$cm. In this figure the quantity of N components existing in the oxide layer and Si substrate is very small compared to that of O_2 and Si component to the 4~5 orders.

Fig.2 shows the depth profile using SIMS for the NH_3 oxide film annealed at 450℃ in the same atmosphere of Fig.1. As shown in this figure, N components existed in oxide film are almost removed. We consider that the N components are substituted to the H components decomposed from the NH_3 gases.

Fig.3 is a qualitative analysis of the NH_3 oxide film using AES under the same condition of Fig.1. In this figure the oxide film grown by NH_3 oxidation method is certainly composed of SiO_2 stoichiometry, considering the Si:O ratio of 1:2, and the peak of N is very small like carbon as a contamination. Observing the slope at Si-SiO_2 interface, its sharp slope and intersecting of Si and O in the ratio of 1:1 show the fixed surface charge is minimized.

III. Conclusion

In this study N components can be ignored by very small quantities, and the very small N components are removed by an annealing of NH_3(7.5%)/N_2 ambient at 450℃ observing the depth profile of SIMS. In qualitative analysis using AES, NH_3 oxidation generates exact stoichiometry of SiO_2 in NH_3 oxide film and sharp slope to minimize the surface charge at the interface state.

Reference

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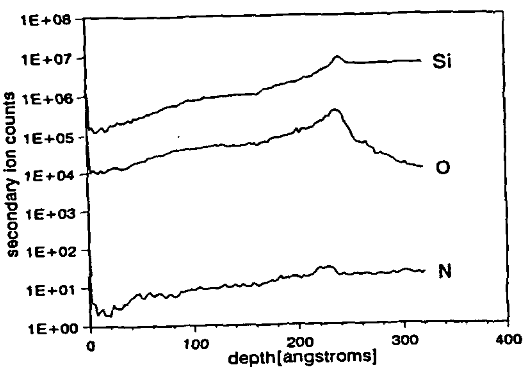

Fig. 1. The depth profile of the as-grown NH_3 oxide film using SIMS

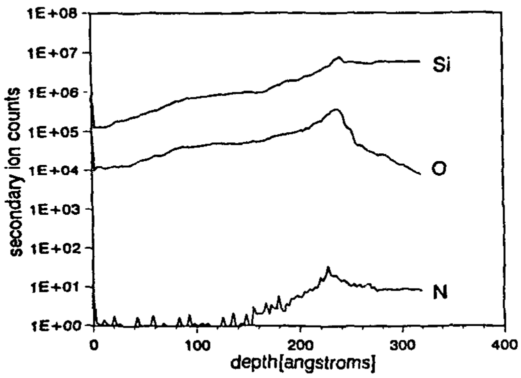

Fig. 2. The depth profile of NH_3 oxide film annealed at 450℃ in NH_3(7.5%)/N_2 ambient.

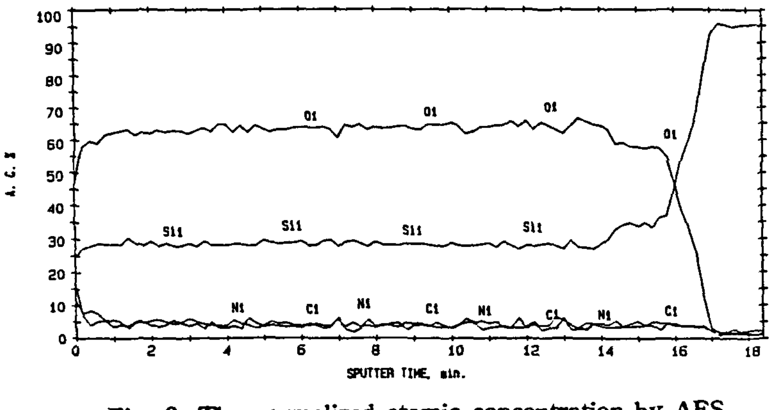

Fig. 3. The normalized atomic concentration by AES.