

RF Power Independence of the Optical Band Gap in Boron Nitride Thin Films on Silicon

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ABSTRACT

Boron nitride (BN) thin films have attracted considerable interest because of their excellent thermal stability, high dielectric breakdown strength, and wide optical band gap, making them attractive for advanced optoelectronic and insulating applications. Among the available deposition techniques, RF magnetron sputtering is advantageous because it enables controlled film growth at relatively low temperatures. Although many studies have reported BN thin-film deposition, the specific influence of RF power on the optical properties of room-temperature deposited films remains poorly understood. Clarifying this effect is important for optimizing deposition conditions and obtaining high-quality BN coatings. This study examines how RF power affects the optical properties and band structure of BN thin films deposited at room temperature. The films were deposited on double-sided polished, (100)-oriented silicon wafers using a 99.5% pure hexagonal boron nitride (h-BN) target in an argon atmosphere (~0.3 Pa) for 30 minutes, with RF power varied between 100 and 190 W. Optical characterizations was performed using UV–visible spectroscopy (200–800 nm). We calculated the absorption coefficient from the absorbance spectra and estimated the optical band gap using Tauc plots $((\alpha h\nu)^2 \text{ vs. } h\nu)$. Data processing and curve fitting were conducted using Python and UVProbe. The band gap ranged from 6.03 to 6.09 eV, showing negligible variation with RF power, indicating stable stoichiometry and bonding. These findings show that room-temperature sputtering produces BN thin films with consistent optical properties suitable for wide-band-gap optoelectronic and dielectric applications.

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INTRODUCTION

Boron Nitride (BN) thin films have attracted interest because of their favorable mechanical, physical, and optical properties. These properties include high resistance to oxidation and chemical reactions, mechanical hardness, and thermal stability (Dahal et al., 2025; Stankus et al., 2024; Wu et al., 2024). Combined with a large optical band gap, these properties make

BN a strong candidate for use in harsh environments. Therefore, BN thin films have been widely applied to applications, e.g., protective coatings, dielectric layers, UV optical components and insulating layers in microelectronic and optoelectronic devices, and insulating layers in microelectronic and optoelectronic devices (C. Liu et al., 2024; Valladares Gonzalez, 2018; Zhang et al., 2001). In recent years, BN has become useful in this respect because it has a high band gap, high thermal stability, and electrical insulating properties, making it suitable for applications where conventional dielectrics are not sufficiently thermally or chemically stable. Nowadays, h-BN has emerged as a crucial research topic as a two-dimensional dielectric material with a large optical band gap, high thermal conductivity, chemical stability, and optical properties. These properties enable applications in advanced electronic and optoelectronic systems where insulating materials must maintain performance under extreme and aggressive environments.

Among the crystalline phases of boron nitride, h-BN (hexagonal boron nitride) and c-BN (cubic boron nitride) are most studied because of their distinct structures and performance features. Hexagonal BN has a layered structure like graphite, with strong covalent bonding within sheets and relatively weaker attractive forces between neighboring sheets. It is a material with high optical transmittance, a large band gap of about 6 eV, and good thermal stability, making it suitable for insulating layers and optoelectronic applications. The wide energy gap between the conduction and valence bands in h-BN crystals allows electromagnetic waves to penetrate, providing good optical transparency. Because of this wide energy gap, BN can serve as an insulating material in a circuit and provide strong support for electron movement without interfering with electron flow, enabling high electron transportability. Another typical application, based on the optical transparency of h-BN, is ultraviolet optical fields, as BN is also transparent in this range under specific fabrication conditions, enabling optical equipment (Roy et al., 2021). The c-BN is a diamond style with strong bonding as well with the characteristics of hardness, thermal conductivity and chemical immutability which makes it usable as advanced protection films and high-performance electronics (Abdullah et al., 2023; Artús et al., 2021; Bilal et al., 2020; Lan, 2023; C. Liu et al., 2022; Molaei et al., 2021; Roy et al., 2021; Singhal et al., 2021; Wang et al., 2023). Researchers have investigated C-BN largely in terms of its mechanisms and structure, whereas h-BN has been studied more for its optical, dielectric, thermal, and electrical properties. Although they have different structures and performance properties, both are useful because of their different natures. Therefore, current work has focused mainly on this material and its fabrication, especially on its direct bandgap property, with h-BN as the target.

With controlled composition, good film uniformity, and quality produced at a low deposition temperature range, RF magnetron sputtering is a method popular among many deposition techniques for thin BN film formation. With these advantages, BN thin films can be produced using RF power, with variations in gas pressure, gas composition, substrate bias, and deposition time. Producing BN films using RF sputtering has made them useful for optical

and electronic applications (Fan et al., 2020; Román et al., 2021; Yamamoto et al., 2023). During sputtering, insulating ceramics require radio-frequency excitation to maintain stable plasma operation; therefore, we used RF magnetron sputtering because BN is an insulating material. Energetic ions from the plasma bombard the target, transferring energy to the target material and causing ejection of species that deposit onto the substrate. Energy and flux of these species vary with RF power and other deposition parameters; thus, RF power is an important parameter that affects the growth rate, surface morphology, density, bonding configuration, defect concentration, and structural characteristics of the films.

Several previous studies have also shown that the microstructure characteristics of sputter-deposited films depend on the deposition parameters. Early work mainly focused on forming c-BN using RF magnetron sputtering. For example, c-BN was successfully deposited under certain deposition conditions by RF magnetron sputtering, emphasizing control of deposition rate and sputtering parameters to alter the coating structure. Ye & Oechsner (2006), for example, investigated the characteristics of sputtered h-BN and found that sputtering conditions influenced the deposition rate and the optical, structural, and mechanical properties of h-BN films. This type of research had a similar outcome: BN film performance was associated with microstructure characteristics derived from altered sputtering conditions. A recent study investigated h-BN growth and found that increased chamber pressure helped enhance the growth rate by reducing ion energy associated with ion bombardment (Roy et al., 2021). Investigations of boron-containing sputtered films also showed differences when deposition conditions were altered. Deposition and post-deposition conditions were correlated with the optical absorption and estimated optical band gap of the sputtered films (Zunger et al., 1976). Because properties vary with changes in experimental and growth conditions, further research is needed to fully understand the fundamental factors controlling BN film properties and their microstructure characteristics under varying deposition parameters. This implies that further study is needed to correlate deposition conditions with the optical response of BN-based films. Thus, the current work is justified to study sputtering parameters systematically.

RF power, one of the deposition variables of interest, is known to influence plasma density and the energy and flux of sputtered species reaching the substrate. This could affect the growth mechanism and the arrangement of atoms in the growing film, which is why it is worth examining in particular. Depending on growth conditions, varying the RF power can affect the density, structure, stoichiometry, or bonding arrangement within the resultant film, as well as the concentration of defects, all of which would then likely affect the position of the film's optical absorption band gap. Although interpreting the trend of changes in RF power with band gap is unlikely to be simple due to the dependence of the resulting optical properties it does appear likely that the film density and structure can influence so to keep all others growth conditions the same other factors such as the working pressure, the substrate temperature, gas composition and film thickness etc. constant to prevent variation from occurring in any other factor for the reason discussed above (it would of course in a real

process also be reasonable to include a substrate bias; it is hoped to introduce this in a later stage of research on the same system). To understand trends with different major parameters while keeping growth conditions constant is useful for clarifying the relationship between growth and the properties of the deposited material.

The optical band gap is a property of particular interest because it provides direct information about the electronic nature and the energy required for optical conversion. The wide optical band gap found for h-BN, for example, is directly related to its insulating property and can be used in applications where UV radiation is present and requires a high-energy optical environment. Structural disorder or defects, stoichiometry, crystallinity, film thickness, and deposition conditions, as mentioned earlier, may affect the measured optical band gap. Defects in h-BN can alter its electronic nature and optical response, potentially producing optical properties different from those of crystalline material, as shown in recent studies. Therefore, controlling deposition conditions is important to achieve reproducible results and understand variations in the optical band gap of the BN film.

Much research has focused on RF magnetron sputtering of BN thin films. However, the effect which varies power during the deposition only but on the same type of substrate (Si (100) wafer) under fixed growth conditions (room-temperature deposition on a Si (100) substrate, of the RF magnetron sputtered BN films) has never been reported for the optical band gap. All investigations have focused on deposition conditions and thin-film crystal structure. Yet the optical band gap value, and how to achieve the most optimized BN film value, have been poorly described. In particular, little effort has focused on systematically varying only the RF power while keeping the substratum, working pressure, deposition time, target composition, and other major deposition conditions constant, and then deriving the optical band gap. Since room-temperature deposition may suffer from the limitation of the surface mobility of the deposition species, which may affect the structural ordering, bonding, and the formation of defects in the deposition, such a systematic study under a controlled room-temperature environment may give useful information on how changes in the RF power may show a detectable change in the electronic and optical properties of the films.

This information could support further work on the possible use of BN thin films in dielectric applications and optoelectronics because of their low dielectric value, wide light-transmission range, and chemical and thermal stability. In addition, studying the effects of RF power could help identify optimum coating conditions with high reproducibility. A small change in RF power could significantly affect film properties if deposition is not controlled within optimal boundaries.

The current research could be further developed by correlating the effect of RF power on optical band gap with relevant structural, morphological, and chemical characteristics of the BN films. For this, X-ray diffraction, Raman spectroscopy, Fourier-transform infrared spectroscopy, X-ray photoelectron spectroscopy, and other methods could be used, as they provide additional information on crystallinity, B-N bonding, chemical composition, and possible alterations to the films' defect structure. Further studies could also investigate the

combined effects of RF power and other deposition processing parameters, such as working pressure, substrate temperature, gas composition, deposition time, and substrate bias. It could also investigate the effects of post-deposition annealing treatments to study how temperature affects the optical band gap and, possibly, the structural quality of the films in more detail. Therefore, these studies could provide a much greater understanding of the relationship between BN film processing parameters and the desired properties.

Thus, BN thin films were deposited at different RF powers to observe the effect of RF power on the optical band gap, characterized by UV-visible spectroscopy and optical band gap determination using the Tauc analysis method. This study aimed to determine whether changing the sputtering power would alter the electronic structure of BN thin films and whether they would emerge as good wide-bandgap dielectric and optoelectronic candidates. Hence, this investigates the influence of magnetron sputtering RF power on the optical band gap of BN thin films deposited on Si (100) substrates at room temperature. We investigated optical absorption in the deposited films, obtained absorption coefficient values from UV-Visible measurements, and then calculated the band gap using Tauc's plot. The bandgap values were compared across different RF powers to determine whether RF power significantly affects the optical band gaps of BN thin films. As such, their properties as possible choices for wide-band-gap dielectric and optoelectronic applications were observed.

Therefore, the final research question is:

- What effect does RF Sputtering power have upon the optical bandgap of boron nitride thin films on Si (100) at room temperature?"

METHOD AND MATERIALS

This study uses an experimental approach to examine the effect of RF magnetron sputtering power on the band gap of BN thin films. This subsection briefly describes the research design, research site, how the samples were prepared for study, how the data were collected (methods of data collection and tools), and how the data were analyzed.

Research Design

The experimental technique adopted here was carried out to study the effect of RF power during sputtering on BN thin films. BN was coated on a silicon wafer, which is known as a substrate. The deposition technique employed here is RF Sputtering. Radio Frequency Sputtering is a technique that allows us to coat uniform, stoichiometric, high-quality thin films under well-controlled process conditions. Here, in the experiment RF Power was chosen as a variable which affect the thin films and all other sputtering parameters (Substrate Temperature, pressure of the gases in chamber) remained constant so the experiment can be focused on determining the effect that can be cause by varying the RF power during sputtering in optical gap of BN Thin Films (Chng et al., 2020; Hasan et al., 2021; C. Liu et al., 2024).

Research Site

The experiments were performed using an RF magnetron sputtering system (13.56 MHz). The BN thin films were deposited under high vacuum onto silicon substrates. The BN films were then characterized using a UV-visible spectrophotometer over 200-800 nm (Rake et al., 2023; Singh, Sharma, Singh, et al., 2024; Singh, Sharma, Vasudev, et al., 2024).

Sample Preparation

For this work, we used (100)-side-polished Si wafers as thick as ~350 μm . Before deposition, the Si was cleaned ultrasonically in acetone, ethanol, and finally deionized water. All were used for 10 minutes to remove organic residue and particulates from the surface. Then, the Si wafer was flushed with high-purity N₂ gas to remove moisture and prevent surface oxidation before deposition (Kandadai et al., 2022). In sputter deposition, a high-purity target was typically used, made of h-BN. The BN disk was approximately 50.8 mm in diameter and 6.35 mm thick, with a certified purity of more than 99.5 percent. This target h-BN was selected for deposition by RF magnetron sputtering which gives more acceptable results. With the application of an h-BN material we can produce a wide-bandgap BN thin film that is useful due to its chemical stability.

Data Collection Procedure

The cleaned silicon substrates are loaded onto the substrate holder at a fixed target-to-substrate distance of 6 cm. To reduce any contamination during the film growth, the sputtering chamber is evacuated to a base pressure below 5×10^{-4} Pa by using a turbomolecular pump. Moreover, to create a constant flow, high-purity argon gas (99.999% pure) is introduced into the chamber where deposition of BN thin films is desired at 50 standard cubic centimeters per minute (sccm), and the working pressure rises to around 0.3 Pa, which is a constant and desired working pressure where the deposition of the film material will happen. BN thin films could then be grown by tuning the Radio frequency (RF) power to be 100, 130, 150, 170 and 190 W, whilst keeping all other growing parameters constant; the deposition duration was 30 minutes, working pressure had been 0.3 Pa, the gas flow rate was 50 sccm, the substrates distance was 6 cm and the process was under room temperature growth conditions during the deposition period, providing the only effect to have been created by power during the test, changing the optical properties of the deposited films.

Data Collection Tools

The optical properties of the deposited BN thin film were investigated as a function of wavelength using a UV-visible spectrophotometer in the wavelength range of 200-800 nm. From the measured transmission spectra, the optical band gap was estimated for each sample.

Data Analysis

The Tauc method using UV-Vis transmission was used to derive the optical band gap of each BN thin film. Tauc plots were obtained by plotting $(\alpha h\nu)^2$ versus photon energy ($h\nu$), as a direct allowed type electronic transition. The band gap was derived from the linear portion of the plotted graph, extrapolated to the photon-energy axis. By comparing the calculated band gap, it is known whether the sputtering power strongly affects the electronic structure of the BN thin film

FINDINGS

This section presents the optical properties of deposited BN thin films, with emphasis on variations in optical transmittance and optical band gap as sputtering RF power changes during deposition. These results are shown and discussed to explain how RF power affects the optical response of BN films.

Optical Transmittance

The transmission spectra of BN thin films deposited on the Si (100) substrate under varying RF powers (between 100 and 190 W) are shown in Figure 1. All samples transmit light over the visible range and show transmittance values over 80%. A steep band-gap absorption edge is observed in the UV region. These results are characteristic of large-bandgap hexagonal boron nitride (h-BN), indicating that the thin films prepared by this technique retain the desirable optical qualities of this phase.

The sudden drop in transmittance below 220nm is due to interband transitions upon exposure to high energy, which provides energy to transfer electrons from low- to high-energy bands. This edge corresponds to an energy of around 6.0eV, which is in good accordance with the reported optical band gap of h-BN. Further, this indicates that the BN films are low in defects and stoichiometric, as there is no significant absorption in the visible region due to light-scattering centers.

With little difference, as predicted, at varying RF powers and similar, almost overlapping curves, it can be assumed that increasing sputtering power from 100W to 190W had little influence on the optical transparency of BN films. This implies that, under the deposition conditions presented here, RF power influences deposition kinetics far more than the film's electronic structure. The constant optical response suggests that higher sputtering powers did not introduce significant structural defects or compositional changes that could alter light-absorption trends.

These results are in agreement with previous studies of RF-sputtered BN thin films. Deng Jin-Xiang et al. (2009) found similar values for the UV absorption edge and high transparency in the visible region for BN films deposited under varying RF sputtering power. Similarly, da Conceição Lorenzini (2007) found that the optical band gap was close to 6.0 eV and that its dependence on moderate variations in deposition parameters was relatively small. This agreement between the present optical characterization results of h-BN and previous

research shows that the optical properties of h-BN are mainly affected by its crystal structure and stoichiometry rather than by moderate changes in RF sputtering power.

The excellent optical transparency and stability in spectral characteristics obtained in these sputtered BN films suggest that room-temperature RF magnetron sputtering may find successful applications in fabricating BN thin films with reproducible optical quality for device applications such as dielectric coatings, optical components in ultraviolet region, protective coatings and wide bandgap optoelectrical devices working where high transparency and low optical loss are important (Wu et al., 2024b), (Fan et al., 2020; Lipp et al., 1989; L. Liu et al., 2006; Smith & Boyd, 2016).

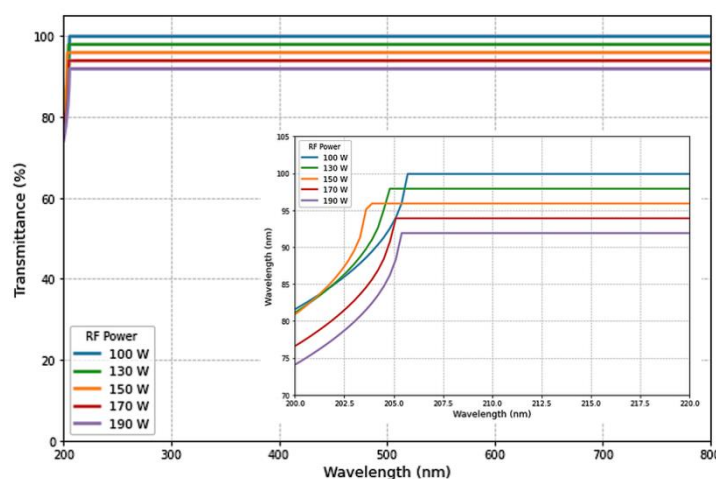


Figure 1. UV-Vis transmittance spectra of BN thin films deposited at different RF powers.

Optical Band Gap Analysis

The Tauc method for direct allowed electronic transitions, given by the following, will be used for the calculation of the optical band gap (E_g) of the deposited BN thin films.

$$(\alpha h\nu)^2 = A(h\nu - E_g)$$

Where α is the absorption coefficient, $h\nu$ is the photon energy, A is a material-dependent constant, and E_g represents the optical band gap. From the recorded spectra, the absorbance (A) values were converted to the absorption coefficient (α) using the relation:

$$\alpha = \frac{2.303A}{t}$$

where t is the film thickness.

The Tauc plot for the films grown at RF Powers of 100W, 130W, 150W, 170W, and 190 W are shown in Figure 2 (a-e). The linear portion of the curve was extrapolated on $(h\nu)$ axis to get the value of the optical band gap, where $(\alpha h\nu)^2 = 0$.

The calculated bandgap values are present in Table 1; values ranging from 6.03 - 6.09 eV, i.e., varied by approximately less than 0.06 eV respectively on varying sputtering power of RF sputtering unit, implies that it can be assumed that RF sputtering power does not affect the electronic structure of the BN film deposited at room temperature and the bonding

configurations of the deposited BN films do not vary even on increasing the sputtering power of the RF sputtering unit or the sputtering or the films are still phase pure since the values are fairly close to constant irrespective of raising the sputtering energy, usually the energy as compared to the RF power. With increased sputtering power, the energy and sputtering rate of the species increase; however, the results indicate that this is not sufficient to change the electronic structure of the BN films. Deng Jin-Xiang et al. (2009) have reported that bandgap values for sputtered BN films remained close to 6.0 eV in all cases.

Overall, the optical observations confirm the stability of deposition conditions. Room-temperature RF magnetron sputtering produced high-quality BN thin films with reproducible wide-band-gap properties, suggesting their potential as optically transparent dielectric materials with stable electronic properties.

Table 1. Optical band gap (E_g) of BN thin films deposited at various RF powers

RF Power (W)	Band Gap (eV)
100	6.04
130	6.09
150	6.05
170	6.03
190	6.06

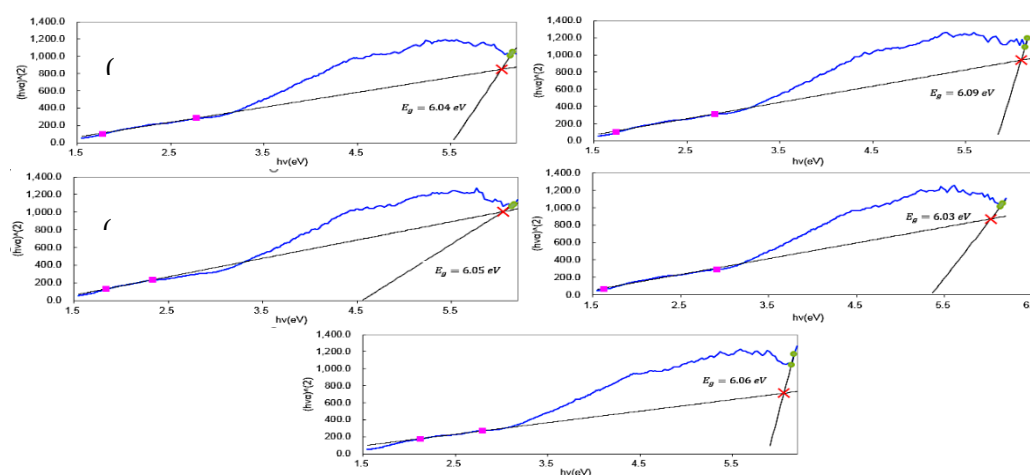


Figure 2. (a-e). Tauc Plots for BN films deposited at 100 W, 130 W, 150 W, 170 W, and

DISCUSSION

The results from samples produced at RF sputtering powers of 100 to 190 W at room temperature indicate a subtle influence of power variation on the material's optical bandgap (ranging from 6.03 to 6.09 eV). All films showed high optical transmittance (>80%) throughout the visible region, indicating that the optical properties of the BN thin films were stable despite small to intermediate variations in the RF power used to produce them. This suggests that RF power plays an insignificant role within the given range in controlling the electronic band structure of BN using this method, resulting in robust optical performance.

The stability of the optical band gap is attributed to the deposition conditions. Since no pre-heating or intentional heating of the substrate was done for any of the depositions, the

diffusion of the sputtered atoms on the surface would be less. Less surface movement restricts phase transformation and large structural rearrangement during film growth, so the bonding/bonding configuration and stoichiometric B: N ratio remain similar. There is not much change when RF sputtering power differs. The small band-gap difference of ~0.06 eV between samples is thus caused by small changes in film density, defect concentration, or local ordering rather than changes in crystal structure.

These results agree with previous studies. Yang et al. (2009) reported bandgap values close to 6.0 eV for RF-sputtered BN thin films deposited without substrate heating. They found that reasonable changes in sputtering power caused only limited changes in the films' optical properties. Similarly, Choi et al. (2023a) observed that increasing RF power below 200 W caused no significant changes in the optical band gap of BN films. At the same time, substrate temperature had a much stronger effect on the crystallinity and optical properties. From these studies, as well as the present one, we conclude that under low-temperature deposition conditions, RF sputtering power mainly affects deposition kinetics rather than the electronic structure of BN itself.

Ko et al. (2013) and Wicher et al. (2025) obtained similar conclusions. BN thin films show significant changes in their properties only with improvement in crystallinity, i.e., by increasing substrate temperature or post-deposition annealing. Thermal activation enhances diffusion, leading to crystal growth and defect removal, which is reflected in the optical band-gap changes they observed. Since this study did not include thermal treatment, film atoms likely did not rearrange to a great extent, and all RF power levels show similar optical properties.

The findings above are similar to previous reports; however, some studies reported a greater effect of sputtering power. Deng Jin-Xiang et al. (2009) observed a slightly reduced optical bandwidth when RF was greater than 200W, stating that this can be correlated with increased bombardment energy and modified bonding forms in the deposited film. This difference may again be due to the different deposition conditions, as the maximum power used was 190W and all depositions were carried out at room temperature. The deposition conditions are relatively mild, and the bombardment from the energetic particles does not play a significant role. It can be seen that only after a critical energy is reached, or when accompanied by high substrate temperatures, does RF power affect the optical properties of BN film.

The results show that RF magnetron sputtering is a stable deposition process for BN thin films, with reproducible optical properties over a wide range of sputtering powers. Its significance is that it allows engineers to moderately adjust RF power when they need to maximize deposition rate or process efficiency without sacrificing the large optical band gap required for dielectric coatings, as well as for ultraviolet optics and micro-electronic insulation layers. This process stability is favorable for the large-area thin-film fabrication required for industrial production.

Despite these encouraging results, the research has limitations. First, we focused on deposition at room temperature, while substrate heating and post-annealing were not investigated, and their effects on structural evolution and the film's optical properties remain unclear. Secondly, no structural or chemical characterization techniques were employed; these techniques include X-ray diffraction (XRD), Raman Spectroscopy, Atomic Force Microscopy (AFM), X-Ray Photoelectron Spectroscopy (XPS) and Transmission Electron Microscopy (TEM), which could yield important data as crystallinity information, surface morphology as measured by AFM, chemical bonding and density of defects and finally lead to a further understanding of the optical behaviour of film. Lastly, no electrical properties were examined (I will discuss electrical devices made from these films in the next blog series), so no correlation is possible between the measured optical properties and the potential electrical properties for device-fabrication applications.

More work is needed across a broader RF power range than 200W, where plasma-induced phenomena may become more prominent. Experiments involving substrate heating and post-annealing, along with more systematic microstructural analyses using other techniques, are needed to establish direct relationships between processing parameters and microstructure and optical behavior, thereby providing a clearer picture of the phenomena affecting the electronic and optical properties of BN RF-sputtered thin films.

From the above, it could thus be clearly observed that varying RF sputtering power over the range of 100-190 W has little effect on the optical band gap of the BN thin films that were deposited at RT on 100 Si. The measured band gap values were approximately 6.05 eV, confirming the excellent optical stability of the coated films. The effect of varying sputtering power over the range on the optical properties of the films can therefore be ruled out, as comparison with past work would clearly emphasize. Also, a previous study showed that other factors, such as substrate temperature and post-deposition thermal treatment, were more prominent. It could eventually be concluded that, for depositing high-quality BN coatings with wider band gaps for dielectric, protective coating applications and Ultraviolet optoelectronic devices, magnetron sputtering operating at room temperature would be a reliable technique.

CONCLUSION

The BN thin films were grown on Si (100) substrates using RF magnetron sputtering, at around room temperature within an RF power range of 100-190W. The grown films appear transparent in the UV/visible range. All films, as expected, show a nearly constant optical band gap (6.03-6.09 eV), averaging about 6.05 eV. This means the BN thin film's optical properties, and thus its electronic band nature, do not respond much to changes in RF sputtering power when the film is grown near room temperature.

The experiments thus answer the posed question: RF power, in this range, plays no major role in controlling the optical band gap of the sputtered BN films, and the optical response remained stable. This also suggests that the deposited films had roughly the same bonding

and stoichiometric structure during deposition. A comparison to previous papers also strengthens this. The results align with reports under similar low-temperature conditions, while higher substrate temperatures and/or RF power yield different behavior, highlighting that structure and resulting optical properties can change quickly due to slight variations in RF power from elevated substrate heating during growth.

Despite its interest, this study has significant limitations. Substrate heating, post-annealing, or a wider range of deposition power, and detailed structural or chemical characterization tools such as XRD, Raman, XPS, and AFM have not been performed. We must undertake this study in the future to fully account for the observed optical behavior by correlating it with microstructure.

The present study shows that BN thin films with reproducible wide-bandgap properties and excellent optical transparency can be routinely achieved by room-temperature RF magnetron sputtering, making the deposited films potential dielectric layers, ultraviolet optical components, and protective coatings for future electronic and optoelectronic devices.

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Author contribution

- Ahmad Sajad Nazari investigated and supervised the study.
- Ahmad Sajad Nazari analyzed the data and wrote the original manuscript.
- Mohammad Ajmal Khaishkai contributed to the manuscript's scientific development.
- Mohammad Rahim Sadeqi developed, revised, and critically edited the manuscript with input from all authors.
- All authors reviewed and approved the final version.

Conflict of interest

The authors declare no conflict of interest.

Data availability statement

Data are available upon request.

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