Supplementary Information for "Enhanced channel mobility of hexagonal boron nitride/hydrogen-terminated diamond heterojunction field-effect transistor"

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A. Time variation of transfer characteristics

The electrical properties of the FET fabricated in this study were maintained over a long period. Figure S1 shows the transfer characteristics measured on different days. A slight increase in sheet conductance was observed between the initial measurement and measurement performed 356 days later. However, no significant change in characteristics was observed between the measurements performed 356 and 705 days later. Between the measurements, the sample was stored in a desiccator filled with nitrogen.

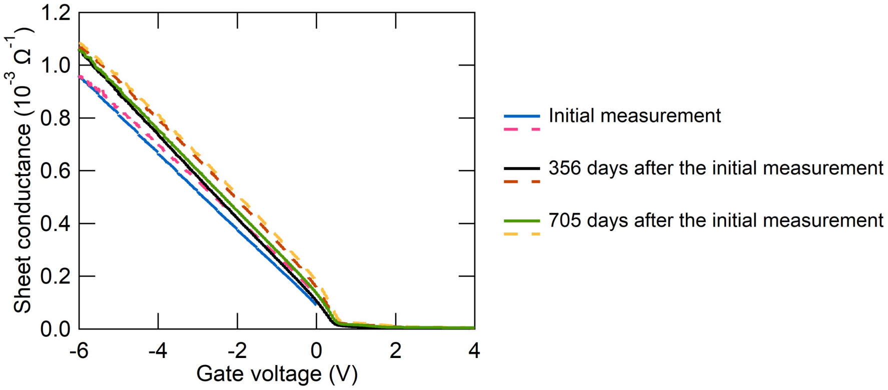

Figure S1: Transfer characteristics of sample B1 measured on different days. The dotted line represents the sheet conductance measured while sweeping the gate voltage in the positive direction, and the solid line represents the sheet conductance measured while sweeping the gate voltage in the negative direction. The initial measurement (blue solid line) was performed simultaneously with the Hall-effect measurement (Figs. 2c,d). The transfer characteristics shown in Fig. 2a are the characteristics measured 356 days after the initial measurement.

B. Calculation of Hall mobility

As mentioned in the main text, a fringe current path is considered to exist in the region where the diamond surface is hydrogen-terminated and covered by h-BN but is outside the area under the gate electrode. To avoid overestimating mobility due to the side current path, we calculate the mobility from the sheet conductance after subtracting the conductance of the side current path using the following equation: $\mu_{\mathrm{Hall}} = (\sigma - \sigma(V_{\mathrm{GS}} = 0)(W_{\mathrm{h-BN}} - W_{\mathrm{G}})/W_{\mathrm{h-BN}})/(n_{\mathrm{H}}e)$. Here, σ is the sheet conductance, $\sigma(V_{\mathrm{GS}} = 0)$ is the sheet conductance at $V_{\mathrm{GS}} = 0$ V, $W_{\mathrm{h-BN}}$ is the width of h-BN, and W_{G} is the gate width. Figure S2 depicts the Hall mobility with and without the inclusion of this correction. The corrected Hall mobility is shown in Fig. 2d of the main text.

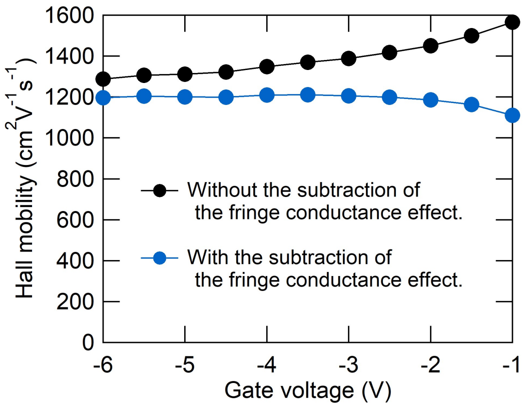

Figure S2: Gate voltage dependence of Hall mobility at 300 K with (blue) and without (black) the subtraction of the fringe conductance effect.

C. Temperature dependence of mobility at different gate voltages

Figure S3a shows the temperature dependence of mobility at $V_{\mathrm{GS}} = -2$, -4 and -6 V. The temperature dependence of mobility at different gate voltages exhibits nearly the same behavior. Figures S3b and S3c show the results of fitting the temperature dependence of mobility at gate voltages of -2 and -4 V with the theoretical model.

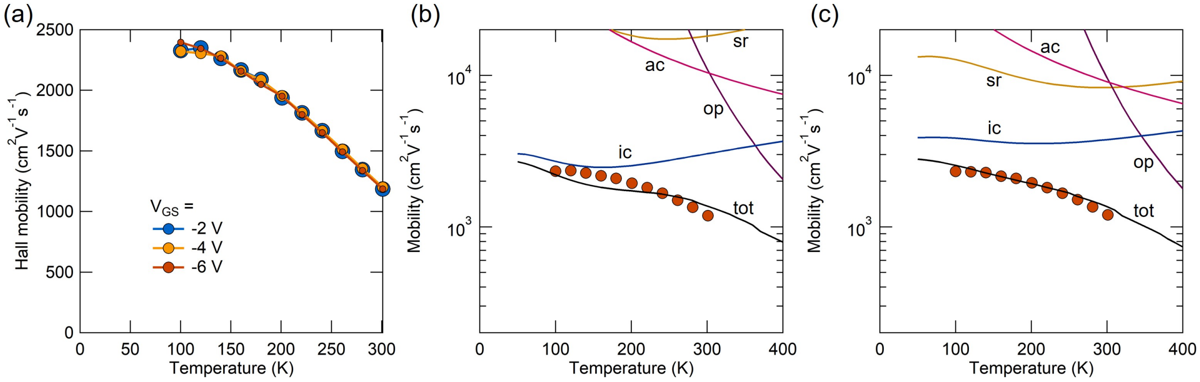

Figure S3: (a) Temperature dependence of mobility at different gate voltages for sample B1. (b)(c) Theoretical analysis of the temperature dependence of mobility at (b) $V_{\mathrm{GS}} = -2$ V and (c) -4 V. Red circles show experimental results. Solid lines show the results of the theoretical calculation of mobility. The labels “ic,” “sr,” “ac,” and “op” indicate the calculated mobilities limited by interface charges, surface roughness, acoustic phonon, and optical phonon, respectively. The mobility limited by background impurity scattering is higher than the plot range. The label “tot” indicates the calculated mobility considering all the above scattering mechanisms.