For fabricating Ge buffer layer for GaAs/Ge/Si tandem type solar cells, the chemical reaction probability at the surface and film quality of Ge are studied in CVD processes using t-C₃H₇GeH₄. Above 366°C, the estimated activation energy (E) is 42 kcal/mol, frequency factors (A) is 1.2×10⁹. Below 361°C, E is 14 kcal/mol, A is 2.5×10⁷. This indicates that the film quality are different depending on growth temperature.

1. Introduction

III-V compounds are used for multijunction solar cells, but the device cost is still too much. III-V/Si tandem cell can decrease the expense of this type solar cells. Germanium (Ge) is an attractive material as a buffer layer for the GaAs growth on Si. But the conventional source gases GeH₄ and Ge₂H₆ are dangerous because of their explosive and pyrophoric natures. So tertialybutylgermane (t-C₃H₇GeH₃) is proposed as a new precursor for Ge deposition[1]. However, surface reaction probability of gas phase species or sticking probability of Ge precursors in this CVD is not clear yet. These parameters are important to control the growth rate and film quality for fabricating tandem solar cells.

In this paper, the chemical reaction probability at the surface and the film quality of Ge are studied in CVD processes using t-C₃H₇GeH₄.

2. Experiment

Ge films were grown using the hot-wall type CVD system[2]. In the furnace, Temperature changed almost lineally depending on the position from 350°C-410°C, and its gradient was about 3.6°C/cm. As substrates, Si (001) wafer with the trench structure(width:1.2μm, depth:2.2μm) were used. Growth time was 20 minutes. The growth pressure was 760Torr. The gas flow rate of t-C₃H₇GeH₃ was 1.3sccm, and that of nitrogen (N₂), which was used as a career gas, was 235sccm. The gas flow velocity in the furnace was about 1.5cm/sec. The thickness and the step coverage of deposited Ge film were determined using Field Emission Scanning Electron Microscopy (FE-SEM). The crystallity was evaluated by Raman.

3. Result & Discussion

The cross-sectional SEM image of Ge film deposited at 375 °C is shown in Fig.1. The step coverage was almost one. The obtained results indicated that the growth rate was limited by the chemical reactions on the surface, not by the mass transportation. The relationship between the reaction probability (η) ; η=Aexp(-E/RT) and substrate temperature is shown in Fig.2. Here, R is gas constant, T is the absolute temperature. There are two types chemical reactions. Above 366°C, the estimated activation energy (E) is 42 kcal/mol, frequency factors (A) is 1.2×10⁹. Below 361°C, E is 14 kcal/mol,A is 2.5×10⁷. This indicates the film quality are different depending on growth temperature.

Fig.1 SEM cross-sectional image of Ge film on the trench substrate deposited at 375°C

Fig.2 Temperature dependence of step coverage and reaction probability