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Emerging 2D Xenes for Innovative Nanoelectronics

Two-dimensional (2D) Xenes (monoatomic sheets, e.g. silicene and phosphorene) have collective properties of mechanical flexibility and tunable bandgap holding great promise for novel nanoelectronics beyond graphene. Nonetheless, there is a challenge in experimental device studies largely due to air-stability related material and process issues. This talk highlights state-of-the-art experimental progress in synthesis, stabilization and device integration of monolayer silicene and thicker derivatives. With a unique sandwich encapsulation process, we enabled silicene transistor debut[1]. By tuning integration process and number of layers[2], we further improved portability and reliability. Electrostatic characteristics of silicene field-effect transistor exhibits ambipolar charge transport with extracted mobility 100-200 cm^2/V-s at residual carrier density ~8×10^9 cm^{-2}, corroborating with theoretical predictions on Dirac cone in band structure. The electronic structure of silicene is expected to be sensitive to substrate interaction, surface chemistry, and spin-orbit coupling, holding great promise for a variety of novel applications, such as topological bits, quantum sensing and energy devices[3]. We applied above strategy to phosphorene, few-layer black phosphorus, and demonstrated mobility 310-1500 cm^2/Vs, gate modulation 10^{3-5} and intrinsic f_T=20 GHz on flexible polyimide substrates[4, 5]. Recent progress on silicene and phosphorene (transferable to other Xenes like stanine and germanene) represent a renewed opportunity for future nanoelectronics complementary to what is available in graphene[6].

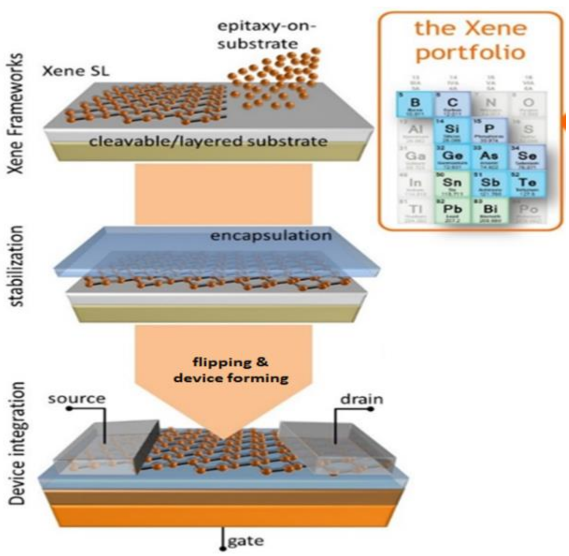

Figure: Xene device integration.

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