# A Scalable PEALD Platform for Dielectric Integration in 2D Electronics

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The development of high-performance nanoelectronic devices based on two-dimensional (2D) materials is strongly limited by challenges in integrating scalable, low-defect dielectric layers. Conventional amorphous oxides optimized for silicon technologies often result in poor interface quality or even material damage when deposited on 2D materials [1,2]. While hexagonal boron nitride is frequently explored as an alternative dielectric, its reduced dielectric performance, restricted availability, and reliance on transfer-based processing limit its suitability for large-scale device fabrication.
We present a fully in-situ dielectric integration approach using plasma-enhanced atomic layer deposition (PEALD) implemented on an Oxford Instruments platform [3,4]. The process begins with a low-dose plasma treatment to gently clean and prepare the 2D material surface, followed by an initial low-dose plasma-assisted dielectric growth step that minimizes damage and protects the underlying 2D material (Figure 1). Subsequent deposition enables the formation of dielectric films with controlled thickness and high uniformity. This sequential method preserves the intrinsic structural and electrical properties of the 2D layers while ensuring a clean interface with minimized process-induced contamination through the elimination of ex-situ surface treatments and careful optimization of deposition conditions for 2D materials. The process is also compatible with temperature-sensitive device architectures. Compared to conventional approaches, this method can provide measurable improvements in interface quality and dielectric integration. By enabling more reproducible dielectric formation under controlled conditions, it represents an important step toward the reliable fabrication of 2D-material-based nanoelectronics.

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References

[1] Y. Illarionov et al., Nat Commun, 11 (2020) 3385
[2] M. Lemme et al., Nat Commun, 13 (2022) 1392
[3] H. Knoops et al., J. Vac. Sci. Technol. A, 6 (2021) 062403
[4] S. Riazimehr et al., Mater. Sci. Semicond. Process., (2025) 109829

Figures

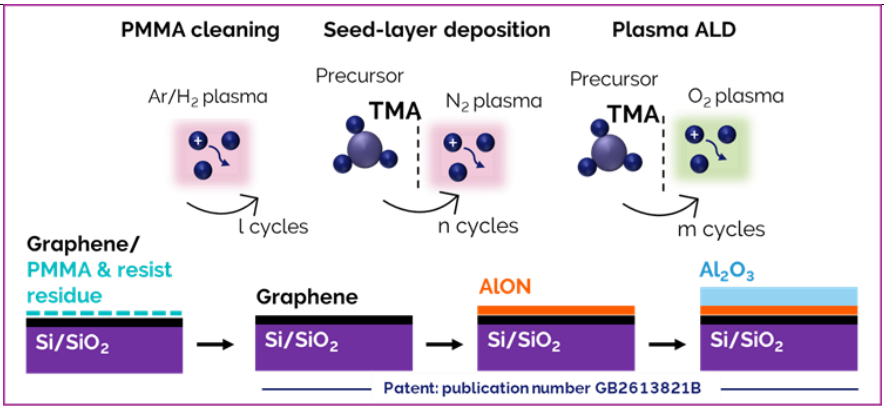


**Figure 1:** Schematic illustration of the process applied to 2D materials (here, graphene) showing the initial cleaning step to remove PMMA and resist residues using low-dose $H_2$ and Ar plasma, followed by the deposition of a protective layer via low-dose $N_2$ and Ar plasma, and concluding with high-quality dielectric deposition.