Conductance Anisotropy in Epitaxial Graphene Sheets Generated by Substrate Interactions

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SUPPORTING INFORMATION Semi-insulating, on-axis (0°±0.5°), 76.2 mm diameter 4H-SiC(000) from Cree and 6H-SiC(0001) wafers from II-VI, epi-ready with chemical-mechanical polished (CMP) surfaces, were diced into 16 × 16 mm^2 samples. The samples were chemically cleaned ex situ using a standard cleaning procedure prior to loading into a CVD reactor.[34] Once the samples were loaded and adequate chamber vacuum was achieved ($<4.0 \times 10^{-7}$ mbar), processing was started by hydrogen etching for 5 to 20 minutes at a pressure of 100 mbar and temperature of 1600°C in order to remove the CMP damage from the surface. Hydrogen etching under these conditions has been observed to be sufficient to remove surface polishing damage and leave behind a well-ordered, uniformly-stepped surface.

For high vacuum growth runs following the hydrogen etch step, the temperature was maintained at 1600°C and argon flowed into the chamber at 100 mbar to flush out the hydrogen. The argon flush was discontinued after 10 minutes and the chamber was

evacuated using a turbopump as the substrate temperature was ramped to the growth target. The pressure during vacuum synthesis began in the 10^{-4} mbar range and steadily decreased over the length of the run, generally ending in the low- 10^{-5} to mid-10^{-6} mbar range.

Following growth, samples were removed from the reactor and graphene was confirmed by a finite electrical resistance (range: ~10^2 to 10^5 Ω) of the epitaxial surface. To choose a proper sample for microscopic measurements, the samples were characterized using Nomarski interference contrast microscopy, AFM, Raman spectroscopy, and macroscopic transport measurements. AFM images of the Si-face and C-face samples used for the transport measurements are shown in Figure S1. Raman spectroscopy was accomplished using a 150 mW 532 nm laser, 0.5 m single-pass spectrometer and nitrogen-cooled CCD array. Raman spectra show a strong characteristic peak at 2700 cm^{-1} indicating the growth of graphene. The macroscopic Hall effect mobilities were measured at both 300 K and 77 K using a van der Pauw configuration with copper pressure clips serving as contacts at the corners of the films. Measurement currents used ranged from 1 to 100 μA and the magnetic field was 2,060 G. The measured mobility and carrier density for the Si-face sample was 107 $cm^2V^{-1}s^{-1}$ and -3.74 x 10^{12} cm^{-2} at 300 K and 601 $cm^2V^{-1}s^{-1}$ and 5.1 x 10^{11} cm^{-2} at 77 K. The measured mobility and carrier density for the C face sample was 425 $cm^2V^{-1}s^{-1}$ and 3.3 x 10^{14} cm^{-2} at 300 K and 1405 $cm^2V^{-1}s^{-1}$ and 7.6 x 10^{13} cm^{-2} at 77 K.

Electrical transport measurements were carried out in UHV with a commercial system containing four independently driven probes which can be positioned with nanometer accuracy on the sample. The probe positions were monitored in situ with a field-emission

scanning electron microscope. The probes consisted of electrochemically etched polycrystalline tungsten wires. The tips were carefully brought into mechanical contact, as judged from the onset of linear four probe current–voltage characteristics. Prior to measurement of the sample, proper current-voltage characteristics were verified on a thin Au film. All four-probe current–voltage curves were measured using a semiconductor test system programmed with home built data acquisition software.

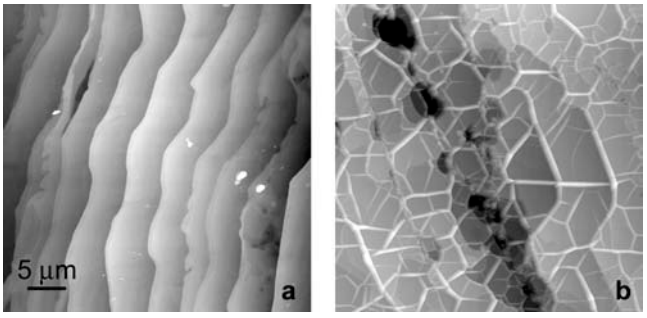

Figure S1. (a) 40 μm x 40 μm AFM image of Si-face graphene sample used in transport measurement. The step edge morphology with preferred direction seen in SEM is clearly present here. (b) 40 μm x 40 μm AFM image of C-face graphene sample used in transport measurements. The distinctive "giraffe stripe" structure is clearly visible, as well as a step structure which, while it is not as ordered as the Si face steps, does seem to indicate a preferred direction in the image.