

From amorphous to hexagonal Boron Nitride by Chemical Vapor Deposition of borazine

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Boron nitride (BN) has emerged as a highly promising material for current and next-generation electronic devices. Over the past decade, sp^2 -hybridized BN has established itself as a key component in the development of graphene-based optoelectronic systems, thanks to its excellent insulating properties and its minimal lattice mismatch with graphene.[1,2] More recently, amorphous BN (aBN) has garnered increasing attention, particularly due to its ultra-low dielectric constant of 1.16 – significantly lower than the value of 4.0 (at 1MHz) typically reported for hexagonal BN.[3] Notably, ultra-thin aBN films (e.g., 3nm-thick with $k=2$) have been successfully demonstrated as novel capping layers for copper interconnects, offering both low- k performance and compatibility with modern microelectronics architectures.[4]

To fully leverage BN's potential in electronics, optoelectronics, and spintronics, precise control over its structure – and therefore its properties – is essential.[5] Among the various thin-film deposition techniques, chemical vapor deposition (CVD) stands out as a versatile and widely adopted method, enabling the growth of high-quality BN films from a variety of precursors. In particular, borazine ($B_3N_3H_6$), a volatile compound with a 1:1 boron-to-nitrogen ratio, has proven to be highly effective for the CVD synthesis of sp^2 -BN, offering stoichiometric control and efficient deposition. Nevertheless, the underlying deposition mechanisms and the influence of key parameters (e.g., temperature, precursor flux, carrier gas, and substrate) on the film's structural and functional properties remain insufficiently understood.

In this study, BN films were deposited by borazine-based CVD on native oxide Si wafers under a range of conditions spanning 400°C to 1350°C, with systematic variation of parameters such as precursor flux and carrier gas type. The resulting films were extensively characterized using a suite of complementary techniques including ellipsometry, XRD, SEM, EDS, TEM, XPS as well as Raman and infrared spectroscopy.

Our results reveal that both borazine flux and deposition temperature play crucial roles in determining film morphology, crystallinity, and chemical bonding. The data suggest a competition between two principal reaction pathways: (1) polycondensation of borazine into oligomeric species, and (2) thermal decomposition into reactive fragments such as BH_3 and NH_3 . the dominance of one mechanism over the other is strongly influenced by the specific CVD conditions, thereby dictating the final film structure. Based on these findings, a proposed reaction mechanism is presented to explain the observed trends.

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References

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