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Strong Electron-ion Coulomb Coupling in Layered Indium Selenide Field-Effect Transistors with Ionic Liquids

Abstract
Two-dimensional (2D) semiconductors feature high surface-to-volume ratio, offering an ideal platform for exploring unique surface and interfacial interactions [1]. An ionic liquid (IL) can be used in an electrostatic gating technique for effectively achieving high carrier density regime in 2D semiconductors by creating an electric double layer (EDL) at the semiconductor/IL interfaces [2-3]. Commonly, the EDL arises when an IL gate voltage is applied and charged ions accumulate at the interface. However, it is rarely discussed how the tuning of the charge carrier density confined in atomically thin layers of the 2D semiconductors can alter the electrostatic coupling between charge carriers and ions at the solid/liquid interfaces. In this work, we systematically studied the electrostatic coupling at the interface between the layered indium selenide FETs and the IL. An anomalous temperature dependence of the transport behaviour was observed when the IL undergoes the phase transition. Interestingly, the field-effect mobility of the InSe devices interfaced with the IL enhanced when the IL is around glass transition point. This phenomena can be attributed to a strong electron-ion Coulomb coupling when ion motion is significantly decrease around glass transition point. This distinctive effect in the InSe devices thus suggests novel functionalities to control the Coulomb coupling in the 2D-semiconductor/IL hybrid systems.

References

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Figures

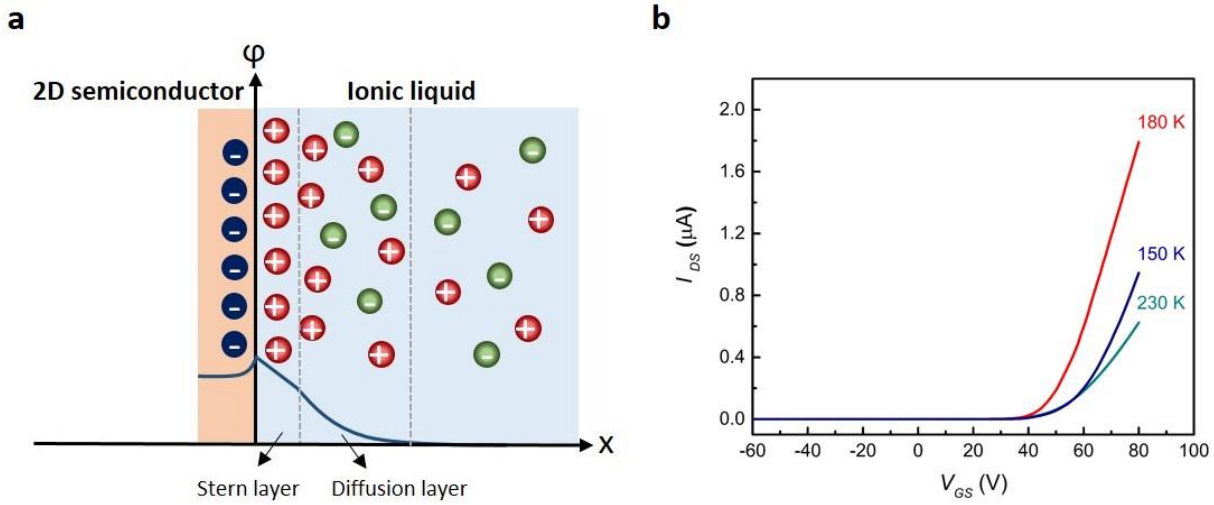

Figure 1: (a) A schematic illustration of the 2D-semiconductor/IL interface, showing the Stern layer and diffusion layer in the IL regime. (b) Temperature dependent transfer characteristics for an InSe FET with the IL when the IL is at T=230 K, 180 K, and 150 K.