Physical understanding of La-silicate gate dielectrics thermally formed by interface reaction on Si(110) and (111)

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Introduction

For further downscaled MOS devices La-silicate gate dielectrics without IL exhibited satisfactory interface properties, and thus is reported the promising high-k dielectrics [1]. For multi-gate architecture, it is interest to investigate the characteristics of MOSFETs fabricated on different surface orientation. In the case of La-silicate gated devices, electrical properties was reported on Si(110)-oriented MOSFETs[2]. Then, the results of physical characteristics that IR spectrum of La-silicate dielectric film suggest that the strain relaxation is expected to occur in the SiO\textsubscript{2} network by high temperature annealing[3]. Relaxation of strain with increasing temperature can be correlated with low interface state density. In this study, the dependence of IR absorption arising from La-silicate on the surface orientation is examined.

Experimental Procedures

After cleaning n-Si(110), (111)-oriented substrate, 4-nm-thick La\textsubscript{2}O\textsubscript{3} dielectrics were deposited by e-beam evaporation at a deposition. Then, tungsten(W) was in situ deposited by RF sputtering. After the electrode area was patterned, the PMA in the forming gas (H\textsubscript{2}:N\textsubscript{2}=3:97) at temperatures at various annealing temperatures for 30 min. The same kind of samples were prepared for FTIR measurement.

Results and Discussion

Fig. 1 shows the annealing temperature dependence of wavenumber at absorption peaks correlated with LO phonon. A shift in Si-O-Si LO phonon toward 1250 cm\textsuperscript{-1} was found. Fig.2 shows dependence of wavenumber at peak absorption on annealing temperature. The same behavior toward high frequency is observed regardless of surface orientation.

Conclusions

The strain relaxation is expected to occur in the SiO\textsubscript{2} network by annealing at temperature over 800 °C regardless of surface orientation.

Figure 1, IR absorbance spectra arising from La\textsubscript{2}O\textsubscript{3}/La-silicate MOS capacitor with annealing temperature as a parameter.

Figure 2 Dependence of wavenumber at peak absorption on annealing temperature.

References