Supporting Information

Single-Step Direct Growth of Graphene on Cu Ink towards Flexible Hybrid Electronic Applications by Plasma-Enhanced Chemical Vapor Deposition

Chen-Hsuan Lu[1], Chyi-Ming Leu[2], Nai-Chang Yeh[3]*

[1]Department of Applied Physics and Materials Science, California Institute of Technology, Pasadena, CA, 91125, USA

[2]Material and Chemical Research Laboratories, Industrial Technology Research Institute, Hsinchu, 31057, Taiwan

[3]Department of Physics, California Institute of Technology, Pasadena, CA, 91125, USA

*Email: ncyeh@caltech.edu

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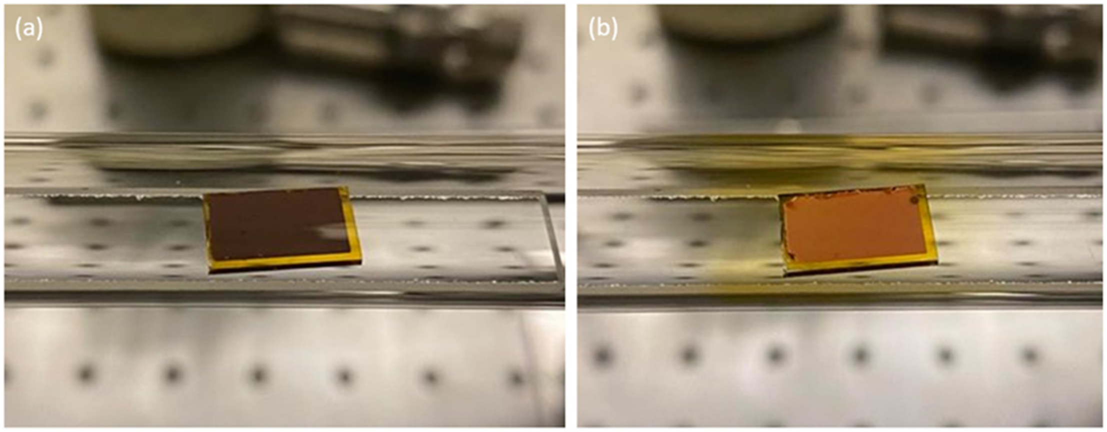

Figure S1: Images of the Cu ink sample (a) before PECVD and (b) after PECVD.

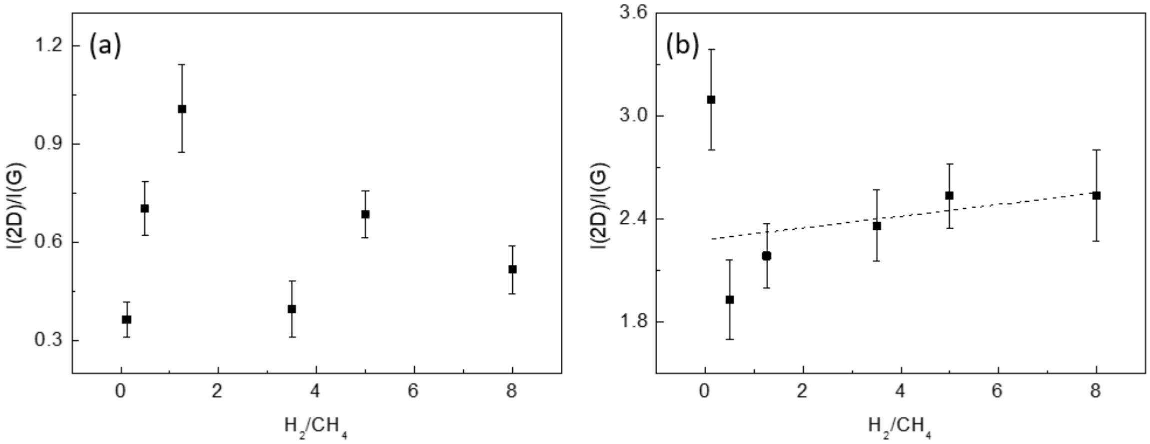

Figure S2. I(2D)/I(G) vs H_2/CH_4 at (a) 500 mtorr and (b) 750 mtorr.

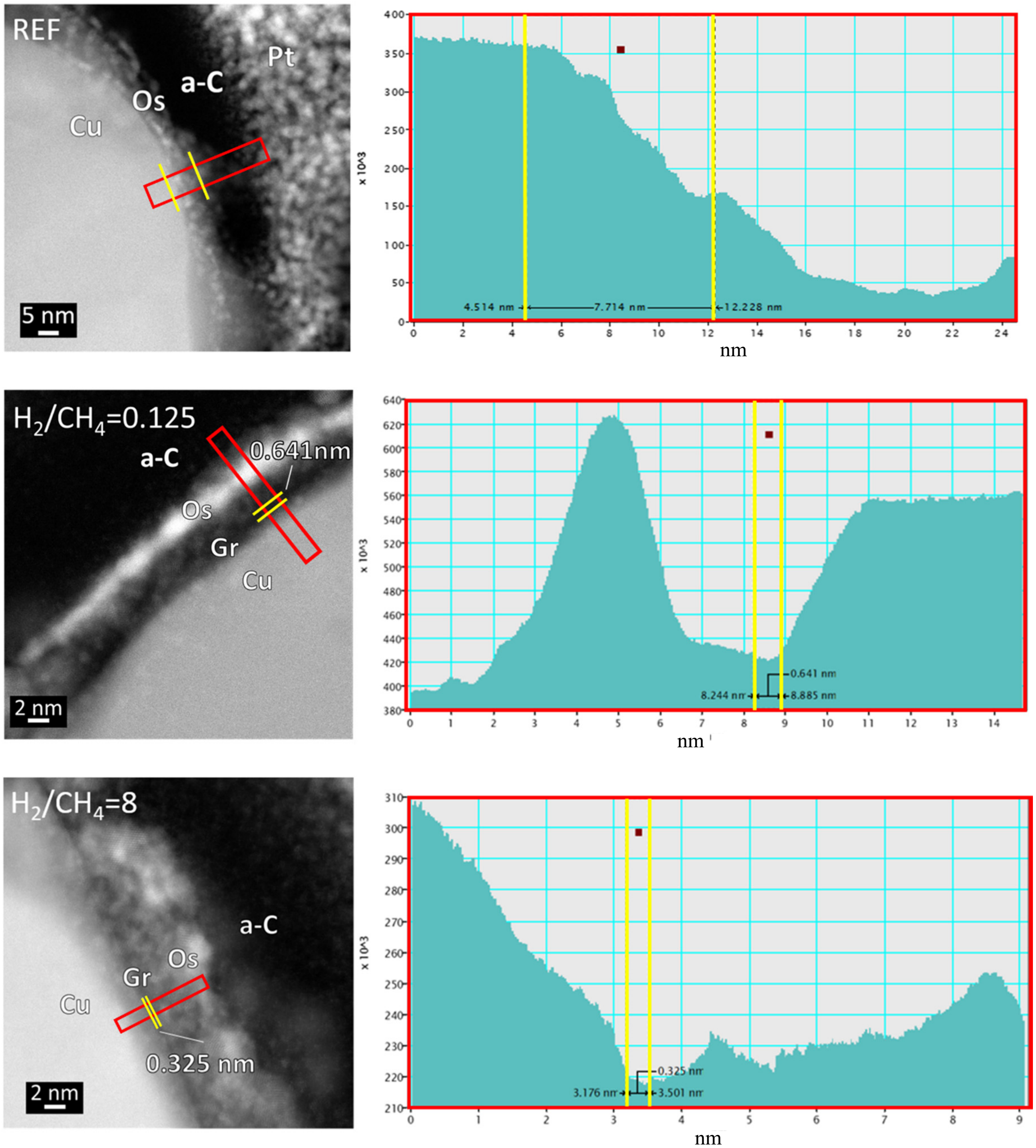

Figure S3: HAADF-STEM image of the Cu ink before and after PECVD of 750mtorr with the corresponding intensity slices.

Section 2. Derivation of the dependence of electron temperature on total pressure

The equation of motion of electrons under the applied oscillating electric field E(t) = E_0exp(iωt) may be written as:

$$m_e \frac{dv_e}{dt} = -eE_0 \exp(i\omega t) - m_e \nu \mathrm{v}_e, \tag{1}$$

where E_0: electric field amplitude, ω: the frequency of the applied electric field, ν: the collision frequency between electron and the neutral, which is proportional to pressure, v_e: the velocity of the electron and m_e: the mass of the electron. Solving for v_e yields:

$$\mathrm{v}_e = -\frac{eE(t)}{m_e\,(\nu^2+\omega^2)}(\nu - i\omega) \tag{2}$$

The time-averaged power absorbed by an electron is:

$$\theta_a = Re\left(\frac{F\cdot v_e^*}{2}\right) = Re\left(-\frac{eE\mathrm{v}_e^*}{2}\right) = \frac{e^2}{2m_e}\frac{\nu}{\nu^2+\omega^2}E_0^2 \tag{3}$$

And the time-averaged kinetic energy of the electron is:

$$E_k = \frac{1}{2}m_e Re(\frac{\mathrm{v}_e\mathrm{v}_e^*}{2}) = \frac{3}{2}k_b T_e \tag{4}$$

Therefore comparing eq(3) and eq(4) we have:

$$\theta_a = 2\nu E_k \text{ or } T_e = \frac{e^2E_0^2}{6k_b m_e}\frac{1}{\nu^2+\omega^2} \tag{5}$$

Under microwave excitation, where $\frac{\omega}{\nu} \gg 1$ we can approximate eq(5) as:

$$T_e \approx \frac{e^2E_0^2}{6k_b m_e}\frac{1}{\omega^2} \tag{6}$$

Therefore, the electron temperature is independent of the collision frequency or pressure.

Reference: Moisan, M.; Pelletier, J., Hydrodynamic Description of a Plasma. In *Physics of Collisional Plasmas: Introduction to High-Frequency Discharges*, Springer Netherlands: Dordrecht, **2012**, pp 203-335.