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Ultraclean Hot-Wall LPCVD System Application for Blanket B-doped SiGe(C) and Selective Si Epi

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INTRODUCTION

We developed high-throughput ultraclean hot-wall LPCVD (low-pressure chemical vapor deposition) system for epitaxial growth to enhance high volume production of SiGe(C) devices and other application of Epi for Si CMOS [1]. The system is based on load-lock type vertical furnace, and has capability of 50 wafers/batch with 200/300mm diameter wafers. It has higher throughput compared with single wafer Epi system and offers easier maintenance than UHV-CVD Epi system.

Using hot-wall LPCVD system, it has been considered that realization of good uniformity for B dopant concentration and good selectivity for selective growth is very difficult. We tried to make solution to the problems in order to apply this LPCVD system to the base layer formation in npn-SiGe-HBT process and the elevated source/drain formation in CMOS process.

BLANKET B-DOPED SiGe(C) EPI

Conventionally B_2H_6 gas has been used for B doping in SiGe epitaxial growth. However, the decomposition of B_2H_6 occurs easily and the consumption rate of B_2H_6 is high. Therefore, it was difficult to acquire good in-wafer and wafer-to-wafer uniformity of B concentration in in-situ B doping of SiGe(C) films using B_2H_6.

To avoid this difficulty, we tried in-situ B doping of SiGe(C) films using other doping gas besides B_2H_6. Figure 1 shows sheet resistance map in 200mm diameter wafer of B-doped SiGe(C) (Ge=26.7%, C=0.1%, B=$8x10^{19}$atoms/cm^3, film thickness=55nm). The sheet resistance in-wafer uniformity is around 2 sigma %. When B_2H_6 was used for B doping in the same condition, it was around 12 sigma %. It is clear that B concentration uniformity is good in this case compared with B_2H_6.

Figure 2 shows high-resolution XRD data of B-doped SiGe(C) (the composition is the same as above). SiGe(C) layer peak and fringes are clearly seen, indicating good epitaxial quality and excellent thickness uniformity.

SELECTIVE Si EPI

In case of hot-wall LPCVD, it has been considered that selective growth is difficult and possible selective Epi thickness is very thin. This is because reactive Si_xH_y formed at hot-wall makes Si nuclei on SiO_2 or SiN surface easily. We solved this problem and succeeded selective growth by contriving reactor parts design.

We tried selective Si growth at the temperature range suitable for CMOS process using Si source gas and other gases mixture. Figure 3 shows SEM picture of selective Si growth using patterned wafer with LOCOS SiO_2. Any Si grain is not observed on LOCOS SiO_2, and selective growth is carried out. We confirmed that selective growth was possible up to 100nm for SiO_2 and SiN patterned wafers.

SUMMARY

We achieved good B-doping uniformity and selective growth using high-throughput ultraclean hot-wall LPCVD system. We will further evaluate selective SiGe growth at low temperatures in future.

REFERENCE

[1] Y.Kunii et al., 1st Int. Workshop on New Group IV (Si-Ge-C), IV-05, Sendai, 2001.

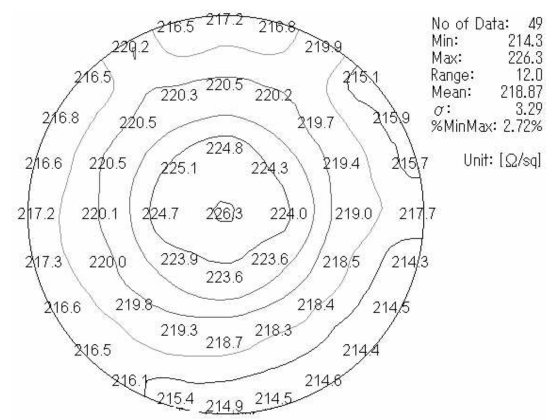

Fig. 1 Sheet resistance map of B-doped SiGe(C).

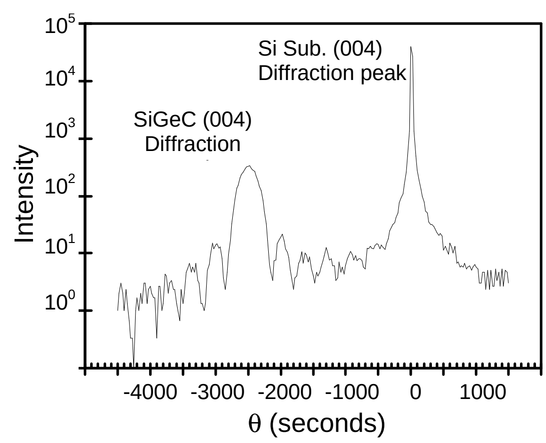

Fig. 2 XRD data of B-doped SiGe(C).

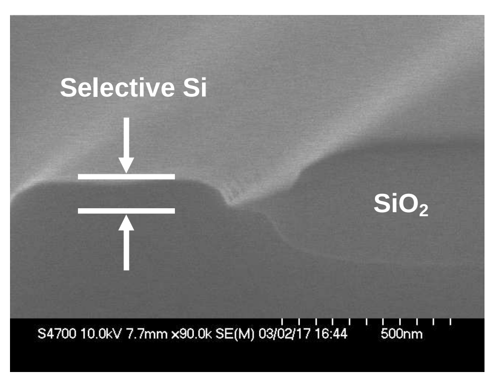

Fig. 3 SEM picture of selective Si.