A stacked sputtered process for β-$FeSi_2$ formation

T. Inamura[1], A. Sasaki[2], K. Aoki[2], K. Kakushima[1], Y. Kataoka[1], A. Nishiyama[1], N. Sugii[1], H. Wakabayashi[1], K. Tsutsui[1], K. Natori[1], H. Iwai[1]

Tokyo Institute of Technology[1], 4259 Nagatsuta, Midori-ku, Yokohama, Japan 226-8502

Toshiba Materials Co., LTD. [2] 8, Shinsugita-Cho, Isogo-Ku, Yokohama 235-8522, Japan

A stakced sputtered processs has been proposed. Only β-$FeSi_2$ crystalline phase was confirmed at annealing temperature as low as 600 °C. Moreovere, from temperature dependence of β-FeSi2, two kinds of activation energy (E_a=0.123eV, E_a=0.039eV) was confirmed.

β-$FeSi_2$ has drawn attention as environmentally conscious material owing to its abundance of resources. Moreover, β-$FeSi_2$ with large optical absorption coefficient (> 10^5 cm^{-1} at 1 eV) associated with a direct band gap of ~ 0.85 eV in the infrared region is considered as a promising light emitters, solar cells material. The problem of β-$FeSi_2$ is that a high-temperature annealing process is required for formation [1, 2]. The other problem of β-$FeSi_2$ for devices application is excess carrier density [3]. This work proposes formation of Fe-silicide by using stakced sputtered process and shows the formation of β-$FeSi_2$ at low temperature and we calculated the activation energy in order to know the reason why carrier density is high.

After SPM cleaning and HF treatment, a set of Fe/Si bilayer was cyclically stacked by RF sputtering on n-Si wafer or SiO_2 substrate, followed by rapid thermal annealing (RTA) in N_2 ambient.

Fig. 1 shows infrared absorption characteristics of β-$FeSi_2$. Increasing in absorption edge around 6400 cm^{-1} in the spectrum can be observed while increasing the annealing temperature from 600 to 900 °C. β-$FeSi_2$ with bandgap of 0.8 eV can be extracted. Fig. 2 shows x-ray diffraction pattern of the sample annealed at 600 °C. One can observe only $FeSi_2$ crystalline phase. Fig. 3 shows temperature dependence of sheet resistance of β-$FeSi_2$. From Arrhenius plot, the activation energy at range from 240K to 340K was confirmed to be 0.123eV and from 40K to 240K to be 0.043eV.

In conclusion, formation of β-$FeSi_2$ using stacked sputtered process has been confirmed at annealing temperature as low as 600 °C. From the temperature dependence of sheet resistance, two kinds of activation energy were found.

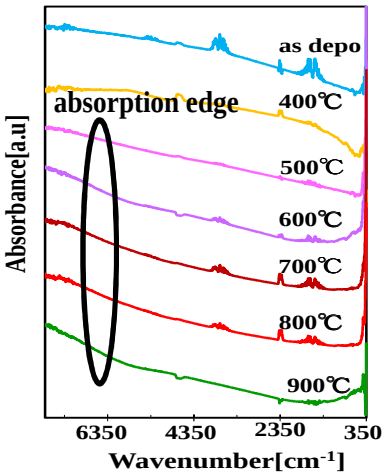

Fig.1 Infrared absorption characteristics of β-$FeSi_2$ using stacked sputtered process

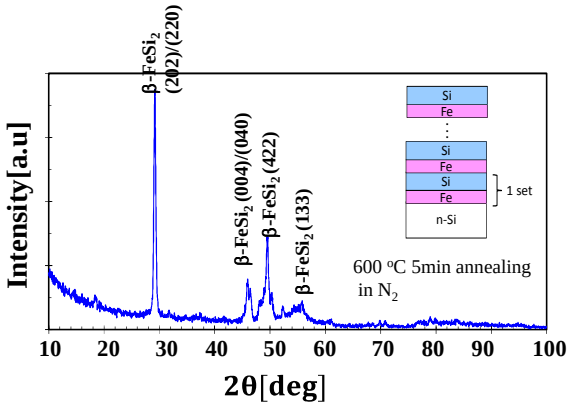

Fig. 2 A typical XRD pattern of β-$FeSi_2$ using stacked sputtered process with a sample annealed at 600 °C

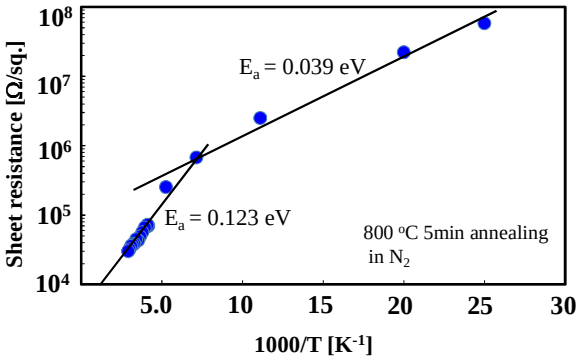

Fig.3 Temperature dependence of β-$FeSi_2$ using stacked sputtered process

References
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