MOCVD Technology for Wafer-Scale Growth of 2D Materials

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Two-dimensional (2D) layered materials, with their unique properties at monolayer thickness, have the potential to address the scaling and performance limitations of current semiconductor technology and to enable novel "beyond Moore" applications. To realize these applications, substantial progress is needed in the synthesis and integration of 2D materials. Especially, achieving wafer-scale growth uniformity and reproducibility is crucial for the reliable and consistent performance of 2D materials devices at the circuit level.

Here, we report on the latest advancements in the synthesis of transition metal dichalcogenides (e.g. MoS_2) and hexagonal boron nitride (hBN) on substrates up to 300 mm using a Close Coupled Showerhead® (CCS) MOCVD system. One advantage of AIXTRON MOCVD technology is the use of in situ techniques, including pyrometry and reflectometry for 2D growth optimization and statistical process control. For process optimization and quantitative uniformity assessment, we introduce metrology and post-processing standards for evaluating the preparation of epitaxial substrates prior to 2D growth, as well as 2D grain size and orientation distribution on sapphire substrates (**Figure 1**). Additionally, we demonstrate the controlled synthesis of multilayer hBN, which is being explored as an active material in memristor applications and sought for dielectric integration, retaining a clean interface with other materials. To efficiently assess hBN films on wafer-scale, we developed a method for evaluating layer thickness using spectroscopic ellipsometry, accounting for stress-induced changes in the optical properties of the epitaxial hBN film on foreign substrates (**Figure 2**).

Overall, the presented developments in MOCVD technology and processes pave the way for the reliable integration of 2D materials into next-generation (opto)electronic devices.

Figures

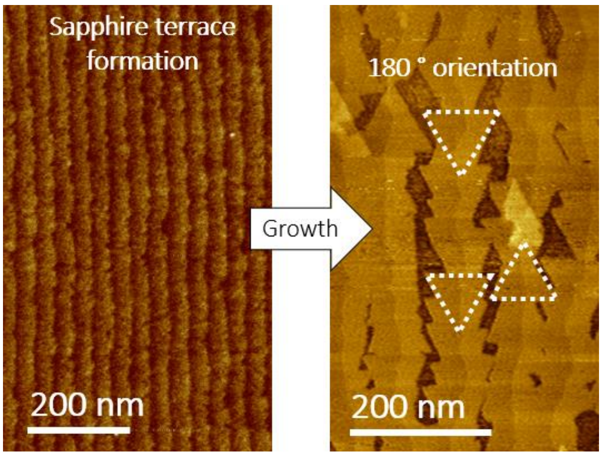

Figure 1: Sapphire terraces (left) and MoS_2 grains after the MOCVD growth process (right). The white triangles indicate bi-oriented grains with 180° angular difference.

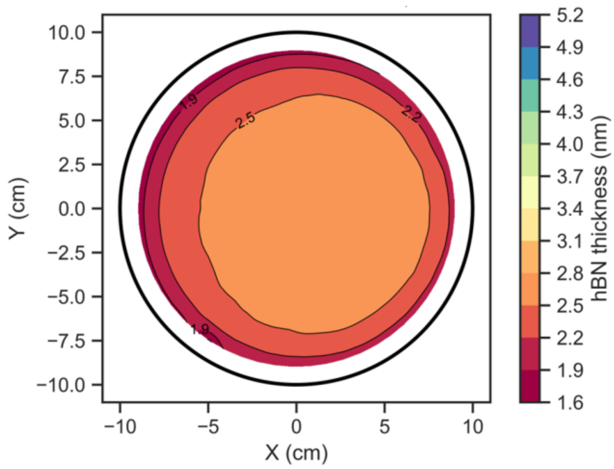

Figure 2: Ellipsometry thickness mapping of hBN on 200 mm sapphire.