Supplementary Information

Model Derivation

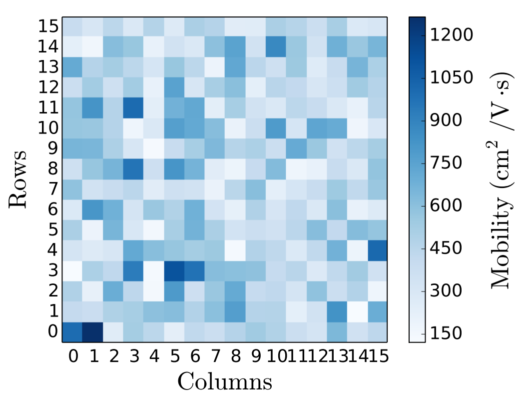
Electron and hole mobilities are assumed constant and equivalent. Contact resistance is assumed symmetric. Saturation velocity may be neglected because of the low bias voltages applied to graphene EGFETs in order to avoid undesirable redox reactions. Top-gate capacitance is approximated as a constant to reduce computational expense. The integrand is treated as three separate cases representing a p-type, n-type, and mixed doping channel. This leads to the following piecewise integral equation. Solving for I_{DS} yields our compact model, which is reproduced here for convenience. Because of space limitations, a number of variables are combined and renamed. The new variables are $k = \mu W/L$, $C = C_{Top}$, $V_X = V_{GS} - V_o$, $n_o' = qn_o$, and $M = kCR_C^2$.

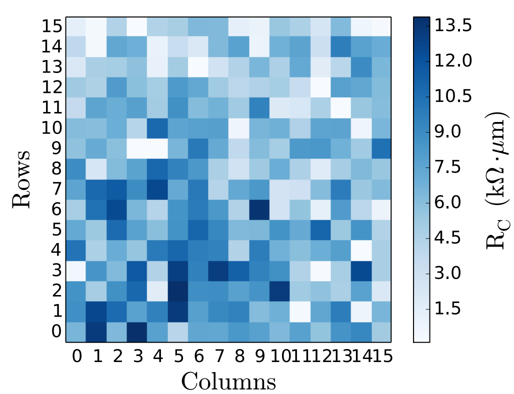
$$I_{DS} \approx \mu\frac{W}{L}\begin{cases} \displaystyle\int_{I_{DS}R_C}^{V_{DS}-I_{DS}R_C} qn_o + C_{Top}(V - V_{GS} - V_o)\, dV & \text{when } V_{GS} - V_o < I_{DS}R_C \\ \displaystyle\int_{I_{DS}R_C}^{V_{GS}-V_o} qn_o + C_{Top}(V_{GS} - V_o - V)\, dV + \int_{V_{GS}-V_o}^{V_{DS}-I_{DS}R_C} qn_o + C_{Top}(V_{GS} - V_o - V)\, dV & \text{when } I_{DS}R_C \leq V_{GS} - V_o \leq V_{DS} - I_{DS}R_C \\ \displaystyle\int_{I_{DS}R_C}^{V_{DS}-I_{DS}R_C} qn_o + C_{Top}(V_{GS} - V_o - V)\, dV & \text{when } V_{GS} - V_o > V_{DS} - I_{DS}R_C \end{cases}$$

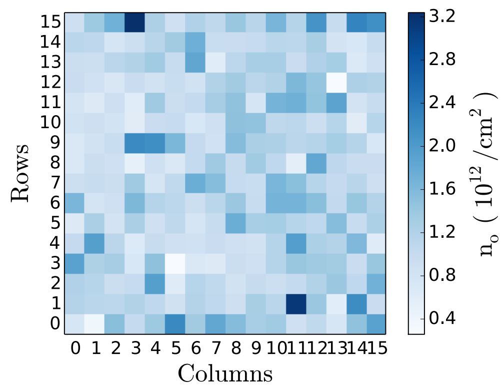
$$I_{DS} \approx \begin{cases} \dfrac{kV_{DS}[C(\frac{V_{DS}}{2} - V_X) + n_o']}{1 + 2kR_C[C(\frac{V_{DS}}{2} - V_X) + n_o']} & \text{when } V_X < I_{DS}R_C \\ \dfrac{1 + kR_C(CV_{DS} + 2n_o') - \sqrt{[1 + kR_C(CV_{DS} + 2n_o')]^2 - 4M[\frac{1}{2}kC[(V_{DS} - V_X)^2 + V_X^2] + kn_o'V_{DS}]}}{2M} & \text{when } I_{DS}R_C \leq V_X \leq V_{DS} - I_{DS}R_C \\ \dfrac{kV_{DS}[C(V_X - \frac{V_{DS}}{2}) + n_o']}{1 + 2kR_C[C(V_X - \frac{V_{DS}}{2}) + n_o']} & \text{when } V_X > V_{DS} - I_{DS}R_C \end{cases}$$

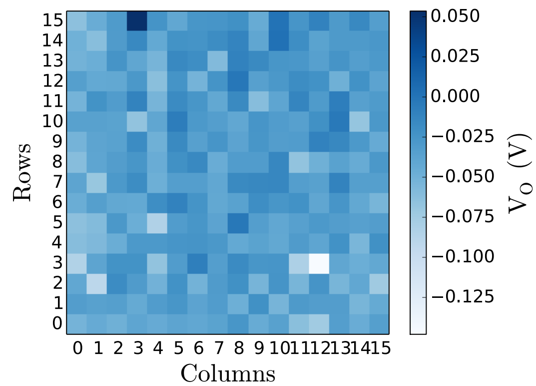
Spatial Trends in Variation

The extracted device parameters from the array show no strong spatial correlations. This indicates successful graphene transfer and a uniformly processed array. Excellent graphene transfer is also supported by the fact that we achieve 100% yield for an array of 256 devices.






Rows
Columns
n_o (10^{12} /cm^2)
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4


Rows
Columns
V_O (V)
0.050
0.025
0.000
−0.025
−0.050
−0.075
−0.100
−0.125