Growth Study of MOCVD-grown Hexagonal Boron Nitride on c-plane Sapphire and Performance in Volatile Threshold Switches

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Abstract

Hexagonal boron nitride (h-BN) is an interesting two-dimensional (2D) dielectric due to its wide bandgap (~5.9 eV), chemical stability, and atomically smooth surface, which makes it promising for energy-efficient electronic devices such as volatile memristive elements [1-3]. Achieving scalable and controllable synthesis of high-quality h-BN films on CMOS-compatible substrates remains a key challenge for integrating 2D materials into future technologies.

In this work, we investigate the metal-catalyst-free metal-organic chemical vapor deposition (MOCVD) of few-layer h-BN films on c-plane sapphire substrates using an industrial AIXTRON 6×2 inch (CCS®) cold-wall system. The h-BN films were deposited using triethylborane (TEB) and ammonia (NH_3) at temperatures of about 1280 °C. The influence of growth time, growth temperature, precursor ratio (NH_3 : TEB), as well as carrier gas for reactor atmosphere on film morphology, thickness, and stoichiometry was studied comprehensively by Raman spectroscopy, AFM, SEM, XRR, XPS, and conductive AFM. At a fixed precursor molar flow ratio of 1762, the growth rate of ~ 0.6 nm/h was observed, while XPS reveals an N:B ratio of the films which is smaller than one, confirming the formation of h-BN (Fig. 1a,b). The increase of NH_3 : TEB molar flow ratio leads to a decrease in the film thickness and the surface roughness, indicating the suppression of the 3D growth mode [4]. Changing the carrier gas from H_2 to N_2 leads to the deposition of h-BN films with increased thickness and decreased full width at half maximum of the E_{2g} peak, indicating an increase in crystallinity (Fig.1 c).

Different qualities of h-BN films obtained from the growth study were transferred and integrated into Ag/h-BN/Pt volatile resistive switching devices. Effects of the film microstructure on the device reliability will be discussed.

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References

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Figures

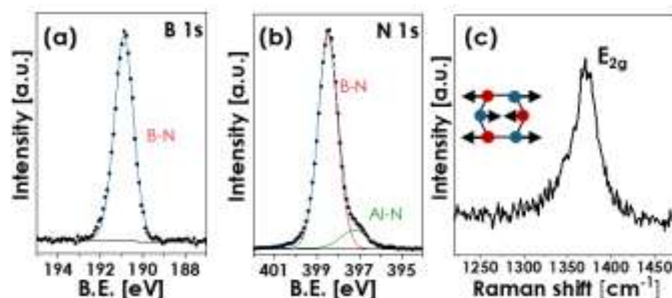

Figure 1: (a,b) XPS spectra of B 1s and N 1s, confirming the formation of h-BN; (c) Raman spectrum of as-grown h-BN on a sapphire substrate showing the characteristic E_{2g} peak.