Synthesis of hexagonal BN on sapphire substrate via pulsed-mode MOCVD growth technique

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Recently, sp^2-bonded hexagonal boron nitride (h-BN) with unique two-dimensional (2D) graphite-like layered structure has attracted considerable attention due to many excellent properties, such as wide energy gap, high mechanical strength and good thermal conductivity, as well as good chemical and thermal stability [1]. These properties make h-BN a promising two dimensional (2D) dielectric material, well suited as a substrate and gate dielectric for novel electronics. Based on these potential applications, many efforts have been made to synthesize h-BN [2, 3]. However, deposition of h-BN on sapphire using pulsed-mode MOCVD technique has not been systematically investigated yet. In this work, we demonstrated direct deposition of 2D layered h-BN films on sapphire. The structure and surface properties of grown BN film under different growth conditions were investigated. The dependence of crystal structure and surface properties of grown BN film on growth parameters, including growth temperature, ratio of nitrogen and boron (N/B) and precursor injection and interruption times, are presented and discussed in detail. BN films were grown on 2-inch c-plane sapphire substrate in a horizontal reactor with hydrogen as carrier gas. In pulsed-mode epitaxy growth, triethylboron (TEB) and ammonia (NH_3), as B and N sources, respectively, are alternatively supplied into the reactor. A schematic of pulsed-mode growth was depicted in Fig.1. One growth cycle is composed of two steps: TEB ON (t_1) and NH_3 ON (t_2) without growth interruption. For the injection steps (ON steps), a fixed TEB flow of 60 sccm was supplied, and NH_3 flow were varied from 0.5 slm-4 slm. Moreover, growth temperature was changed at 1080 ℃–1380 ℃ and the reactor pressure was maintained at 29 Torr during the entire growth procedure. Depending on the growth conditions, the injection times (i.e., t_1 and t_2) were controlled as well. The improved quality of BN layer was grown at a higher growth temperature of 1380°C, as shown in XRD 2θ–ω scan in Fig.2. The observed peaks correspond to the (0002), (0004) BN planes and the (0006) sapphire plane. Meanwhile, wrinkle-like morphology was observed on BN surface by AFM in Fig. 3. Besides, the crystal structure of the grown BN and epitaxial relationship between BN and sapphire were also revealed in this study. Further discussion will be presented in the conference.

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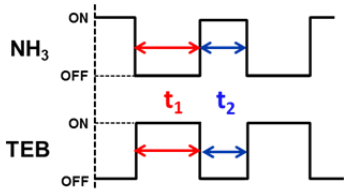

Figure 1.Schematic of TEB and NH_3 feeding in pulsed-mode growth.

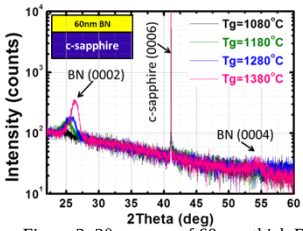

Figure 2. 2θ–ω scan of 60 nm-thick BN layers grown at different temperature.

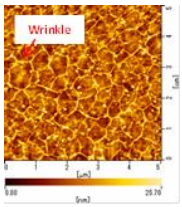

Figure 3. AFM image of 60 nm-thick h-BN