Generating extreme electric fields in 2D materials by dual ionic gating

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We demonstrate a new type of dual gate transistor to induce record electric fields through two-dimensional materials (2DMs). At the heart of this device is a 2DM suspended between two volumes of ionic liquid (IL) with independently controlled potentials. The potential difference between the ILs falls across an ultrathin layer consisting of the 2DM and the electrical double layers above and below it, thereby producing an intense electric field across the 2DM. We determine the field strength via i) electrical transport measurements and ii) direct measurements of electrochemical potentials of the ILs using semiconducting 2DM, WSe_2. The field strength across a bilayer WSe_2 sample reaches ~2.5 V/nm, the largest static electric field through the bulk of any electronic device to date. Our approach grants access to previously-inaccessible phenomena occurring in ultrastrong electric fields.

Figures

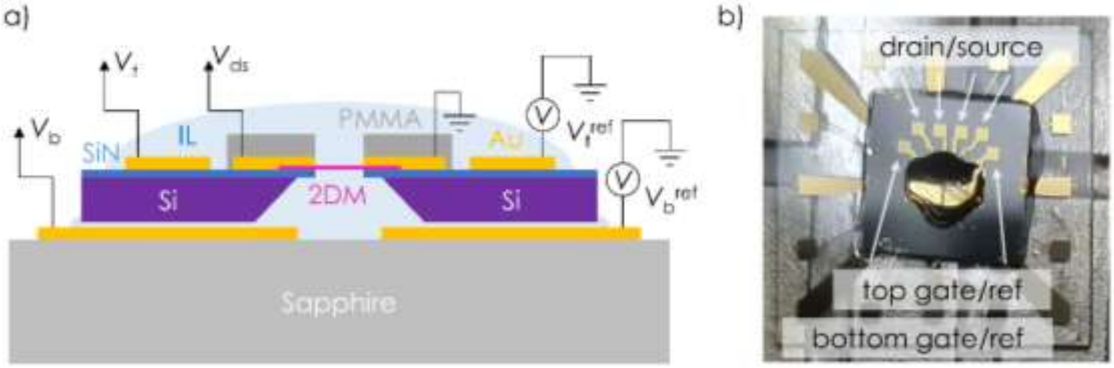

Figure 1 Dual ionic liquid gate device and measurement overview. a) Side-view cartoon of the device and measurement scheme. **b)** Photograph of a device just before measurement.

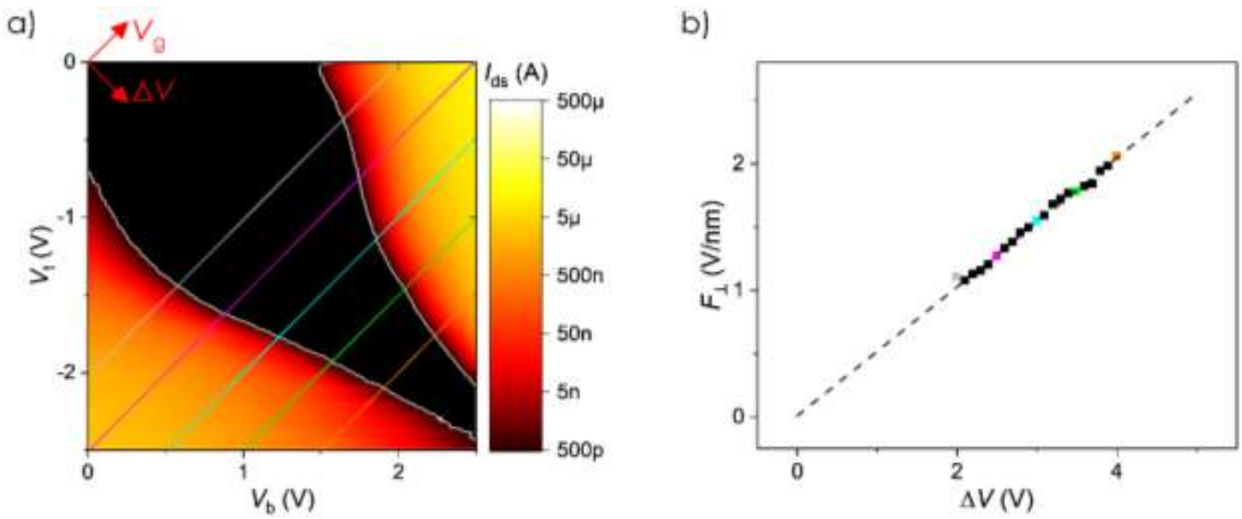

Figure 2 Transport measurement of dual ionically-gated bilayer WSe_2. a) Map of I_{ds} vs. (V_b, V_t) for bilayer WSe_2. As the perpendicular electric field, $F_\perp$ (controlled by $\Delta V = V_b - V_t$), increases, the bandgap shrinks. Each colored line represents constant ΔV from 2 V (gray) to 4 V (orange). **b)** Calculated $F_\perp$ vs. ΔV from the map in *a*). The field should depend linearly on ΔV, so we form a fit to the data (dashed line). The colored dots correspond to the lines of constant ΔV in *a*). The largest ΔV we apply in the map is 5 V, where the fit shows that we reach a perpendicular field of ~2.5 V/nm.