A Study on Physical Properties of BP

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Abstract

Boron Phosphide films were deposited on (111) Si substrate at 650 ℃, by the reaction of B_2H_6 with PH_3 using APCVD. N_2 was carried out as carrier gas. The optimal gas rates were 20 mℓ/min for B_2H_6, 60 mℓ/min for PH_3 and 1 ℓ/min for N_2. After as grown the films were insitu annealed for 1hour in N_2 ambient at 550℃ and measured.

The measurement of AFM shows that the RMS is 29.626Å for the reaction temperature at 650℃. The measurement of XRD shows that the films have the orientation of (101). Also, the measurement of AES is shown that the films have $B_{13}P_2$ stoichiometry.

Key Words : CVD, Boron, Phosphide,

1. Introduction

Since 1890s, BP(Boron Phosphide) have been regarded as one of III-V compound semiconductor. Early 1890s, study about composition of B(Boron) and P(Phosphorous) was begun by M. Besson etc [1]. And in 1960s, from R. C. Vickery, R. J. Archer and V.I. Matkovich, study about BP's evaporation method and the properties of material had continuously[2].

In 1970s, study about crystal growth had from T. L. Chu, K. Shohno and T. Nishinaga and is accomplishing mainly study of BP until present. Since 1980s, the growth concertion was appeared good result by C. J. Kim, Y. Kumashiro and A. Goossens[3].

From 1990s, until the now, achieved by H. W. Leite Alves, Yunle Gu and J. Goossens[4].

BP is compound semiconductor that the composition elements of group III and group V of elements. BP is very suitable to high temperature thermoelectric device that have high efficient thermoelectric conversion rate. Also, it can be used usefully as protective materials because of very stable chemically and very strong physically. In the case of thin films, for use windows layer of solar cell. When BP formed hetero-junction is deposited on silicon, for use active layer of solar cell being progressing study that to use good quality about absorption coefficient for photon that have high energy.

Therefore, BP is compound materials as stable compound semiconductor chemically and not take-out at manufacturing process of semiconductor. These materials were deposited the thin film at low temperature and characteristics of the material measured, and it can apply directly in various semiconductor manufacturing process.
In this study, It was various physical characteristics of $B_{13}P_2$ that deposit using APCVD method that can do cost cutting.

2. Experimental

In this study, BP thin films were deposited on the (111)Si substrate using APCVD(Atmospheric Pressure Chemical Vapor Deposition). 1% B_2H_6(Diborane) in H_2 and 5% PH_3(Phosphine) in H_2 were employed as reaction gas. The carrier gas used to N_2. The substrate size is 1.5 cm^2. The substrate was cleaned using trichloroethylene ($ClCHCCl_2$), D. I. Water, acetone (CH_3COCH_3) and methanol (CH_3OH) by the ultrasonic cleaner for 5 minutes, respectively. After it was removed water on the substrate surface, and steamed water in the vacuum oven. It was deposited at 650℃. Reaction gases were B_2H_6 and PH_3. Films were annealed for 1 hour in N_2 ambient. In the experiments, it found out optimum conditions of the reaction gas rate and the carrier gas rate. The optimum reaction gas rate of B_2H_6 and PH_3 were 20 cc/min., 60 cc/min., respectively. The optimum carrier gas rate was 1

l/min. Films were annealed at 550℃ for 1 hour for crystallization and stabilization in N_2 ambient. Fig. 1 shows the process flow chart of experiments.

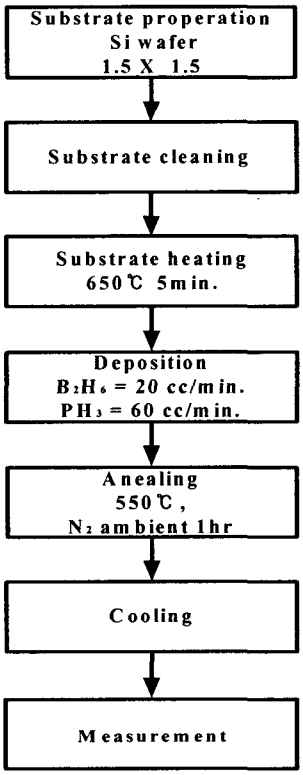


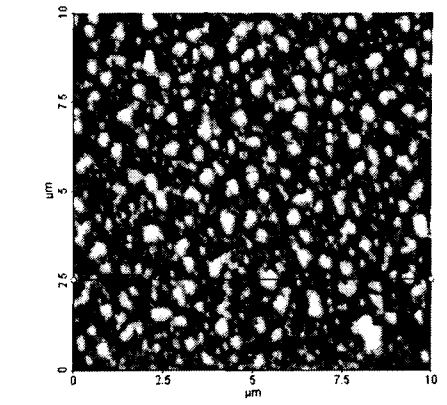
Fig. 1 Process Flow Chart

3. Results and Discussion

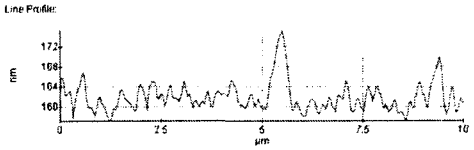
To analyze the crystal property of the $B_{13}P_2$ thin film, the roughness of a surface was recognized by AFM and the orientation property of a thin film measured by XRD. In this section, the stoichiometry of a BP thin film was observed by AES.

For the result of AFM the scanning area is all 10 ㎛ × 10 ㎛ with a surface to measure surface roughness of a BP thin film.

AFM image and the line profile which measured a surface of deposited $B_{13}P_2$ thin film in 650℃ were shown in Fig. 2, respectively. The RMS of a $B_{13}P_2$ thin film was 29.626Å. From the line profile of Fig. 2, the surface of a $B_{13}P_2$ thin film could know that it was stable and smooth.



(a)



(b)

Fig. 2 AFM Image as deposited at 650℃ (a) and line profile(b).

When it makes angle of diffraction from 20°to 80°the result of XRD each sample was shown in Fig. 3. The X-rays were used in diffraction experiment by having the Cu-K α that a wavelength is 1.54A. For the Fig. 3 these diffraction peaks can know the direction of $B_{13}P_2$ (1 0 1) when the diffraction range is 20 ~ 80, and it was observed near by a 2Θ = 29°, and a peak appears with the neighborhood in 38°, 41° and 61°.

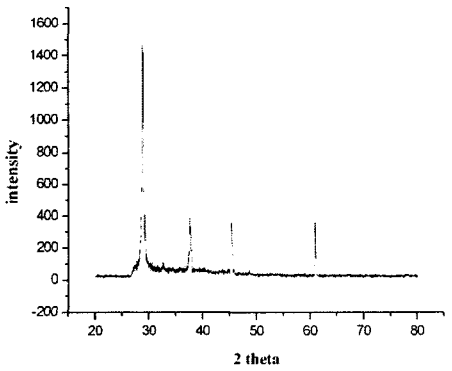


Fig. 3 Result of XRD for the deposited thin film at 650℃

Fig. 4 is showing elemental concentration detected from the deposited BP thin film according to sputtering time. For the concentration ratio of the atom along sputtering time of B and P could know in Fig. 4, the B is with approximately 85%, and P appears with approximately 13%. It was known that the BP

concentration ratio is about 13 : 2.

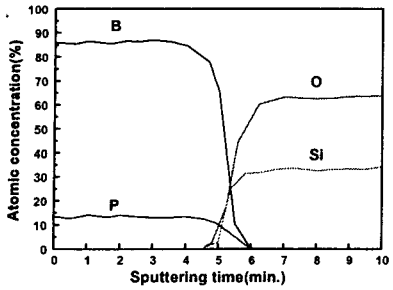


Fig. 4 Elements concentration by sputtering time as deposited at 650℃

4. Conclusions

In this study, we discussed the physical characteristics of $B_{13}P_2$ as compound semiconductor. It can be used usefully as protective material because of very stable chemically and very strong physically. So, we studied to physical characteristics of $B_{13}P_2$.

To analyze the surface roughness of $B_{13}P_2$ films grown by APCVD, the AFM was used in this study. The result of surface roughness measurements using AFM was shown that RMS was 29.626Å. So, we could know every commonplace thing. The XRD was used to analyze the preferential orientation and crystallinity of $B_{13}P_2$ thin films. The measurement of XRD shows that the films have the peak 29°, 38°, 41°and 61° in reflective degree between 20°and 80°and have the preferred orientation of (1 0 1).

Also, the measurement of AES is shown the films have $B_{13}P_2$ Stoichiometry. So, we could see that deposited $B_{13}P_2$ thin film.

References

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