Patterning, Characterization and Chemical Sensing Applications of Graphene Nanoribbon Arrays Down to 5 nm Using Helium Ion Beam Lithography

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Supporting Information

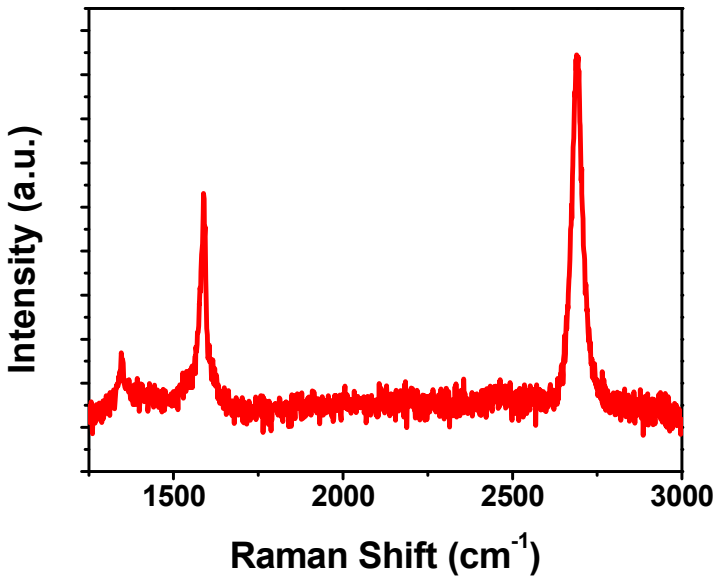

Figure S1. Raman spectrum of monolayer graphene used in this study. Laser wavelength is 514 nm.

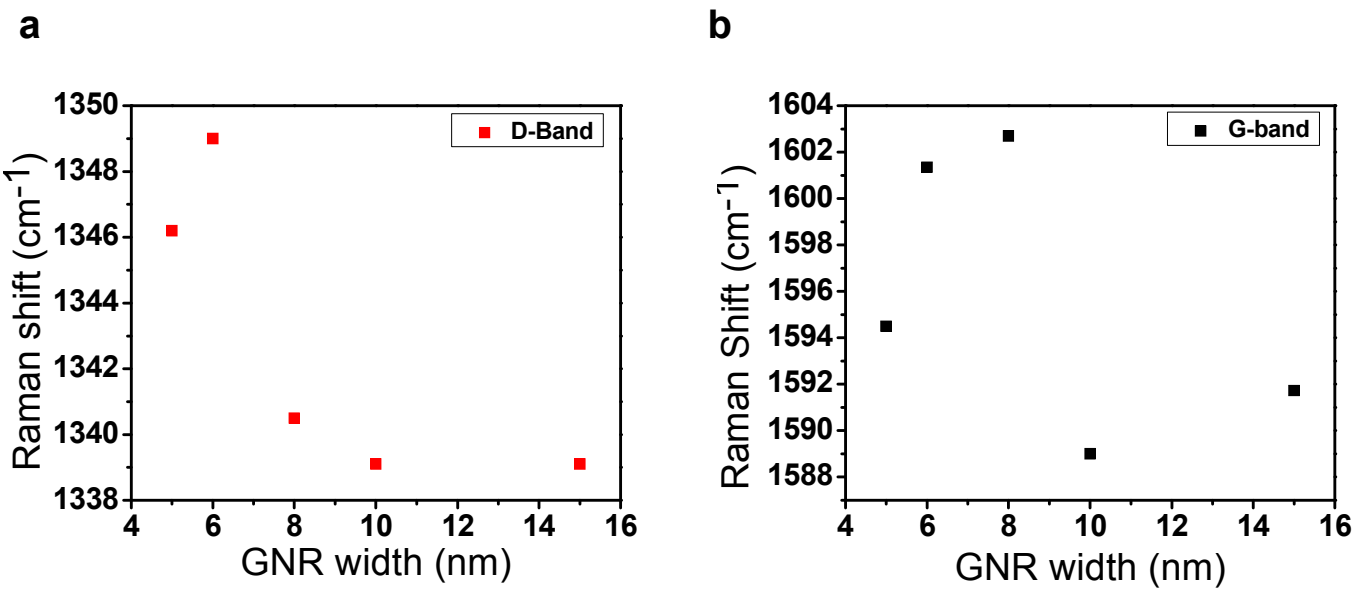

Figure S2. a) D-band and b) G-band peak positions *vs*. the widths of GNR arrays.

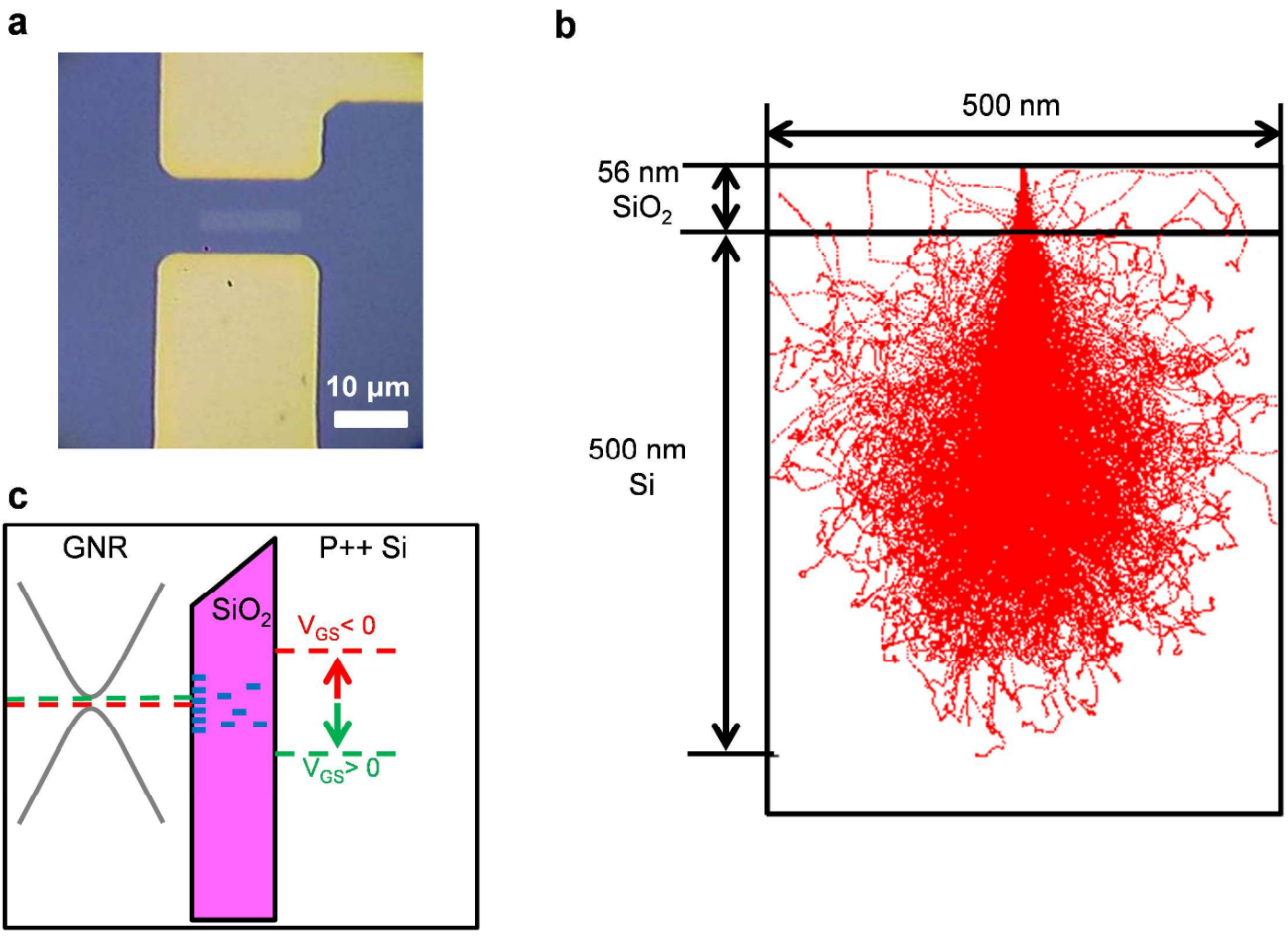

Figure S3. a) An optical image of a HIBL patterned device after etching GNR showing a color contrast under the patterned area due to helium ion bombardment. b) Monte Carlo simulation of helium ions, with 30 KeV energy, scattering into the substrate used in this work. Each red line trace represents the scattering path of a single helium ion. c) Energy band diagram showing the effect of defect states on Fermi level modulation in the GNR array channel *(i.e.* blue lines) created by energetic helium ions in the SiO_2. Green and red dashed lines represent the Fermi levels in both the P^{++} Si back gate and GNR arrays as the gate voltage (V_{GS}) is swept to positive and negative values, respectively.

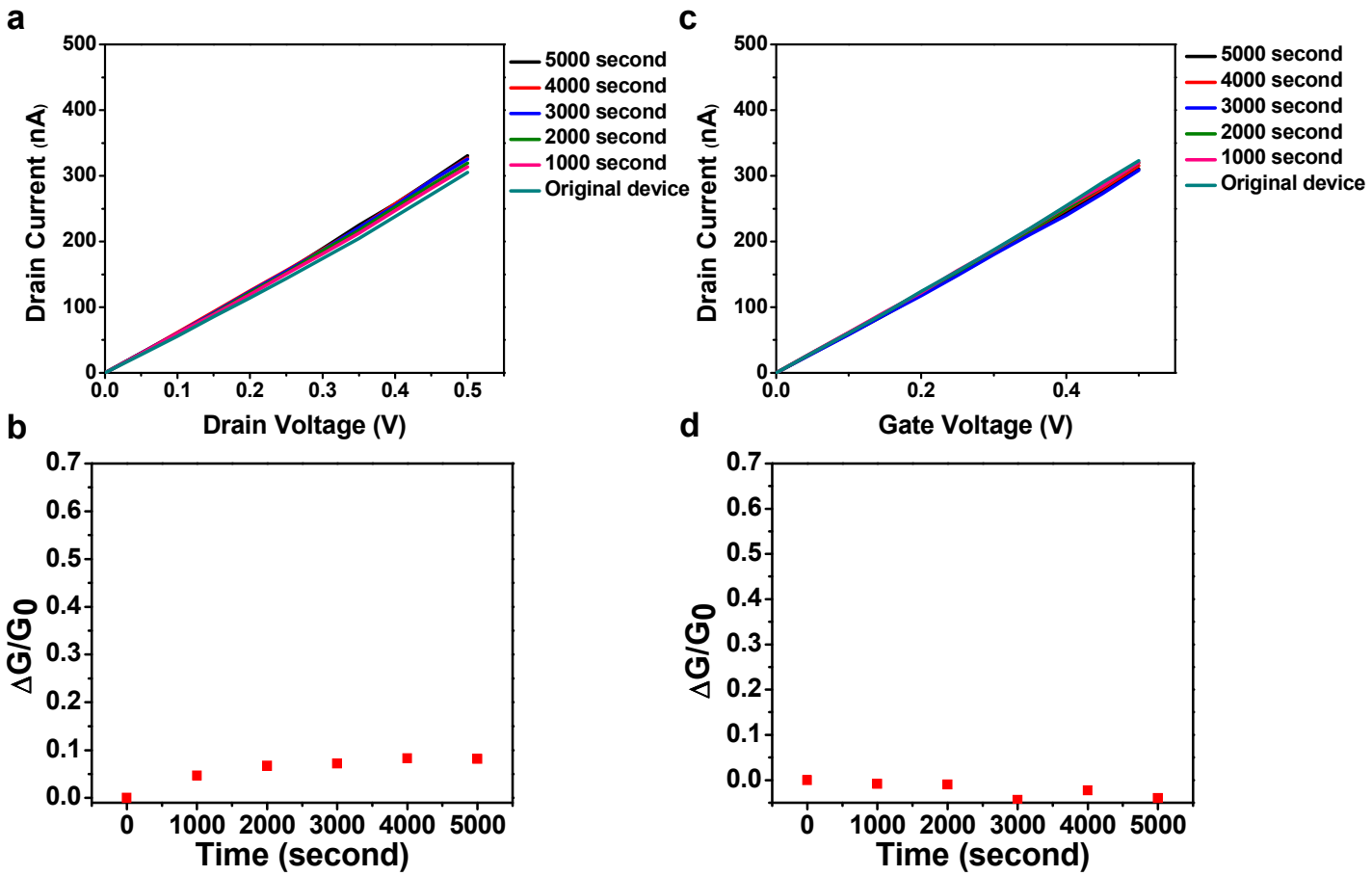

Figure S4. Output characteristics of the 5 nm half-pitch GNR array device while subject to a control experiment to examine the device drift over time. In the experiment, nitrogen (a) and argon (c) was flowed with a constant flow rate and measurements were repeated every 1000 seconds. b, d) Conductance changes ($\Delta G/G_0$) of devices in (a) and (c) as a function of time when subjected to nitrogen (b) and argon (d).

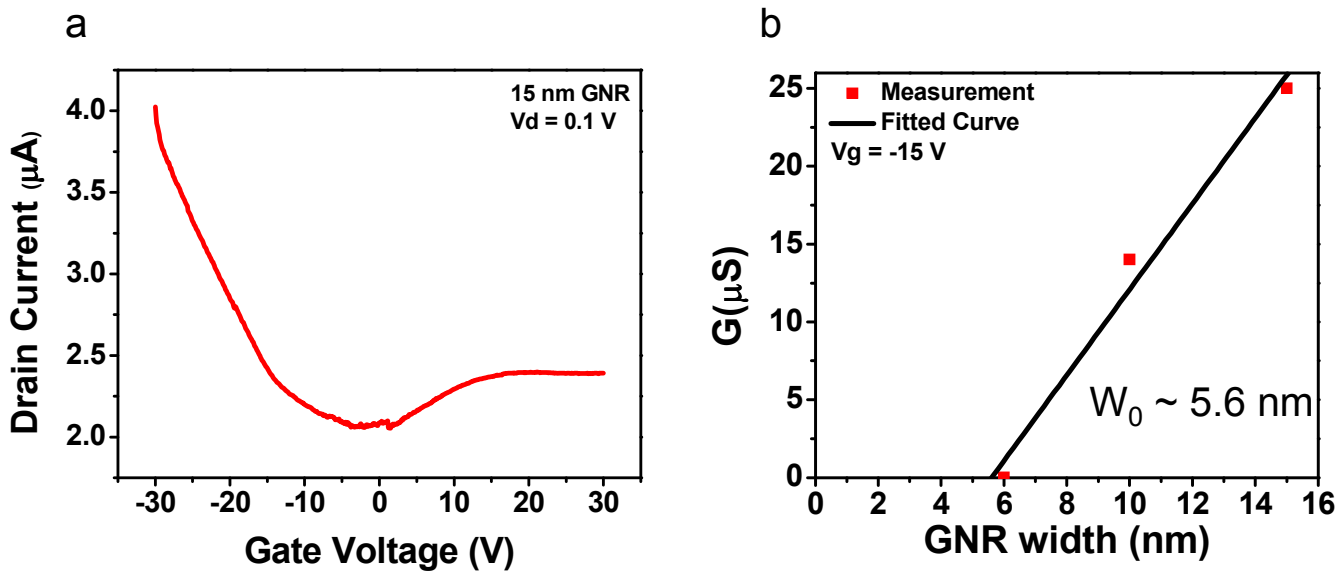

Figure S5. (a) Transport characteristics of 15 nm wide HIBL GNR array showing ON current of 4 μA and (b) Measured conductance of 15 nm, 10 nm, and 6 nm wide HIBL GNR at a gate voltage of -15 V. The linear equation conductance fit ($G= \sigma(W-W_0)/L$) yielded a W_0 of 5.6 nm.