Structural and surface analysis of chemical vapor deposited boron doped aluminum nitride thin film on aluminum substrates

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Chemical vapor deposition (CVD) process was conducted for synthesis of boron (B) doped aluminum nitride (B-AlN) thin films on aluminum (Al) substrates. To prevent melting of the Al substrates, film deposition was carried out at 500 °C using tert-buthylamine ($t\text{BuNH}_2$) solution delivered through a bubbler as a nitrogen source instead of ammonia gas (NH_3). B-AlN thin films were prepared from three precursors at changing process parameters (gas mixture ratio). X-ray diffraction (XRD) technique and atomic force microscope (AFM) were used to investigate the structural and surface properties of B-AlN thin films on Al substrates. The prepared thin films were polycrystalline and composed of mixed phases {cubic (1 1 1) and hexagonal (1 0 0)} of AlN and BN with different orientations. Intensive AlN peak of high intensity was observed for the film deposited at a flow rate of the total gas mixture of 25 sccm. As the total gas mixture flow decreased from 60 sccm to 25 sccm, the crystallite size of AlN phase increased and the dislocation density decreased. Reduced surface roughness (10.4 nm) was detected by AFM for B-AlN thin film deposited on Al substrate using the lowest flow rate (25 sccm) of the total gas mixture.

Keywords: B-AlN; thin film synthesis; CVD; Al substrate structural parameter; surface analysis

1. Introduction

Aluminum nitride (AlN) is a promising ceramic material from group III nitrides which has high thermal conductivity ($260 \text{ W} \cdot \text{m}^{-1} \cdot \text{K}^{-1}$), high mechanical strength, and excellent electrical insulation [1–3]. Due to the excellent properties of AlN, it has attracted attention in producing thin films by various methods, such as reactive sputtering [4–6], pulsed laser deposition [7, 8], reactive molecular beam deposition [9], and chemical vapor deposition (CVD) [10–12]. CVD has advantages over physical vapor deposition (PVD), such as high deposition rate, large deposition area and the fact that ultra-high vacuum condition is unnecessary, which is very advantageous for industrial mass production [13]. Ammonia gas (NH_3) is a common nitrogen source for nitride growth in CVD process to synthesize AlN, [14, 15]. However, the high thermal stability of NH_3 requires high

synthesis temperature (typically ≥ 1000 °C, thus high-temperature substrates to deposit high quality AlN thin films, which seriously limits the choice of substrate materials available for suitable application in modern electronics where Al substrates are considered as the best choice due to cost effectiveness and efficient thermal management. Moreover, NH_3 is hazardous to health and requires proper exhaust system during the synthesis process.

To reduce the substrate temperature, plasma-enhanced CVD (PECVD) [16] system has been suggested by other researchers where the plasma activated reactions occur at lower temperature, however, the technique is difficult to control and expensive. To overcome this, metal-organic precursors, such as hexa(dimethylamido)dialuminum [$\text{Al}_2(\text{NMe}_2)_6$] [17] and hexamethylaluminum [$\text{Al}_2(\text{CH}_3)_6$] [18] have been developed to overcome the problem. However, the precursors are not easy to handle and not stable in the presence of oxygen and moisture. There are other reports where single-source precursor,

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such as trimethylaluminum ammonia $[(\text{Me}_3\text{Al}(\text{NH}_3))]$ adduct [19] has been utilized to simplify the precursor usage in CVD process. Nevertheless, the preparation of single-source precursors may involve complex and costly procedures which are not recommended for conventional CVD technique as it has very low vapor pressures ($\ll 133$ Pa at room temperature), which requires the heating of source and reactor lines and the use of high-vacuum CVD equipment. Moreover, this type of single source precursor needs higher temperature (>900 °C) to produce high quality AlN thin film [20].

Alternatively, tert-buthylamine (${}^t\text{BuNH}_2$) was chosen as nitrogen source instead of NH_3 due to its vapor pressure (4.5×10^4 Pa at 25 °C) suitable for the deposition conditions [21]. There were many reports on the successive use of ${}^t\text{BuNH}_2$ as nitrogen source at lower temperature (400 °C to 600 °C) [22, 23] but the deposition of AlN thin film on Al substrates has not been considered probably because the conventional CVD system should be modified and need a proper precursor delivery system like gas bubbler. Many elements, such as Cr [24], Si [25], Mg [26], Mn [27] etc., have been suggested as a dopant to AlN to modify the properties for particular electronic applications. The properties of AlN thin film, especially dielectric function, were improved by the addition of B into AlN material using sputtering process as reported in the literature [28]. Except our author group, there are no other reports on using B as a dopant and synthesizing B doped AlN (B-AlN) thin films over Al substrate using CVD approach with a gas bubbler setup as a liquid precursor delivery system especially for ${}^t\text{BuNH}_2$ solution. To optimize the synthesis methodology, it is mandatory to study the structural parameters and surface properties of B-AlN thin films on Al substrates derived from CVD equipped with the gas bubbler setup.

In this work, B-AlN thin films were synthesized by CVD method using gas bubbler arrangement and their structural and surface properties were characterized for various flow rates of precursors using X-ray diffraction technique and atomic force microscopy (AFM). In our previous study, the same methodology was employed to deposit

B-AlN on Si substrates and it was reported in [29]. The obtained results are compared and discussed here.

2. Experimental

The arrangement of the gas bubbler system integrated with a conventional CVD system is explained schematically in Fig. 1. A fused quartz tube was chosen as a working tube for the deposition of B-AlN thin films and placed in a three zone furnace (OTF-1200X-III, MTI Corp) with independent temperature controllers. Aluminum chloride (AlCl_3) powder (anhydrous sublimed, ≥ 98 %, Sigma-Aldrich), boron trichloride (BCl_3) solution (1 M solution in hexane, Acros Organics) and ${}^t\text{BuNH}_2$ solution (98 %, Aldrich Chemistry) were selected as Al source, B source and nitrogen source, respectively, for the B-AlN thin film deposition process. 8 g of AlCl_3 powder was filled in a boat type crucible and positioned at the left zone of the furnace as shown in Fig. 1.

Well cleaned Al substrates (25 mm $\times$ 25 mm $\times$ 3 mm) were positioned at the central zone which was the deposition zone of the furnace. Initially, the air inside the fused quartz tube was evacuated by rotary vacuum pump and the tube was filled with nitrogen (N_2) gas to maintain the inert atmosphere inside. The left zone temperature was set at 400 °C and the temperature of the center and right zone was maintained at (optimum) 500 °C to prevent the Al substrate melting and assure effective deposition.

Fig. 1. Schematic diagram of CVD system for B-AlN thin film deposition.

The temperature of 400 °C was maintained at left zone to avoid the deposition during the transport of reactive mixture before reaching the center

zone. Gas (air) bubbler was employed as the liquid precursor delivery system for $t\text{-BuNH}_2$ solution as it is a convenient and reliable method to achieve uniform mixture of vapor with other sources of elements [30]. N_2 gas was used as a carrier gas in the bubbler and its flow rate was controlled by a digital mass flow controller (MFC). The $t\text{-BuNH}_2$ solution was bubbled and its vapor were fed into the CVD tube at the left zone where it was mixed with AlCl_3 vapor before it reached the center zone. The Al substrates were positioned at the center zone of the CVD tube where the mixed vapor flowed through for the deposition. BCl_3 solution was bubbled with N_2 carrier gas and the vapor was fed into the CVD reaction tube for about 30 minutes to enable the B doping process. The coating process was conducted for about one hour under atmospheric pressure. After deposition, the B-AlN thin films were subjected to annealing at 300°C for 3 hours with 10 sccm flow of N_2 gas. Various process conditions were designed by changing the flow rates of carrier gases and source materials. In order to check the thickness of deposited film, Si substrates were placed along with Al substrates during the deposition process and used for thickness analysis. The thickness was measured by capturing the cross-sectional image of each samples by field emission scanning electron microscope (FE-SEM) and communicated in another work from the same author group (Fig. 2) [31]. The detailed information of the process conditions used in this study was already reported in the previous work, where we used Si as substrates, and reproduced here for the ease of understanding (Table 1).

Fig. 2. FE-SEM cross-section images of thin film samples prepared at various process conditions.

The structural properties of deposited B-AlN thin films were analyzed using X-ray

Table 1. Deposition parameters of B-AlN thin films obtained by CVD method.

Process	Gas mixture ratio	Average thickness [nm]
CVD 1	AlCl_3 carrier gas (N_2)	10 sccm
	tert-buthylamine	25 sccm
	BCl_3	25 sccm
CVD 2	AlCl_3 carrier gas (N_2)	5 sccm
	tert-buthylamine	25 sccm
	BCl_3	25 sccm
CVD 3	AlCl_3 carrier gas (N_2)	2.5 sccm
	tert-buthylamine	15 sccm
	BCl_3	15 sccm
CVD 4	AlCl_3 carrier gas (N_2)	5 sccm
	tert-buthylamine	10 sccm
	BCl_3	10 sccm

diffractometer (XRD) technique (XRD, X'Pert-PRO, Philips, Netherlands) and the structural parameters such as crystallite size (D), lattice parameters (a and c), dislocation density (δ), residual stress (σ), and strain (ϵ) were calculated from the XRD pattern. A $\text{CuK}\alpha$ ($\lambda = 1.54056 \text{ \AA}$) source was used, and the 2θ scanning range was selected between 20° and 80° . The X-ray beam was operated at 40 kV and 40 mA to investigate the structural properties. The surface topography was investigated with atomic force microscope (AFM) (Bruker AXS) in a tapping mode at $10 \mu\text{m}$ scan range. The results obtained are compared and discussed here.

3. Results and discussions

3.1. XRD analysis

Fig. 3 shows the XRD patterns of all B-AlN thin films deposited at different process conditions (by changing the gas mixture ratio). It clearly indicates the formation of polycrystalline mixture of AlN and BN phases in all samples. It also reveals

that the cubic (1 1 1) oriented AlN phases dominated the growth of the synthesized samples. Fig. 3 provides the peak intensity comparison of c-AlN (1 1 1) peaks observed for CVD 1 to CVD 4 samples. The positions of these predominant peaks are observed between 38.3° and $38.6^\circ(2\theta)$. Along with predominant (1 1 1) oriented AlN peak, two peaks with relatively low intensity related to hexagonal (1 0 0) {h-(1 0 0)} oriented and cubic (1 1 1) {c-(1 1 1)} oriented BN phase are also found in the XRD patterns at 2θ in the range from 40.1° to 40.4° and from 43.0° to 43.3° , respectively, which is clearly shown in Fig. 4. A strong peak at 44.7° is indexed to Al substrate and indicated in Fig. 4. The peak intensity decreases from 1322 a.u. to 864 a.u., when the flow rate of carrier gas of AlCl_3 decreases from 10 sccm to 5 sccm (CVD 1 to CVD 2). When the total gas flow rate for CVD 2 (55 sccm) is further reduced to 32.5 sccm (CVD 3), the peak intensity of AlN slightly increases to 913 a.u. where the flow rate of ${}^t\text{BuNH}_2$ and BCl_3 carrier gas is further reduced compared to the flow rate conditions used in CVD 1 and CVD 2.

Fig. 3. XRD patterns of B-AlN coated Al substrates.

As the flow rate of ${}^t\text{BuNH}_2$ and BCl_3 for CVD 2 decreases from 25 sccm to 10 sccm (CVD 4), the intensity of (1 1 1) oriented AlN peak increases significantly to 5617 a.u. if the flow rate of carrier gas for AlCl_3 is still maintained at the same level of 5 sccm. From the results, it can be stated that the peak intensity of AlN depends on the flow rate of ${}^t\text{BuNH}_2$ and AlCl_3 which are nitrogen and Al sources for AlN phase respectively. By reducing

the total gas flow rate, the mixed vapor would have enough time to react with each other on the surface of substrate before the concentration of chemicals in the tube becomes saturated, thus more crystalline AlN can grow and higher peak is detected. Considering BN peaks, both observed h-(1 0 0) and c-(1 1 1) peaks are of low intensity. The highest intensity value (401 a.u.) was achieved for h-(1 0 0) oriented BN peak of the sample obtained in CVD 3 process where the flow rate of BCl_3 was maintained at 15 sccm, while for c-(1 1 1) oriented BN peak, the peak intensity was relatively small, in the range between 170 a.u. and 322 a.u., in all processes other than CVD 3. From these observations, it is concluded that the CVD 3 process conditions are suitable to grow the mixed phase of AlN and BN using CVD process with the gas bubbler setup. The lack of BN peak may be explained by the fact that the product was either amorphous or had smaller grain sizes [32]. The B atoms might also diffuse into AlN structure under high temperature condition during the process [33].

3.2. Structural parameters analysis

Based on the XRD results, the structural parameters were evaluated to study the influence of process conditions, especially carrier gas flow rate, on structural changes and properties of B-AlN thin films. The average thickness of every thin film sample was obtained from the cross-sectional image recorded from FE-SEM and the values are displayed in Table 1. It was found that the thicknesses achieved in all process conditions except for CVD 3, are very close to each other and the difference is very small (Table 1). High rate of deposition and high thickness of the deposited film was observed for CVD 3 process compared to all other 3 processes. This shows that the effect of gas flow rate on the rate of film growth is significant. The growth rate may increase by changing other parameters such as deposition temperature or pressure in the tube.

According to the peak positions (2θ) recorded from the XRD pattern (Table 2), peak shifting from standard 2θ can be observed in all peaks as summarized in Table 2. For c-(1 1 1) oriented AlN peak,

Fig. 4. Peak intensity of (1 1 1) oriented cubic AlN.

the peak shifting towards greater 2θ value occurs for the film deposited in the processes CVD 1 and CVD 2. The shifting is higher ($2\theta = 0.108^\circ$) for the film deposited in CVD 2 process as compared with CVD ($2\theta = 0.076^\circ$), where the total gas flow rate was reduced from 60 sccm (CVD 1) to 55 sccm (CVD 2). For the films deposited in CVD 3 and CVD 4 processes, the AlN peak position shifts toward lower 2θ , and the degree of shifting of the peak obtained in CVD 4 is higher ($2\theta = 0.137^\circ$) than in CVD 3 ($2\theta = 0.048^\circ$). The left shifting may be connected with the N_2 carrier gas flow rate of $AlCl_3$ being 5 sccm. It reveals that the Al content may be reduced in this sample with respect to the nitrogen and B content. The peak shifting of AlN phase is most probably the evidence of B dopant that incorporates into the crystal structure during the growth process [32]. It causes greater structural defects in the film as compared with the pure AlN. Both h-BN (1 0 0) and c-BN (1 1 1) peaks

experienced also a shift towards lower 2θ value, except c-BN (1 1 1) of CVD 2 which shows minor right shifting behavior.

In Fig. 3, the peak broadening can also be observed for different process conditions. The peak broadening is correlated with the crystallite size in the B-AIN thin film. The peak broadening was estimated by measuring the full width at half maximum (FWHM) of the concerned peak from the XRD pattern. Consequently, the FWHM of all peaks was measured using the XRD software and employed to calculate the crystallite size (D) using Debye-Scherrer formula [34] as given below:

$$D = 0.94\lambda / \beta \cos \theta \quad (1)$$

where λ is wavelength (in Å), β is the FWHM (in radians), θ is the Bragg diffraction angle. The calculated values are given in Table 2. It clearly shows that the crystallite size is increasing with decreasing total carrier gas flow rate for all peaks. Nanocrystallites were found in c-(1 1 1) oriented AlN phases obtained in CVD 1 and CVD 2 processes. Bigger crystals were observed for CVD 3 and CVD 4 samples where the flow of carrier gas of nitrogen and B source was low as compared with CVD 1 and CVD 2. In BN phase, the crystallite size is slightly bigger than the AlN crystallites size for the respective process conditions. For h-(1 0 0) orientation, the crystallite size increases with a decrease in the total carrier gas flow rate up to the sample obtained in CVD 3 process. It is attributed to the effect of carrier gas flow rate from $AlCl_3$ source. It slightly increases for CVD 4 process and hence the smaller crystallite size of BN phase can be observed.

During the film growth and annealing process, residual stress is developing which may cause heterogeneous plastic deformation, thermal contractions and phase transformation. The plastic deformation and thermal contractions are expected since B-AIN thin film is processed at elevated temperature. Moreover, the B doping may also cause a residual stress during the film growth. For clear understanding, the influence of doping and annealing on the change in residual stress

Table 2. Structural properties of B-AlN thin film prepared at various CVD gas flow rates.

Process	Identity	Observed 2 θ [°]	Standard 2 θ [°]	FWHM [°]	Crystallite size [nm]	Lattice constant [Å]	Reference No.
CVD 1	c-AlN (1 1 1)	38.607	38.531	0.157	53.769	4.036	00-046-1200
	h-BN (1 0 0)	40.345	40.828	0.092	91.666	a = 2.234 c = 3.648	00-049-1327
	c-BN (1 1 1)	43.297	43.298	0.120	71.204	3.617	00-025-1033
CVD 2	c-AlN (1 1 1)	38.639	38.531	0.085	99.359	4.033	00-046-1200
	h-BN (1 0 0)	40.403	40.828	0.079	106.311	a = 2.231 c = 3.643	00-049-1327
	c-BN (1 1 1)	43.346	43.298	0.096	89.020	3.613	00-025-1033
CVD 3	c-AlN (1 1 1)	38.483	38.531	0.062	136.553	4.049	00-046-1200
	h-BN (1 0 0)	40.246	40.828	0.074	113.684	a = 2.239 b = 3.656	00-049-1327
	c-BN (1 1 1)	43.175	43.298	0.096	88.967	3.626	00-025-1033
CVD 4	c-AlN (1 1 1)	38.394	38.531	0.057	148.884	4.058	00-046-1200
	h-BN (1 0 0)	40.138	40.828	0.100	84.552	a = 2.245 b = 3.666	00-049-1327
	c-BN (1 1 1)	43.075	43.298	0.096	88.937	3.634	00-025-1033

of B-AlN thin film has been considered. Consequently, the internal stress (σ) developed in the deposited film is calculated using the following relation:

$$\sigma = -E(d_a - d_o)/(2d_oY) \quad (2)$$

where d_o and d_a are the d spacing of bulk and thin film forms, respectively [35]. The Young modulus (E) and Poisson ratio (Y) of AlN and BN are $E_{\text{AlN}} = 308$ GPa [36], $E_{\text{BN}} = 748$ GPa [37], $Y_{\text{AlN}} = 0.29$ [38], and $Y_{\text{BN}} = 0.19$ [39], respectively. The stress exerted on the film can be identified by the sign of the calculated value. Positive sign represents compressive stress whereas negative sign denotes tensile stress. With the reference to 2θ from Table 2, the peaks shifted to higher angle mean that the film experienced tensile stress whereas the peaks shifted to lower 2θ angle refer to compressive stress during the film growth. As far as AlN phase is concerned, the stress developed during the film growth in CVD 1 and CVD 2 process conditions is tensile in nature and it is increasing with carrier gas flow rate of AlCl_3 .

A conversion from tensile to compressive was noticed in CVD 3 and CVD 4 process conditions where the total carrier gas flow rate was reduced. It is noticed from Table 3 that the observed stress values are very low when compared with the value

for BN phase in the prepared B-AlN thin film. For h-(1 0 0) oriented BN phase, the stress value increases with the total carrier gas flow rate decrease. The stress conversion from compressive to tensile is observed for c-(1 1 1) AlN phase along with a conversion from tensile to compressive stress for c-(1 1 1) BN phase. c-(111) BN phase shows higher value of compressive stress than the value of c-(1 1 1) AlN phase. Dislocation density (δ) is a measure of defects resulting from the crystallite size change during the growth of films as well as post deposition process. Since several factors influence the CVD process, it has to be addressed and evaluated by the relation [40]:

$$\delta = 1/D^2 \quad (3)$$

The obtained values are summarized in Table 3. From Table 3, it is seen that the δ values for c-(1 1 1) oriented AlN phase decrease with the total carrier gas flow rate decrease. Considering BN phases (both cubic and hexagonal), the δ value decreases for the film processed at reduced carrier gas flow rate of AlCl_3 until the flow conditions set at CVD 3 and a small increase in δ value is noticed in case of CVD 4, where the AlCl_3 carrier gas flow rate has slightly increased. High (3.46×10^{14} lines/m²) and low (4.51×10^{13} lines/m²) values of δ are noticed

for c-(1 1 1) AlN phase for CVD 1 and CVD 4 process conditions, respectively. As particle size changes, the micro strain inside the lattice may also change. The microstrain (ϵ) developed in the synthesized films has been calculated using the relation [41]:

$$\epsilon = \beta \cot \theta / 4 \quad (4)$$

The results are summarized in Table 3. It is noticed that the changes in the microstrain are following the same trend as it is observed for dislocation density. Thus, the high (1.95×10^{-3}) and low (7.08×10^{-4}) values of ϵ are noticed for c-(1 1 1) AlN phase developing in CVD 1 and CVD 4 process conditions, respectively.

3.3. Surface analysis

A comparison of surface morphologies of a bare Al substrate and B-AlN thin film coated Al substrates is presented in Fig. 5. The images show that the surface is composed of drop-like randomly oriented nanosized grain structure. The root mean square (RMS) surface roughness and particle size have been analyzed from the images using the nanoscope software and are recorded in Table 4.

It is found that the surface roughness of bare Al substrate is reduced by B-AlN film coating for the films deposited in all process conditions except for CVD 3 process. The surface has relatively high roughness of 30.8 nm as compared with those of other substrates. It is clearly seen in Fig. 5d which shows very large grains on the surface of the B-AlN thin films. The average particle size of CVD 3 is also large (1068 nm), and it can be noticed from Fig. 5d that the drop-like particles are larger than the other ones.

It shows that reduced N_2 carrier gas flow rate (2.5 sccm) does not result in reduction of surface roughness and particle size. In case of CVD 2 and CVD 4, the flow rate of N_2 carrier gas of 5 sccm promotes the growth of thin films with lower roughness and particle size as compared with 10 sccm used in CVD 1. When the flow rate of tert-buthylamine and BCl_3 are further reduced from 25 sccm (CVD 2) to 10 sccm (CVD 4), the surface roughness can be further reduced from 10.4 nm

Fig. 5. AFM surface images of bare Al (a) and B-AlN thin films on Al using (b) CVD 1, (c) CVD 2, (d) CVD 3, (e) CVD 4 process conditions.

to 9.18 nm, but in contrast, the particle size slightly increases from 436 nm to 601 nm and it is clearly seen in Fig. 5e that more grains are formed as compared to Fig. 5c.

4. Conclusions

In this work, B-AlN films were successfully deposited on Al substrates at 500 °C by CVD method using $tBuNH_2$ as nitrogen source with a gas bubbler setup. The synthesized films were polycrystalline with mixed phases and predominant c-(1 1 1) AlN peak with high intensity. BN peaks were also identified and influenced by the growth of c-(1 1 1) AlN on Al substrates. The peak shifting caused by B doping of AlN crystal lattice was observed. The structural studies revealed the formation of AlN with low residual stress and reduced defects. Over all, the crystalline quality was improved for decreased total gas mixture ratio. From AFM analysis, the improved surface

Table 3. Internal stress (σ), dislocation density (δ) and strain (ϵ) of B-AlN thin film in all deposition conditions.

Process	Identity	Internal stress, σ [GPa]	Dislocation density, δ [lines/m ²]	Strain, ϵ
CVD 1	c-AlN (1 1 1)	-1.01	3.46×10^{14}	1.95×10^{-3}
	h-BN (1 0 0)	22.34	1.19×10^{14}	1.10×10^{-3}
	c-BN (1 1 1)	0.03	1.97×10^{14}	1.32×10^{-3}
CVD 2	c-AlN (1 1 1)	-1.44	1.01×10^{14}	1.05×10^{-3}
	h-BN (1 0 0)	19.64	8.85×10^{13}	9.44×10^{-4}
	c-BN (1 1 1)	-2.10	1.26×10^{14}	1.05×10^{-3}
CVD 3	c-AlN (1 1 1)	0.65	5.36×10^{13}	7.70×10^{-4}
	h-BN (1 0 0)	26.93	7.74×10^{13}	8.86×10^{-4}
	c-BN (1 1 1)	5.30	1.26×10^{14}	1.06×10^{-3}
CVD 4	c-AlN (1 1 1)	1.84	4.51×10^{13}	7.08×10^{-4}
	h-BN (1 0 0)	31.90	1.40×10^{14}	1.19×10^{-3}
	c-BN (1 1 1)	9.64	1.26×10^{14}	1.06×10^{-3}

Table 4. Surface roughness and particle size evaluated by AFM software analysis.

Sample	Roughness (Ra) [nm]	Particle size [nm]
Bare Al	19.6	697
CVD 1	14.8	732
CVD 2	10.4	436
CVD 3	30.8	1068
CVD 4	9.2	601

properties were also observed for the film grown at the low total gas mixture ratio in CVD 4 process condition as the XRD peak intensity of c-(1 1 1) oriented AlN phase was the highest among all the films obtained at the four deposition parameters. From the obtained results, it is concluded that the cubic phase AlN could be deposited on Al substrates by using CVD process. The obtained structures can be used for heat dissipation in electronic devices for efficient thermal management.

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