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Enhanced Breakdown Reliability and Spatial Uniformity of Atomic Layer Deposited High-k Gate Dielectrics on Graphene via Organic Seeding Layers VINOD SANGWAN, DEEP JARIWALA, STEPHEN FILIPPONE, HUNTER KARMEL, JAMES JOHNS, JUSTICE ALABOSON, Department of Materials Science and Engineering, Northwestern University, Evanston, Illinois 60208, TOBIN MARKS, Department of Chemistry and Materials Science and Engineering, Northwestern University, Evanston, Illinois 60208, LINCOLN LAUHON, Department of Materials Science and Engineering, Northwestern University, Evanston, Illinois 60208, MARK HERSAM, Department of Materials Science and Engineering, Chemistry and Medicine, Northwestern University, Evanston, Illinois 60208 — Ultra-thin high-κ top-gate dielectrics are essential for high-speed graphene-based nanoelectronic circuits. Motivated by the need for high reliability and spatial uniformity, we report here the first statistical analysis of the breakdown characteristics of dielectrics grown on graphene. Based on these measurements, a rational approach is devised that simultaneously optimizes the gate capacitance and the key parameters of large-area uniformity and dielectric strength. In particular, vertically heterogeneous oxide stacks grown *via* atomic-layer deposition (ALD) seeded by a molecularly thin perylene-3,4,9,10-tetracarboxylic dianhydride (PTCDA) organic monolayer result in improved reliability (Weibull shape parameter $\beta > 25$) compared to the control dielectric directly grown on graphene without PTCDA ($\beta < 1$). The optimized sample also showed a large breakdown strength (Weibull scale parameter, $E_{BD} > 7$ MV/cm) that is comparable to that of the control dielectric grown on Si substrates.

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