Damage Free Deposition of High-κ Dielectrics on Graphene using Plasma-enhanced ALD

Sarah Riazimehr[1]
Harm Knoops[1], Ardeshir Esteki[2], **Katie Hore**[1], Gordon Rinke[3], Martin Otto[3], Zhenxing Wang[3], Max C. Lemme[2,3]
1) Oxford Instruments Plasma Technology UK, North End, Yatton, Bristol, United Kingdom
2) Chair of Electronic Devices, RWTH University, Otto-Blumenthal-Str. 2, Aachen, Germany
3) AMO GmbH, Otto-Blumenthal-Str. 25, Aachen, Germany
katie.hore@oxinst.com

Integrating graphene with high-quality dielectrics is crucial for the development of graphene-based electronics and photonic devices. However, the deposition of high-quality dielectrics on graphene is challenging, as it can introduce defects onto the graphene lattice, which can negatively impact the electronic and optical properties. In this work, we describe a novel method to deposit high-κ dielectrics on graphene through an in-situ-prepared protective aluminium nitride (AlN) seed-layer, using an Oxford Instruments Atomfab™ plasma ALD system. Short, low power process steps with remote plasma conditions[1] were applied to directly grow a thin layer of AlN on graphene, followed by the deposition of aluminium oxide (Al_2O_3) (Fig. 1). The effect of dielectric deposition onto graphene was studied by Raman spectroscopy. A statistical analysis of the I_D/I_G peak intensity and the full-width-half-maxima (FWHM) of the I_{2D} peaks indicate that the process damage was negligible across the entire 6-inch wafer (Fig. 2). In this process, the AlN seed-layer protects the graphene effectively and creates functional groups, enabling plasma assisted deposition of high-quality thin dielectrics without damaging the graphene. Our proposed technique can tackle one of the important challenges for transferring graphene-based electronics from laboratory to industrial production by providing a precise, reliable, and scalable method for depositing thin films on graphene.

This project has received funding from the European Union's Horizon 2020 research and innovation program 2D-EPL (952792)

References

[1] H. Knoops et al., J. Vac. Sci. Technol. A, 39(6), 2021

Figures

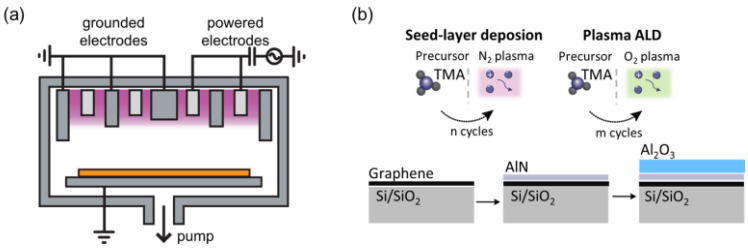

Figure 1: (a) A side view schematic of Atomfab's plasma source [patent application PCT/GB2019/052763]. (b) Process scheme of AlN seed-layer deposition and Al_2O_3 plasma ALD.

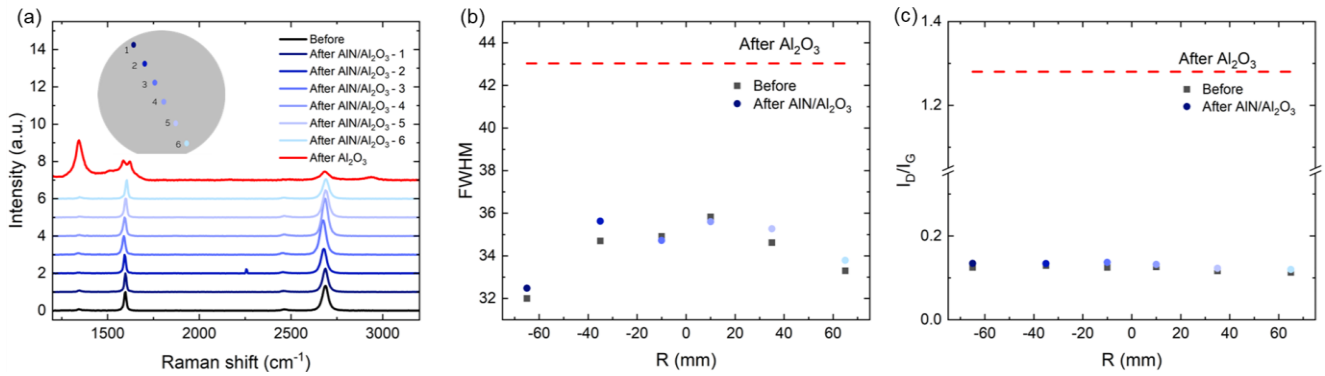

Figure 2: (a) Raman spectra, (b) I_D/I_G Ratio and (c) FWHM (2D) across the wafer radius (R) (inset) for Gr/SiO_2/Si wafers before and after Al_2O_3 deposition, with (different shade of blue) and without (red) AlN seed-layer. Example data without seed-layer is from previous deposition run and experiment.