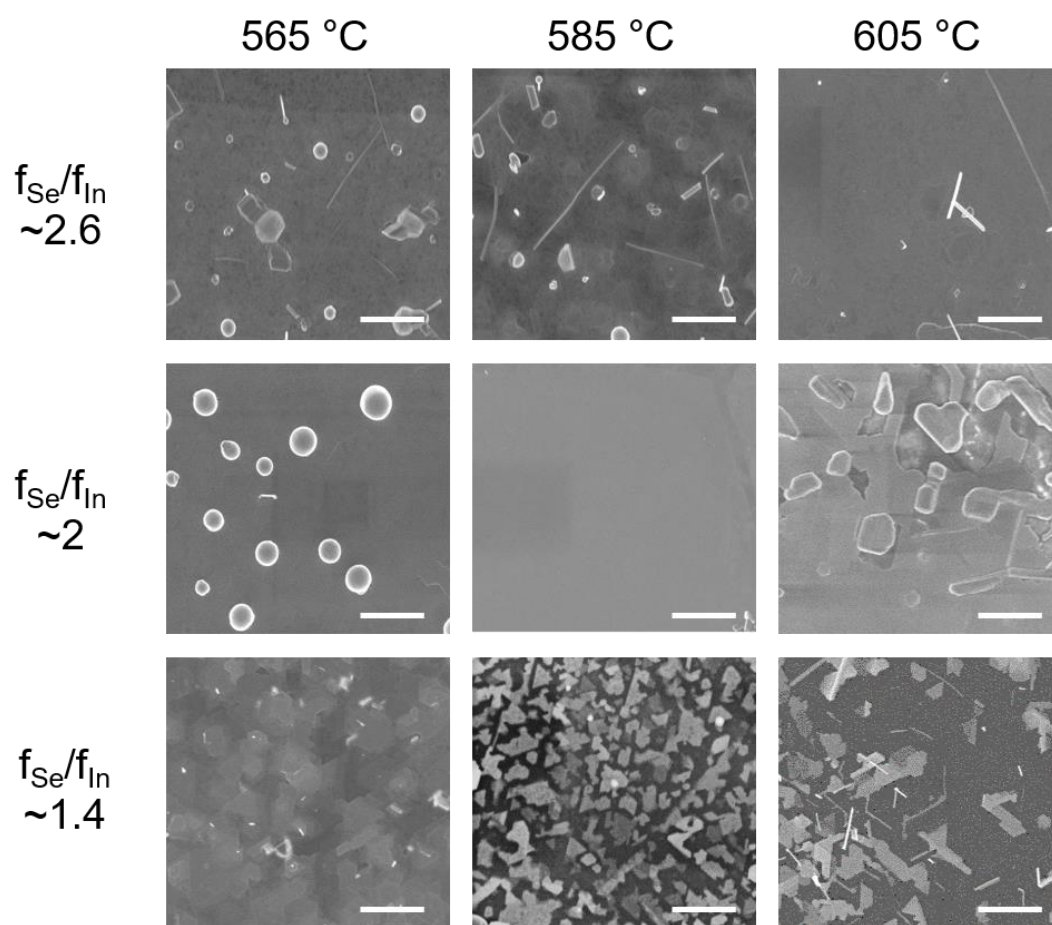
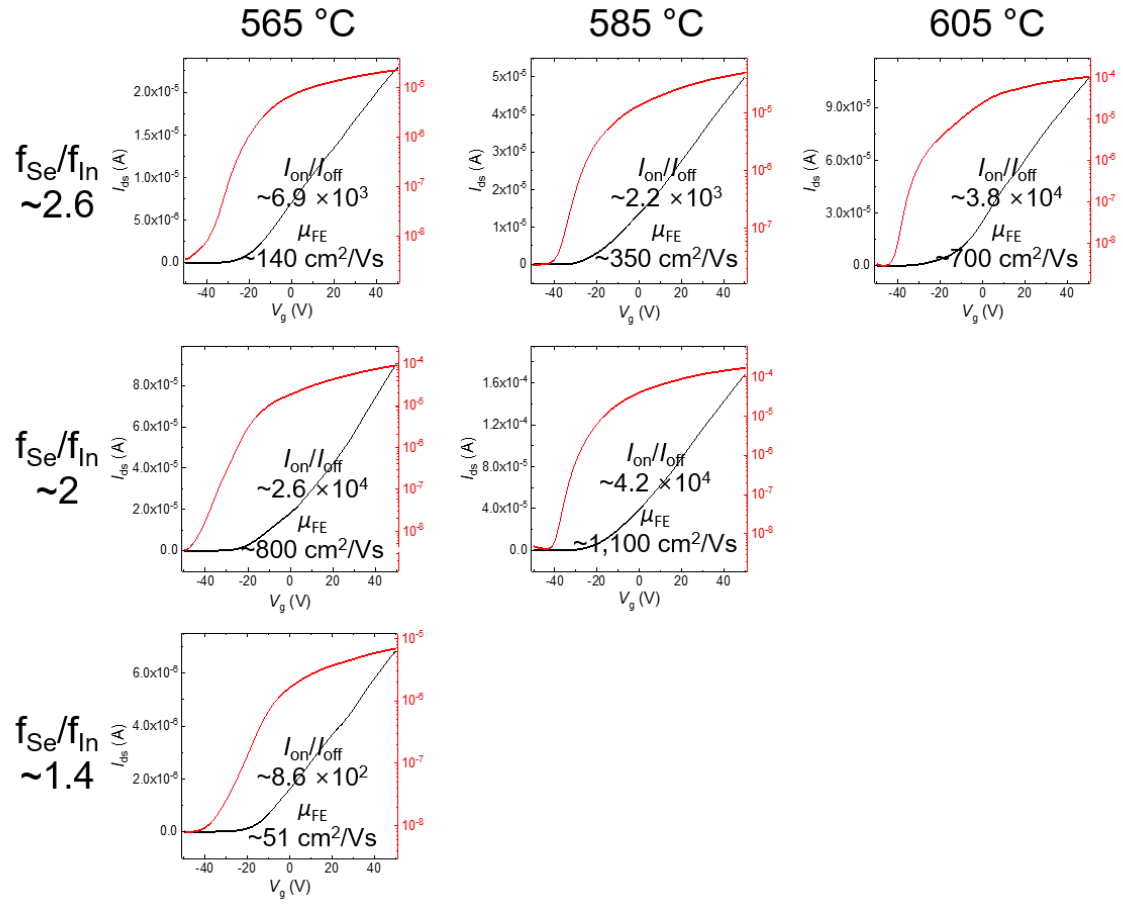
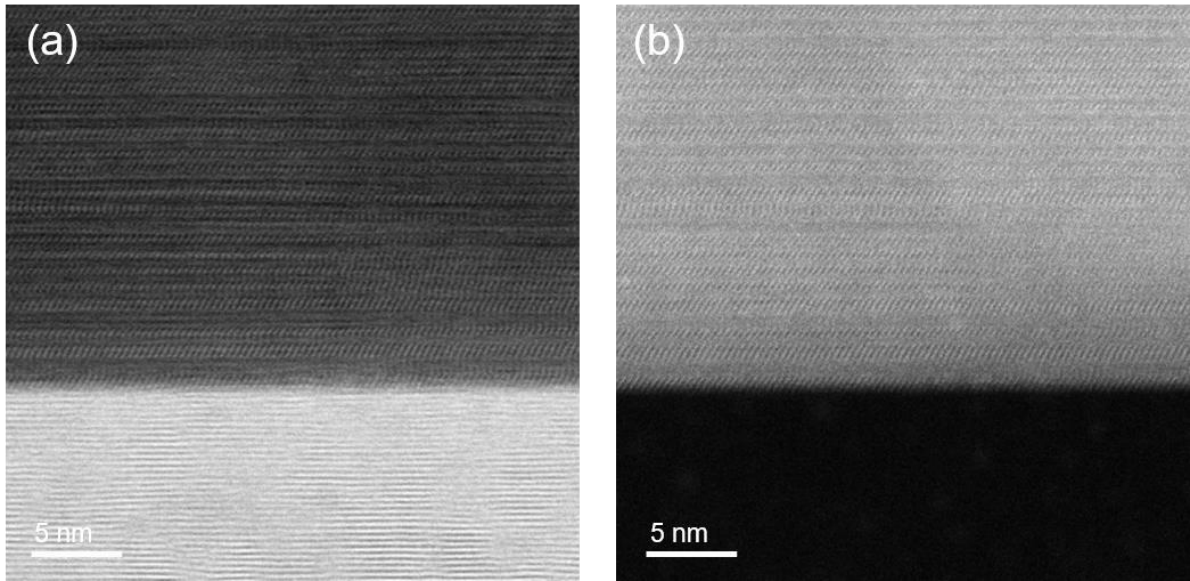




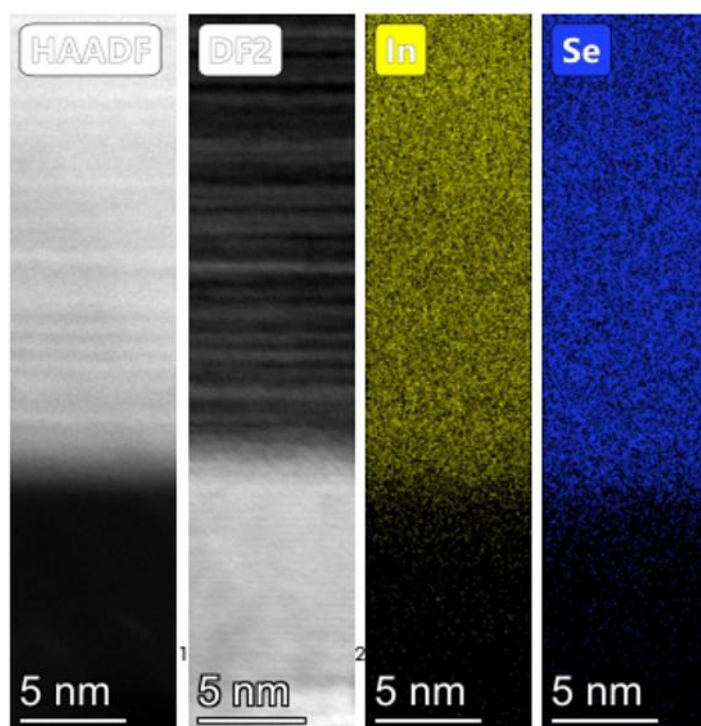
Supplementary Fig. 1. SEM images of InSe grown on *h*-BN at different Se/In flux ratios (~ 2.6 , ~ 2 , and ~ 1.4) and growth temperatures (565, 585, and 605 °C). A smooth, continuous film is obtained only at $f_{\text{Se}}/f_{\text{In}} \sim 2$ and 585 °C. Scale bars: 500 nm.



Supplementary Fig. 2. Transfer characteristics of InSe FETs fabricated from films grown at different $f_{\text{Se}}/f_{\text{In}}$ flux ratios (~ 2.6 , ~ 2 , and ~ 1.4) and growth temperatures (565, 585, and 605 °C). The field-effect mobility and on/off ratio extracted from each device are indicated.

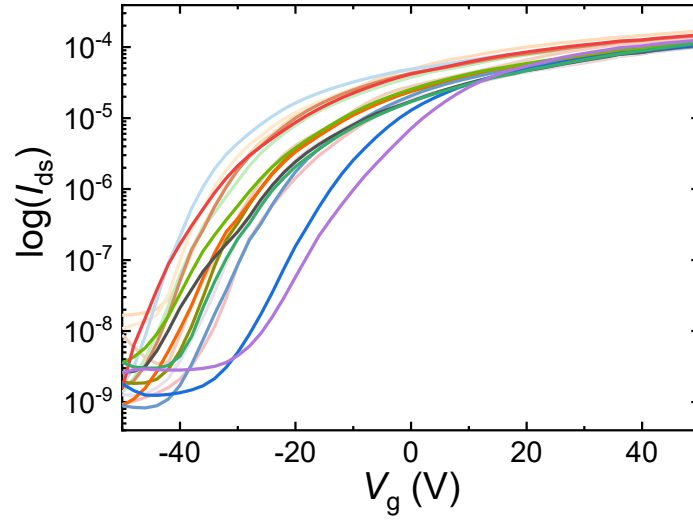


Supplementary Fig. 3. High-resolution STEM image. (a) Annular bright-field (ABF). (b) High-angle annular dark-field (HAADF) scanning transmission electron microscopy (STEM) image showing a clean interface between InSe and *h*-BN.

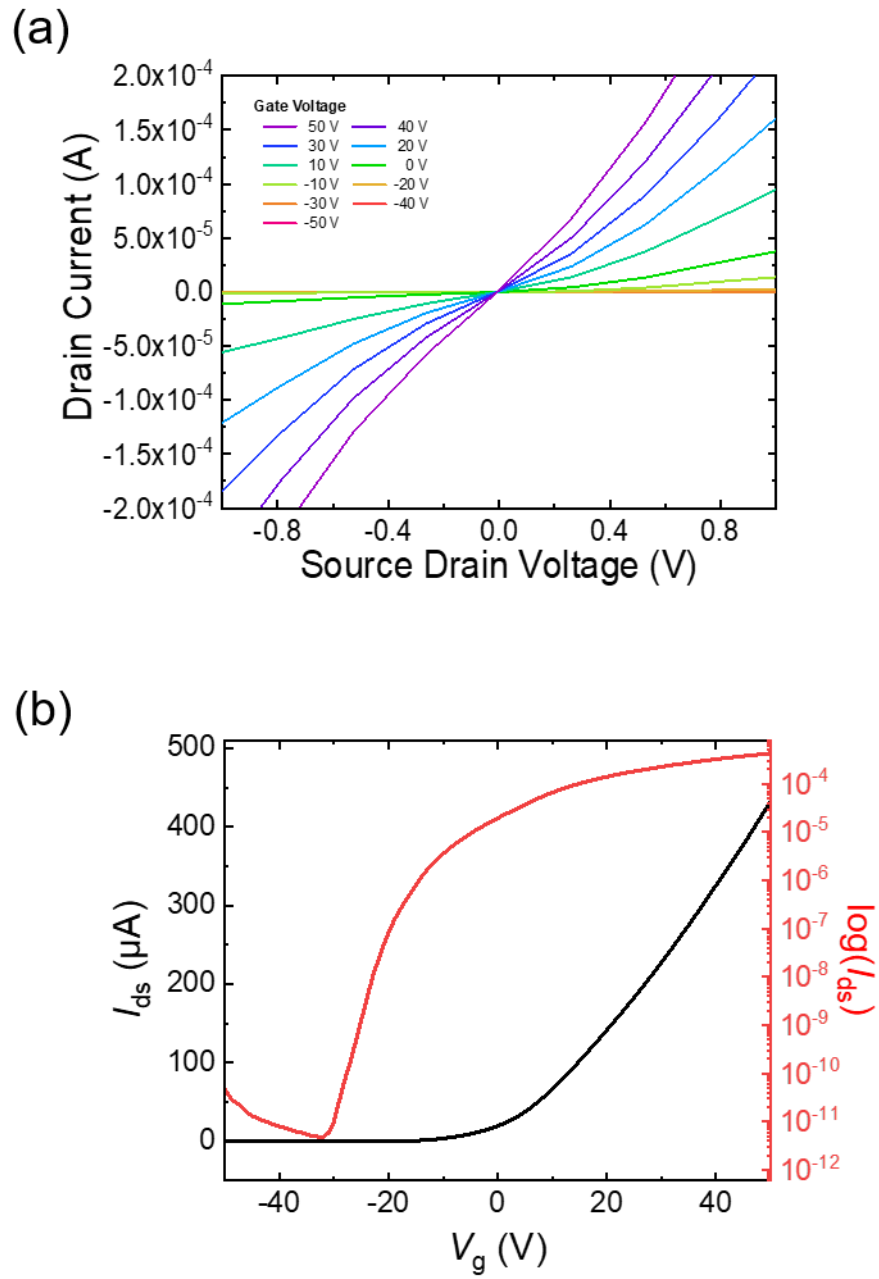


Supplementary Fig. 4. Cross-sectional STEM-EDX image of InSe on *h*-BN.

Supplementary Fig. 4. presents a cross-sectional HAADF-STEM image together with corresponding EDX elemental maps of the InSe/*h*-BN heterostructure. The EDX elemental maps show that the In and Se signals are primarily localized within the bright HAADF region, whereas no apparent diffusion of these elements into the *h*-BN region is observed within the experimental resolution. Although the EDX mapping was acquired with a reduced dwell time to minimize beam-induced damage, the observed elemental distributions are consistent with an abrupt InSe/*h*-BN interface, supporting the formation of a chemically clean heterointerface.



Supplementary Fig. 5. Semilogarithmic transfer characteristics of all 17 InSe FETs included in the statistical analysis of field-effect mobility and on/off ratio (Figures 3d and 3e). All curves were measured at $V_{ds} = 1$ V at room temperature.



Supplementary Fig. 6 Low-temperature electrical characteristics of the InSe FET measured at 40 K. (a) Output curve as a function of gate voltages. The main plot displays the low-bias region. (b) Transfer curve plotted on linear (left) and logarithmic (right) scales.