# **Electronic Supplementary Information**

## Direct Deposition of Nanocrystalline Graphene on Insulating Substrates for Large-Scale Nanoelectromechanical Switches

Jian Sun,<sup>1,\*</sup> Marek E. Schmidt,<sup>1</sup> Manoharan Muruganathan,<sup>1</sup> Harold M. H. Chong,<sup>1</sup> Hiroshi Mizuta<sup>1,2</sup>

<sup>1</sup> School of Materials Science, Japan Advanced Institute of Science and Technology, Nomi 923-1211, Japan

<sup>2</sup>Nanoelectronics and Nanotechnologies Research Group, Faculty of Physical Sciences and Engineering, University of Southampton, Highfield, Southampton SO17 1BJ, U.K.

\*Corresponding author Email: sun-jian@jaist.ac.jp (J.S.)

### **Raman Spectrum Analysis**

We provide the detailed information of the Raman spectrum fitting. Figure S1 is the representative Raman spectrum of sample with  $T_d = 800$  °C which is plotted as Figure 1a in the main text.



**Figure S1**. Raman spectrum of the NCG film with  $T_d = 800$  °C with 532 nm laser. Thin curves are the component curves obtained from peak fitting, and they are labeled accordingly.

Here, we used Lorentzian curve shapes for all sub-peaks with the exception of the D' peak (1627 cm<sup>-1</sup>), which was fitted by a Fano-line shape. The individual components of the fit model are shown. Three primary peaks D, G and 2D peaks – the characteristic for defective graphene – locate at 1350, 1593, and 2675 cm<sup>-1</sup>, respectively. Furthermore, the G-peak location is insignificantly affected by the excitation wavelength (confirmed with 532, 633 and 785 nm laser). Such characteristics, i.e.  $I_{G}/I_{D} \approx 0.5$ , G-peak location of ~1590 cm<sup>-1</sup> and its insensitivity to excitation wavelength, had been reported before for the graphene with nanocrystalline domains.<sup>[11]</sup> Other peaks observed in this spectrum are  $2A_{1g}$ , D', D+D'', and D+D' (from low Raman shift to high), which had been reported for carbon films before.<sup>[2,3]</sup> Their detailed information is listed as following.  $2A_{1g}$  at 1270 cm<sup>-1</sup> originates from active vibrational modes of *sp*<sup>3</sup>-bonded carbon network; D' at 1627 cm<sup>-1</sup> is from intravalley defect; D+D'' at 2440 cm<sup>-1</sup> is due to intervalley double resonance; and D+D' at 2934 cm<sup>-1</sup> is a defect related band. The fitted Raman spectrum of a different sample deposited with  $T_d = 750$  °C is provided in Figure S2. The 2D peak is also clearly observed.



**Figure S2.** Raman spectrum and its peak-fitting of the NCG film with  $T_d = 750$  °C with 532 nm laser.

Additional mapping measurements of  $I_{2D}/I_{G}$ ,  $L_{a}$ , d



**Figure S3**. (a), (b), and (c) are the mapping of  $I_{2D}/I_G$ ,  $L_a$ , and *d* of a 4 cm × 4 cm at the same location in the film deposited at  $T_d$  of 850 °C, respectively. The dash-lines in (a) and (b) show the guidance of the boundaries of topographic patterns.

### **AFM Topographic images**



**Figure S4.** Additional AFM images and the extracted rms roughness values  $R_{\rm rms}$  of the samples deposited at the varied  $T_{\rm d}$  with other conditions fixed (deposition time: 5 min, gas flow rates: CH<sub>4</sub> 60 sccm, H<sub>2</sub> 75 sccm).

#### **Supplementary References**

(1) Ferrari, A. C.; Robertson, J. *Philos. Trans. R. Soc. A* 2004, 362, 2477.
(2) Malard, L. M.; Pimenta, M. A.; Dresselhaus, G.; Dresselhaus, M. S. *Phy. Rep.* 2009, 473, 51.

(3) Martins Ferreira, E. H.; Moutinho, M. V. O.; Stavale, F.; Lucchese, M. M.; Capaz, R. B.; Achete, C. A.; Jorio, A. *Phys. Rev. B* **2010**, 82, 125429.