Encapsulating-layer-assisted transfer for fabricating two-dimensional material devices with ultrahigh carrier mobility and long-term stability

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The wafer-scale fabrication of two-dimensional (2D) materials with excellent performance, uniformity, and long-term stability is crucial for the future electronics applications. However, the lack of techniques for transferring 2D materials onto application-specific substrates and efficiently encapsulating 2D materials against airborne contamination still leads to variations in the reported devices' performances, such as carrier mobility. Here we report an integrated method for transferring and encapsulating 2D materials simultaneously using inorganic molecular crystal Sb_2O_3, which exhibits a uniformly strong interaction with 2D materials to avoid crack and wrinkle formation during the transfer. The clean interface and efficient encapsulation by Sb_2O_3 facilitate the highly improved device performance across 4-inch wafers with a maximum carrier mobility of 29,000 cm^2 V^{-1} s^{-1} and an average carrier mobility of 14,000 cm^2 V^{-1} s^{-1}, which is higher than previously reported values. This study offers a reliable method for fabricating wafer-scale 2D material devices with outstanding device yield and satisfactory performance, and indeed propels advancements in electronic applications of 2D materials.

Figures

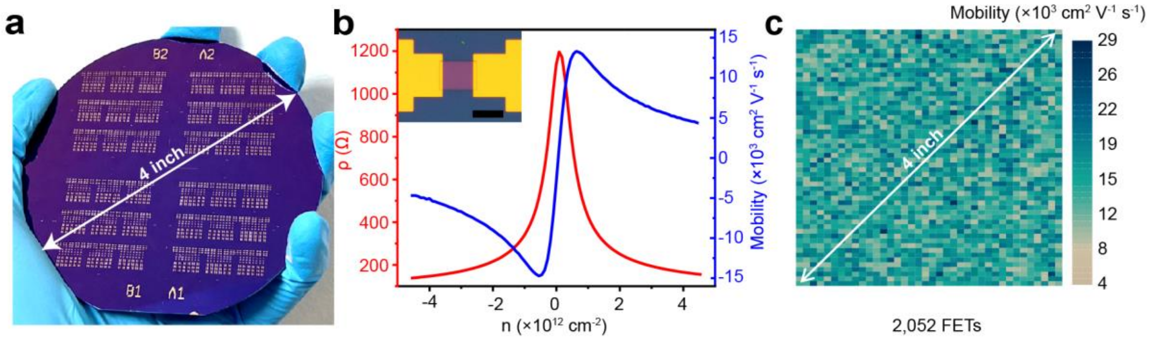

Figure: **a**, Photograph of the graphene FET arrays over an entire 4-inch wafer. **b**, Representative transfer curve of graphene device encapsulated by Sb_2O_3, with measured channel resistance (red) and extracted carrier mobility (blue). Inset: Corresponding OM image of measured graphene device. Scale bar, 20 μm. **c**, Mapping of the extracted carrier mobilities across the entire wafer.