졸겔법에 의한 보론 포스파이드의 박막 증착 및 특성에 관한 연구

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Properties of Sol-Gel derived $B_{13}P_2$ Thin Films

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Abstract : Boron phosphide thin films were prepared on the glass substrate from boron and phosphorous alkoxide precursors by sol-gel processing. Boron phosphide sol with equivalent ratio $(CH_3O_3)B : C_{18}H_{15}P = 13 : 2$ was selected. Films spin-coated at 4000 rpm for 30 s were coated uniformly. Decomposition and crystallization behavior were examined using DSC/TGA and XRD. The films were sintered at 250, 300 and 400 ℃. It was determined that crystal structure has a rhombohedral phase. The microstructure of thin film was observed using SEM. Thin films approximately showed a visible ray transmittance of 85 %.

Key Words : boron phosphide, $B_{13}P_2$, BP, sol-gel, thin films

1. Introduction

BP is one of the compound semiconductors which are composed of group III and V element. It can be used usefully as a protective material because it is very stable chemically and very strong physically[1]. General application would be promising a high temperature electronic devices owing to a wide band gap[2,3] and BP films retained transparency[4]. Therefore it is expected that BP will have wide applications such as display and solar cell.

BP thin films have been generally fabricated by CVD, MBD, and sputtering[5,6]. Sol-gel processing is characterized by low temperature preparation leading to thin films of high purity, good homogeneity, and controlled chemical composition.

So far as we know, deposition of $B_{13}P_2$ thin films by sol-gel was not established. In this work, we have investigated formation of $B_{13}P_2$ films by sol-gel.

2. Experimental

Boron alkoxide and phosphorus alkoxide precursors were combined in a 13 : 2 molar ratio, dissolved and diluted with methanol. The procedure is as follows, trimethyl borate and triphenyl phosphine were mixed and dissolved in methanol for 6 h at room temperature under constant stirring. The precursor solutions were transparent.

Conditions for spin coating were optimized in order to obtain uniform layers with a minimum number of visible defects. Immediately prior to the solution deposition, glass substrates were cleaned, blown, and dried on a hot plate. The precursor solution was syringed onto the glass substrate, and spin-coated 4000 rpm for 30 s. After deposition, the samples were heat-treated on a hot plate at 150 ℃ for 30 min to remove solvents. The deposition and heat treatment were repeated 3 ~ 5 cycles to obtain a required film thickness.

3. Results and discussion

Figure 1 illustrates DSC and TGA curves for dried gel powder. For the preparation of aerogel powders, distilled water was added to sol for hydrolysis. Decomposition occurs at approximately 100 ℃, as revealed by the endotherm associated with a weight loss. The weight loss of a powder from BP precursor is almost terminated at about 600 ℃ and coincides with crystallization DSC peak with its maximum at about 230 ℃. The weight loss due to decomposition of organic residues continues up to the crystallization temperature. TGA analysis shows that ~ 70 % of weight has been lost after heating to 800 ℃.

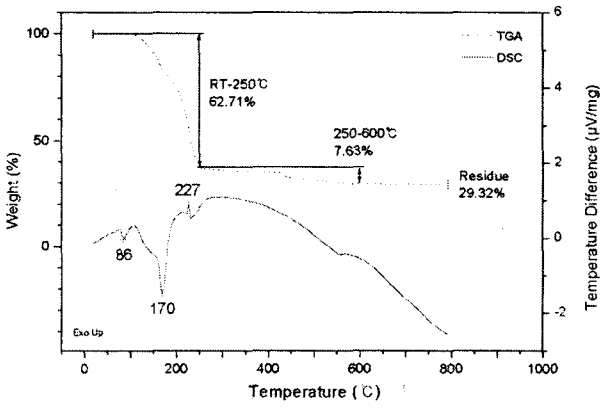

Figure 1. DSC/TGA of dried gel powders

Figure 2 illustrates the x-ray diffraction patterns for $B_{13}P_2$ films sintered at 250, 300 and 400 ℃ for 30 min. It is noted that rhombohedral crystal structure is found in $B_{13}P_2$ films on the glass substrates at various temperatures. Sintered films have the preferred orientation of (0 2 1).

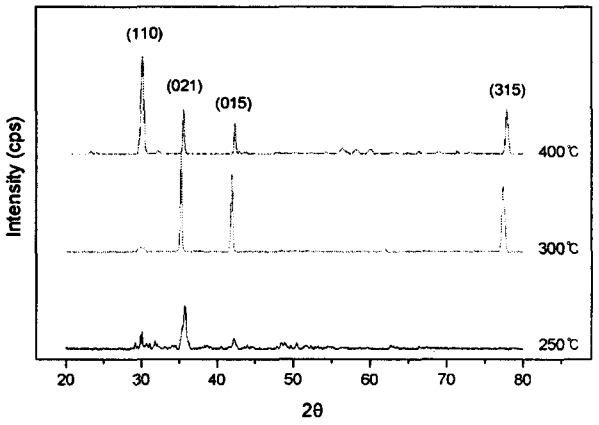

Figure 2. XRD patterns of $B_{13}P_2$ films sintered at various temperatures for 30 min

Microstructure of $B_{13}P_2$ film with increasing of sintering temperature has been investigated as shown in figure 3. The film showed a good densification behavior at low temperature. As a result, nanostructured dense $B_{13}P_2$ film with a fine crystallite size were obtained at 300 ℃.

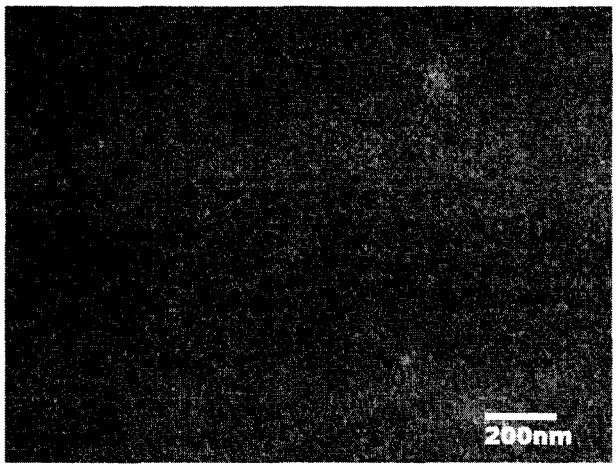

Figure 3. SEM photograph of $B_{13}P_2$ film sintered at 300 ℃ for 30 min

The films retained transparency. Figure 4 shows transmittance. The average transmittance of films was 82.8, 85.0, 85.1 % at 250, 300, 400 ℃, respectively. The degree of transparency was slightly increased after sintering at temperatures above 250 ℃. The transmittance of $B_{13}P_2$ films showed good quality in visible light ranges.

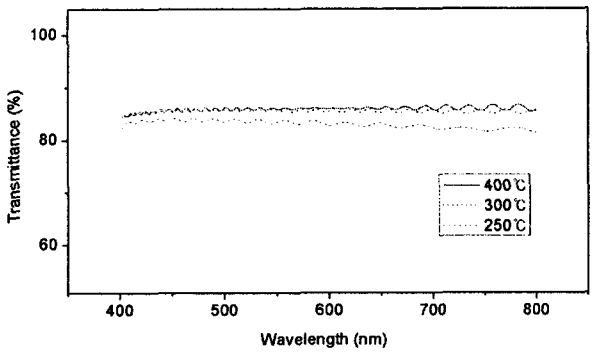

Figure 4. Transmission spectra of $B_{13}P_2$ films sintered at various temperatures for 30 min

4. Conclusion

Boron phosphide films were deposited on the glass substrate at low temperature by sol-gel processing and studied properties of the films.

X-ray diffraction patterns for $B_{13}P_2$ films sintered at 250, 300 and 400 ℃ for 30 min. It is noted that rhombohedral crystal structure is found in $B_{13}P_2$ films on the glass substrates at various temperatures. Sintered films have the preferred orientation of (0 2 1). The films showed a fine crystallite size. Transmittance of $B_{13}P_2$ films was 82.8, 85.0, 85.1 % at 250, 300, 400 ℃, respectively. The degree of transparency was slightly increased after sintering at temperatures above 250 ℃ and films showed good quality in visible light ranges.

Boron phosphide films were deposited at low temperature by sol-gel processing. It means that a problem of a substrate limitation can be solved and a cost of manufacturing process can be lowered because of low temperature process. Furthermore, deposited films can be used as a material for display which requires the glass as a substrate.

Reference

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