

Supporting information

A Systematic Study of Atmospheric Pressure Chemical Vapor Deposition Growth of Large-Area Monolayer Graphene†

Lixin Liu^{a,b,§}, Hailong Zhou^{a,§}, Rui Cheng^b, Yu Chen^b, Yuan Liu^b, Yung-Chen Lin^b, Yongquan Qu^a,
Jingwei Bai^b, Ivan A. Ivanov^a, Gang Liu^a, Yu Huang^{b,c,*}, and Xiangfeng Duan^{a,c,*}

^a Department of Chemistry and Biochemistry, University of California, Los Angeles,
California 90095 USA. E-mail: xduan@chem.ucla.edu

^b Department of Materials Science and Engineering, University of California, Los Angeles, California
90095 USA. E-mail: yhuang@seas.ucla.edu

^c California Nanosystems Institute, University of California, Los Angeles, California 90095 USA

§ These authors contributed equally to this work.

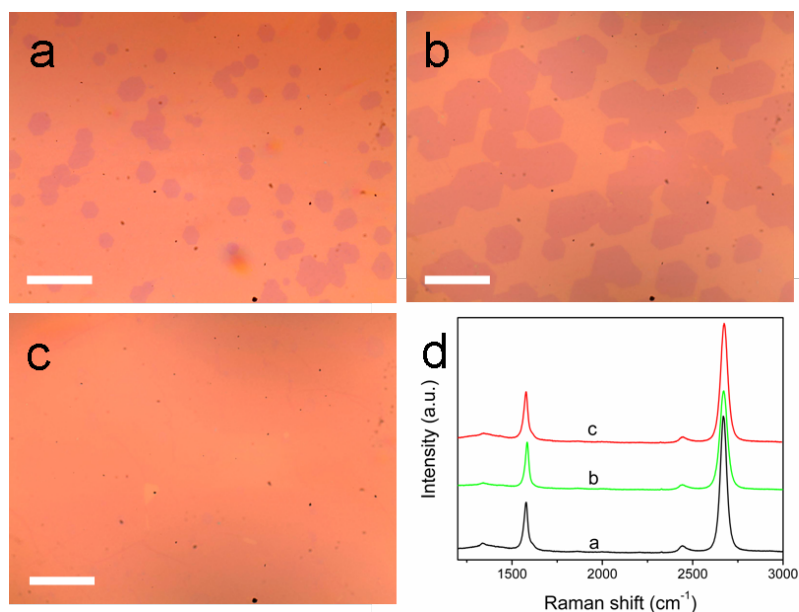


Fig. S1 OM images of graphene synthesized with mixed gas flow Ar:H₂:CH₄=420:30:50 sccm under

1050 °C at different growth stages: (a) 5 min growth with ~6.4% coverage; (b) 30 min growth with ~43% coverage; (c) 2 h growth with nearly full graphene coverage (>95%); scale bars are 20 μm . (d) Raman spectra of the samples in (a)-(c).

Fig. S1 shows the time dependence of graphene coverage on the Cu foils at 1050 °C with $\text{Ar:H}_2\text{:CH}_4=420:30:50$ sccm. The coverage of the total area is ~ 6.4 %, ~ 43 %, and over 95 % for growth times 5 min (Fig. S1a), 30 min (Fig. S1b), and 2 h (Fig. S1c), respectively. The domain density is always kept at ~ 6000/ mm^2 , which is independent of the growth time, as shown in Fig. S1a and S1b. Raman spectra were obtained to determine the graphene in each growth step, as shown in Fig. S1d. Raman spectra were collected by an objective lens with $50\times$ magnification with a 514 nm laser. The disorder-induced D bands of the three samples show relatively low intensity, indicating the high quality of the graphene domains and films. The narrow and symmetric 2D peak with FWHM of ~ 35-40 cm^{-1} and intensity ratio of $I_{2D}/I_G = 2.1\text{-}2.9$ are found for all three samples, which is in agreement with the features of monolayer graphene reported previously.¹

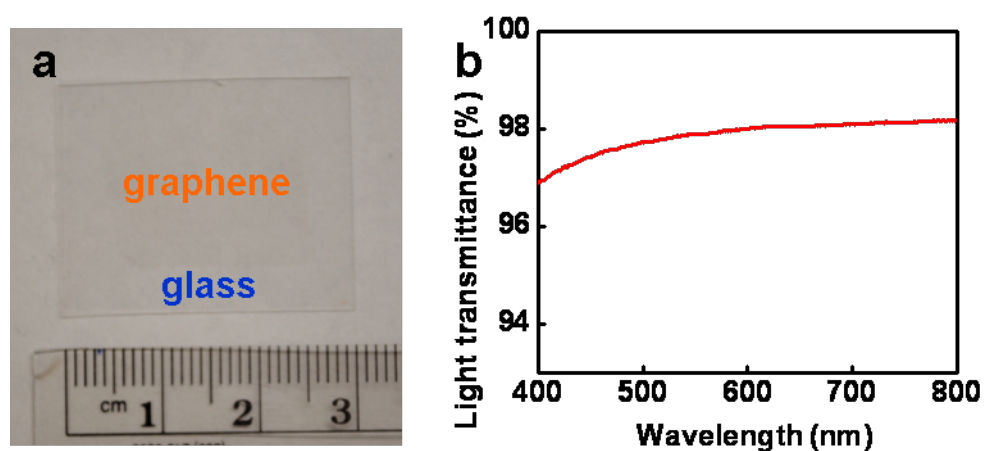


Fig. S2 (a) Photograph of a graphene film transferred onto a glass plate. (b) Transmittance spectrum of the

graphene film.

Fig. S2a shows a photograph of a large-area graphene film transferred on a glass plate, which was grown at 1050 °C with Ar:H₂:CH₄=420:30:50 sccm for 2h. The 2 × 2 cm² graphene film shown is optically transparent and uniform. Optical spectroscopy (UV-Vis Spectrophotometer, DU-800) was employed to evaluate the optical properties of the graphene. The transmittance spectrum of the graphene film (Fig. S2b) shows that the transmittance is 97.7 % at λ=500 nm and changes from 98.2 % (λ=800 nm) to 96.9 % (λ=400 nm), which is similar to the opacity of single layer of 2.3 ± 0.1 % reported by R. R. Nair et al.² This further confirms monolayer nature of our large-scale graphene. Slightly higher transmittance than the results from R. R. Nair et al. can be mainly ascribed to the ~ 95% coverage of the as-grown graphene films.

Reference

- 1 S. Bhaviripudi, X. T. Jia, M. S. Dresselhaus and J. Kong, *Nano Lett.* 2011, **10**, 4128.
- 2 R. R. Nair, P. Blake, A. N. Grigorenko, K. S. Novoselov, T. J. Booth, T. Stauber, N. M. R. Peres and A. K. Geim, *Science* 2008, **320**, 1308.