19B/2006G009

Electronic States of Fe/4H-SiC Interface by SXFS

M. Hirai*[1], T. Wakita[2], H. Okazaki[3], D. Koishihara[2], Y. Muraoka[1] and T. Yokoya[1]
1) Division of Frontier and Fundamental Sciences, Graduate School of Natural Science and Technology,
2) Research Laboratory for Surface Science, Faculty of Science,
3) Mathematics and Physics, Graduate School of Natural Science and Technology,
Okayama University, Okayama 700-8530, Japan

Introduction

Silicon carbide (SiC) is one of hopeful materials in hard electronics such as high-power, high-frequency, high-temperature and high-radiation field because of high saturation electron velocity and high breakdown electric field compared with silicon (Si). For the application of electronic devices it is necessary that the physical properties of metal-SiC contact system are clarified.

In this report the partial density of states for Fe/4H-SiC(0001) C-face contact system is studied by soft X-ray florescence spectroscopy (SXFS).

Experimental

The samples were prepared as follows.

(i) A wafer of 4H-SiC(0001) C-face was cleaned by being rinsed in ethyl alcohol, dipped in 5% HF solution and flashed under ultra-high vacuum (UHV) condition.

(ii)Fe metal was evaporated on the surface of this substrate by heating of tungsten boat with Fe plates.

(iii)The sample of Fe/4H-SiC(000$\bar{1}$) contact system was thermally treated with electric furnace in flowing H_2+N_2 gases at 700 and 900 C for 30 minuets.

The film thickness of evaporated Fe was about 50nm. The soft X-ray florescence spectroscopy (SXFS) was studied by using a beamline of BL-19B at the SR facility of Photon Factory in KEK. This SXFS is characterized considering partial density of states in the total energy states due to dipole selection rule of electron transitions.

Results and Discussion

Figure 1 shows Si $L_{2,3}$ SXE spectra of (a) 4H-SiC substrate and of samples annealed at (b) 700°C and (c) 900°C for Fe(50nm)/4H-SiC(0001) C-face contact systems. The photon energy for excitation is 135eV. The sampling depth of detected photons is estimated to be 150nm [1]. The spectra of (b) and (c) have characteristics of two peaks at ~89eV and ~95eV. We must take notice that the spectra shape of Fig. 1(b) and (c) are entirely different from that of (a). Further the spectrum of (a) has a peak of ~86eV and no peak in (b) and (c) at the corresponding energy region. Although the peak position of high photon energy at ~95eV is the same for Fig. 1(b) and (c), another one is different, that is, at ~90eV for the sample annealed at 700°C and ~89eV for the annealing temperature of 900°C. Further one can see in such a way that the intensity ratio of two peaks in Fig. 1 is different between (b) and (c). Therefore, it is considered that the interface electronic states of Fe/4H-SiC(0001) C-face contact system annealed at both 700 and 900°C are the similar silicide such as FeSi and β-$FeSi_2$ which are described elsewhere [2], although the deposited film is not composed of the same silicides for two annealing temperatures. Further we have obtained the results that the similar silicide such as FeSi and β-$FeSi_2$ in the interface is formed from annealed at 700°C for both Fe/4H-SiC(0001) Si-face and C-face. On the other hand, annealed at 900°C, it is concluded that the silicide of deposited film on Si-face is the similar as β-$FeSi_2$ and that on C-face is as FeSi and β-$FeSi_2$ including another silicide and/or ternary compound. Then it is suggested that the increase of annealing temperature for C-face may form the silicide such as β-$FeSi_2$.

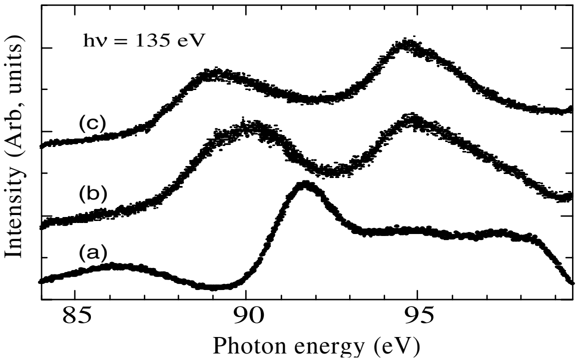

Fig. 1. Si $L_{2,3}$ florescence spectra obtained from different samples: (a) 4H-SiC substrate; Fe(50nm)/ 4H-SiC(0001) C-face contact system annealed at (b) 700°C and (c) 900°C. Excitation photon energy was 135eV.

Summary

These results are summarized as follows.

The interface reacted region is composed of Fe-Si compound; silicide and/or ternary compound.

References

[1] B. Sonntag and R. Haensel, Solid State Commun. **7** (1969) 597.

[2] M. Kasaya, S. Yamauchi, M. Hirai, M. Kusaka, M. Iwami, N. Nakamura and H. Watabe, Appl. Surf. Sci. **75** (1994) 110.

*hirai@science.okayama-u.ac.jp