Oxygen Transport in Highly Boron Doped Silicon Melt

K .Terashima, K.Abe ,S.Maeda and H.Nakanishi

Silicon Melt Advanced Project
Shonan Institute of Technology,
1-1-25 Tsujido-nishikaigan,Fujisawa,Kanagawa 251, Japan

Influences of boron addition on the oxygen solubility in silicon melt and the amount of evaporation loss from the melt surface were investigated. It has been found the oxygen concentration increases from $2x10^{18}$ to $4x10^{18}$ atoms/cm^3 with increasing boron concentration in silicon melt from non-doped to 10^{21} atoms/cm^3. The amount of evaporation loss was found to vary widely depending on the melt temperature. The amount of SiO evaporating from boron doped ($\sim 10^{21}$ atoms/cm^3) silicon melt at 1550℃ is about twice as much as the value of non-doped melt.

1. Introduction

Oxygen is one of the most important species in the silicon single crystals, because the interstitial oxygen is precipitated during the device process and yield of it is strongly dependent on the behavior of the oxygen. As semiconductor devices become more integrated, stricter control of oxygen concentration and distribution is needed. Several recent papers dealt with investigations of solubility of oxygen in liquid silicon in equilibrium with its oxide at elevated temperature [1-4]. Huang et al. investigated the influence of antimony addition on the oxygen solubility[5].

Recently heavily boron doped silicon wafers have been required . Aoki et al. reported the iron getterring effect of P^+ substrates[6]. Choe reported that oxygen precipitation is different from boron doped or non-doped crystals[7]. But there is no data on the dependence of oxygen solubility on the concentration of boron in silicon melt in contact with SiO_2.

In addition, evaporation loss of oxygen from the silicon melt surface is essentially important to discuss the oxygen concentration variation in the growth crystals. Huang reported the amount of evaporation loss from Sb doped silicon melt[8]. But there is no report on evaporation loss from boron doped silicon melt. This paper describes the oxygen solubility in boron doped silicon melt and the amount of evaporation loss from boron doped silicon melt.

2.Experimental

The experimental method is basically the same as Huang reported[5]. A silicon rod 13 mm in diameter and 33 mm in length was charged in a 13-mm-inner-diameter quartz rod with a flat bottom. The quartz ampoule with a pure silicon rod or silicon rod with boron powder inside was covered with a graphite holder, and heated to various temperatures in the range of 1430-1470℃ for 120 min. in an Ar atmosphere, and quenched. The samples for measuring impurity concentrations were cut from the quenched specimens. The oxygen and boron concentration were measured by SIMS (CAMECA, IMS-3f/4f). The evaporation loss was measured from weight variation of silicon melt in quartz crucible by using a weighing device. The chemical species evaporated was analyzed by EPMA.

3.Results and Discussion

It was found that the oxygen concentration increases from $2x10^{18}$ to $4x10^{18}$ atoms/cm^3 with increasing boron concentration in silicon melt from non-doped to 10^{21} atoms/cm^3 as shown in Fig.1. Boron atoms gather oxygen atoms by weak attraction in boron doped silicon melt. By the chemical analysis indicate about 52% of all oxygen atoms in silicon melt relate to boron atoms added. The physical mechanism is now under investigation.

It was found that the amount of evaporation loss widely varies depending on the melt temperature. The results of chemical analysis indicated that the chemical species evaporated from boron doped silicon melt was silicon mono oxide(SiO). There was no signal of boron atoms, nor boron oxides.

The amount of evaporation loss increases with increasing boron concentration added at 1550℃, as shown in Fig.2. While the amount of evaporation loss is small and it is not widely varies as a function of boron concentration at 1450℃. The amount of an SiO evaporating from boron doped($\sim 10^{21}$ atoms/cm^3) silicon melt at 1550℃ is about twice as much as the value of non-doped melt. More detailed results on oxygen solubility and amount of evaporation loss will be discussed.

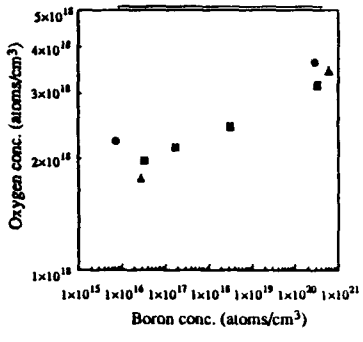

fig.1 Dependence of the oxygen concentration on the B doped Si melt temperature

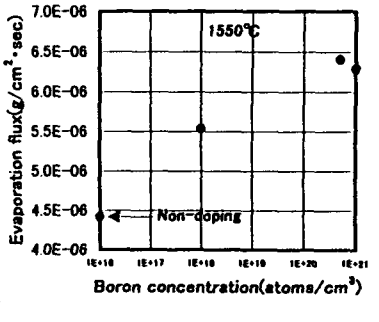

fig.2 Evaporation rate of oxide as a function of B concentration

4.Conclusion

The influence of boron addition on the oxygen solubility in silicon melt and the amount of evaporation loss from the boron doped silicon melt were studied. The main results are as follows.

(1)Oxygen concentration increases with increasing boron concentration in silicon melt.

(2)Boron gathers oxygen atoms by weak attraction in boron doped silicon melt.

(3)The amount of evaporation of an SiO evaporating from boron doped ($\sim 10^{21}$ atoms/cm^3) silicon melt at 1550℃ is about twice as much as the value of non-doped melt.

Acknowledgment

The authors deeply thanks Dr.S.Kimura of of National Institute for Research in Inorganic Materials for his fruitful suggestion. This work was conducted as JSPS Research for the Future Program in the Area of Atomic-Scale Surface and Interface Dynamic.

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