Highly conformal high-k dielectrics integrated with graphene on off-axis 4H-SiC for next-generation high-frequency and power devices

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Two key challenges to efficiently integrate graphene-based high frequency devices with Silicon Carbide power-electronics are (i) the formation of uniform epitaxial graphene (Epi-Gr) on off-axis 4H-SiC wafers and (ii) the growth of conformal high-k insulators on the inert Gr surface [1]. In this work, uniform and large-area 1L-2L Epi-Gr on 4°-off 4H-SiC(0001) has been obtained by an optimized high-temperature (1825°C) annealing in Ar ambient within a furnace compatible with 200 mm wafers. Furthermore, plasma-enhanced atomic layer deposition (PEALD) of Al_2O_3 with an AlON seeding layer [2] enabled the growth of a very thin (~8 nm) high-k film, highly conformal with Epi-Gr residing on the steps typical of off-axis SiC, as demonstrated by AFM and TEM analyses (Fig.1(a)-(c)). Interestingly, Epi-Gr crystalline quality was preserved during this PEALD process, with an increase of Epi-Gr compressive strain (from ~0.1% to ~0.4%) and slight reduction of n-type doping due to the deposited dielectric film, as deduced by Raman mapping and the correlative 2D vs G plot in Fig.1(d). Very good insulating properties of this high-k film onto Epi-Gr/SiC have been demonstrated by current mapping at different voltages using C-AFM (Fig.1(e)-(f)), indicating a breakdown field of 9-10 MV/cm. The demonstrated scalable approaches pave the way to the development of new Epi-Gr/SiC devices monolithically integrating RF and power conversion functionalities.

This work was supported by the WBG Pilot Line (G.A. 101183211), jointly funded by Chips-JU, through the Digital Europe and Horizon Europe programmes, as well as by the participating states Italy, Sweden, Poland, Finland, Austria, France and Germany.

References

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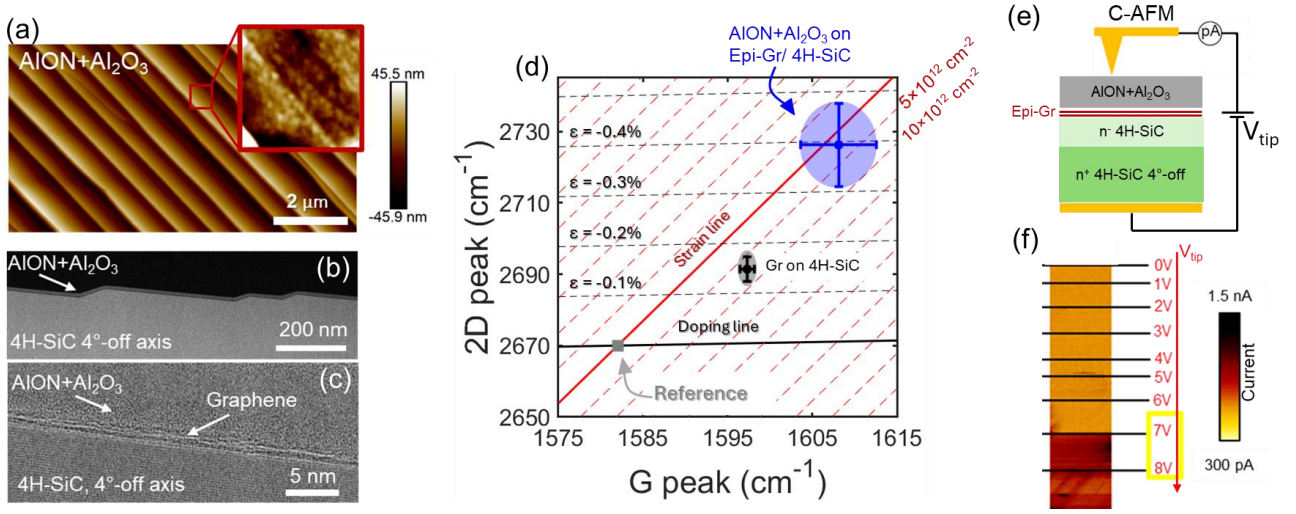

Figure 1: (a) AFM, (b) large view HAADF-STEM and (c) high-resolution ABF-STEM of the PEALD grown AlON+Al_2O_3 film (~8 nm) onto 1L-2L Epi-Gr on 4°-off 4H-SiC. (d) Correlative 2D vs G Raman plot, showing the impact of ALD deposition on the strain and doping of Epi-Gr. (e) C-AFM setup and (f) current map at increasing tip bias, indicating a breakdown field of the dielectric of 9-10 MV/cm.