Synthesis of Graphene Films by Rapid Heating and Quenching at Ambient Pressures and Their Electrochemical Characterization

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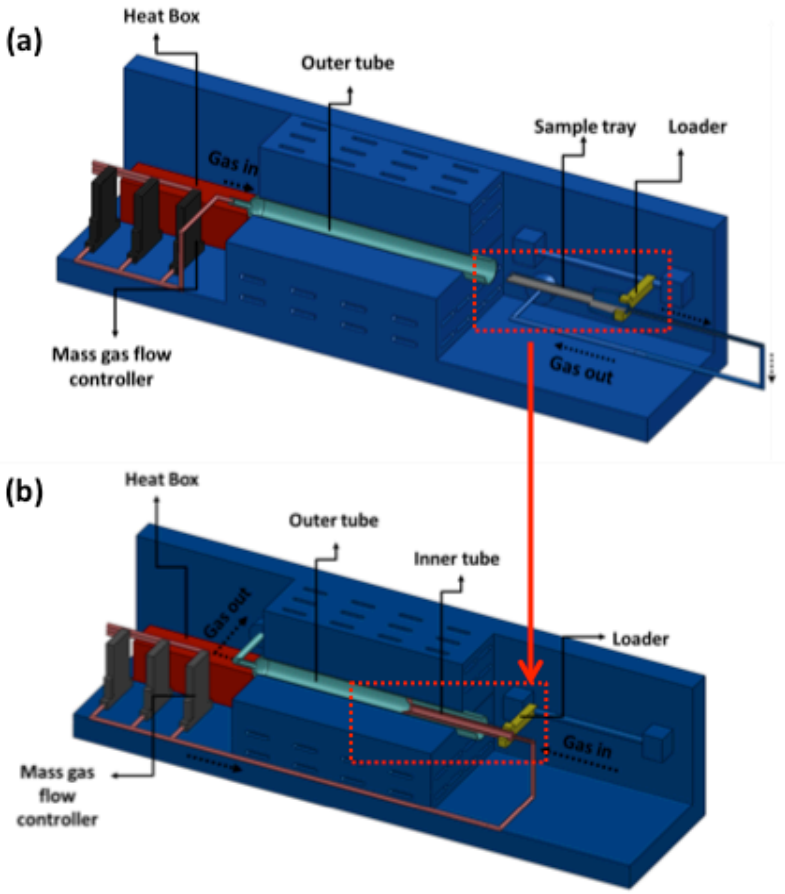

FIGURE S1. (a) Graphical representation of the CVD furnace before modifications. The sample is placed in the sample tray that slides into the quartz tube with help of a loader. (b) Modified Furnace: Sample tray is replaced by a smaller concentric inner tube that acts as the sample holder. The inner tube slideS in and out of the hot zone while still maintaining the inert Ar atmosphere around the specimen.[1] [Also see the animaton file].

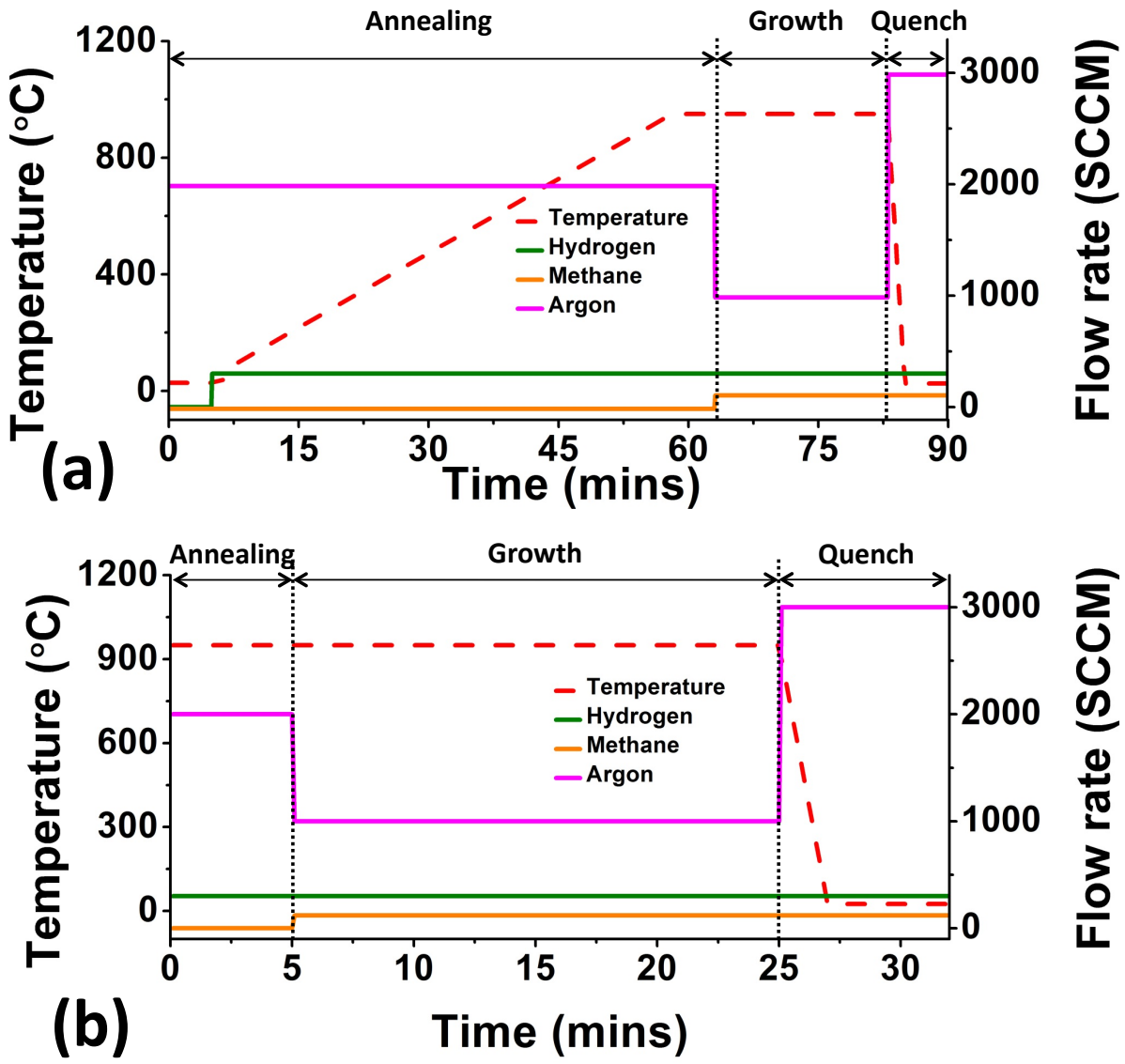

FIGURE S2. Representative plot showing various growth parameters for: (a) CVD/I and (b) CVD/II method for synthesis of graphene.

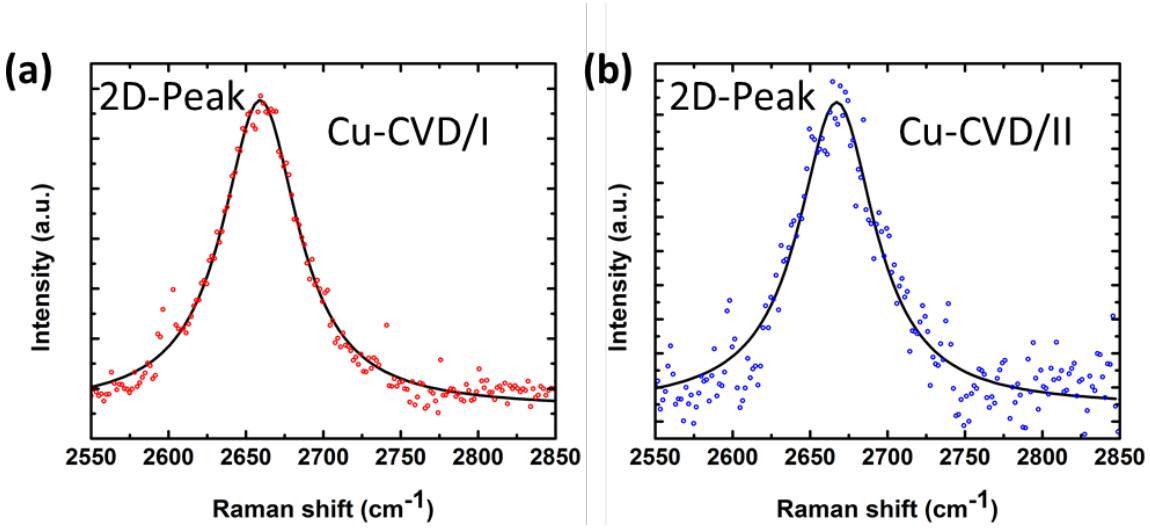

FIGURE S3. Comparison of Raman 2-D peak for Cu-G specimen prepared by (a) slow heating/ quenching (950-10-10-C) and (b) rapid heating/quenching (950-20-30-HC). The full width half maxima (FWHM) were (a) 59.27 and (b) 58.20 cm^{-1}. A single Lorentzian peak fit along with the SAED pattern in the TEM suggests formation of turbostratic graphene on Cu.

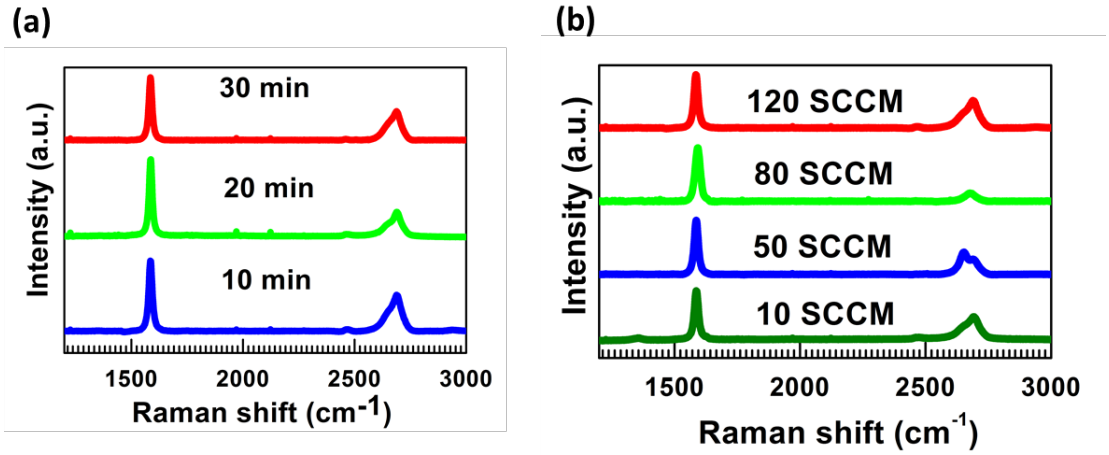

FIGURE S4. The Raman spectra of various specimen synthesized using CVD/II on Ni (rapid heating/quenching): effect of varying growth time (a) and CH_4 flow rates (b).

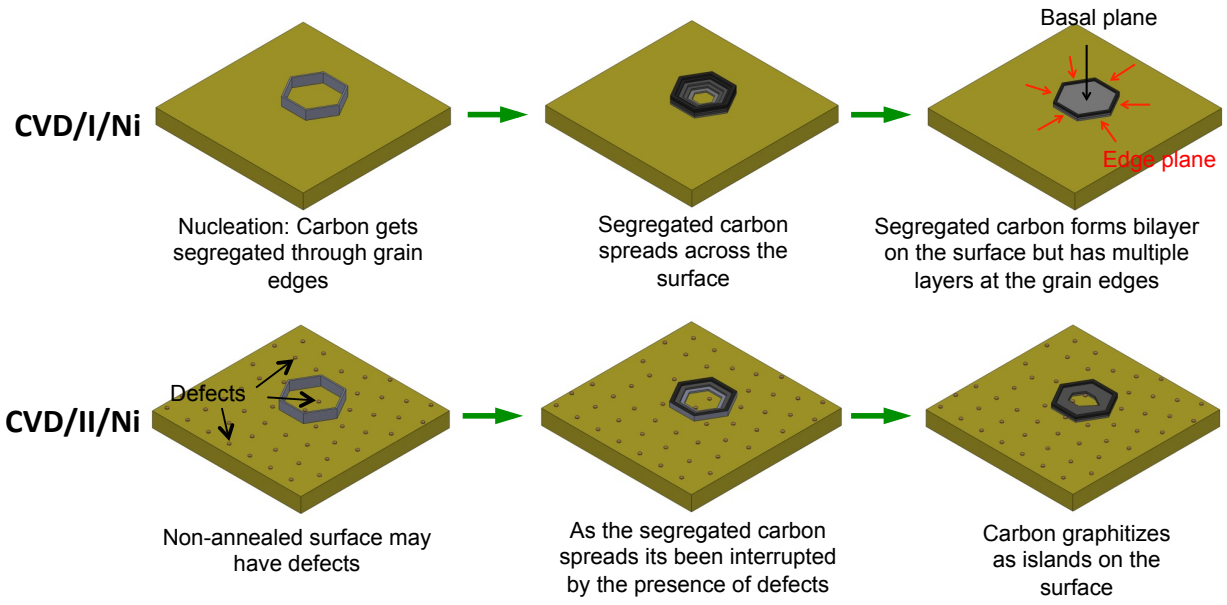

FIGURE S5. Schematic showing predicted mechanism for carbon segregation, nucleation and graphitization on Ni substrate for CVD/I (slow heating/quenching) and CVD/II (rapid heating/quenching) methods.

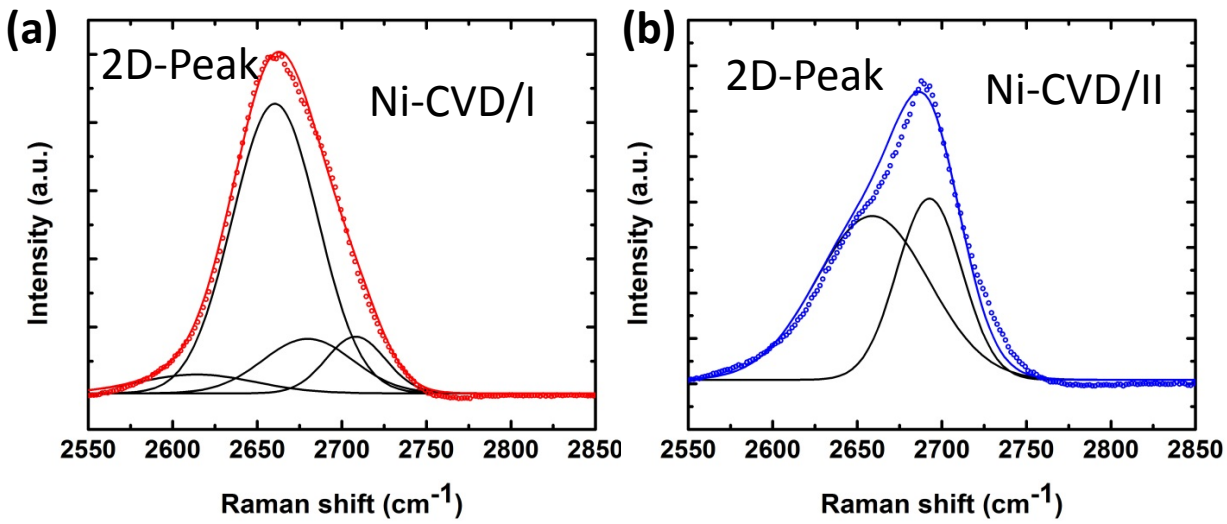

FIGURE S6. Comparison of Raman 2-D peak from (a) Ni-G using (slow heating/quenching): FWHM: 69.74 cm^{-1} (suggests formation of FLG) and (b) Ni-G using (rapid heating/quenching): FWHM: 71.4 cm^{-1} (suggests formation of graphitic islands).

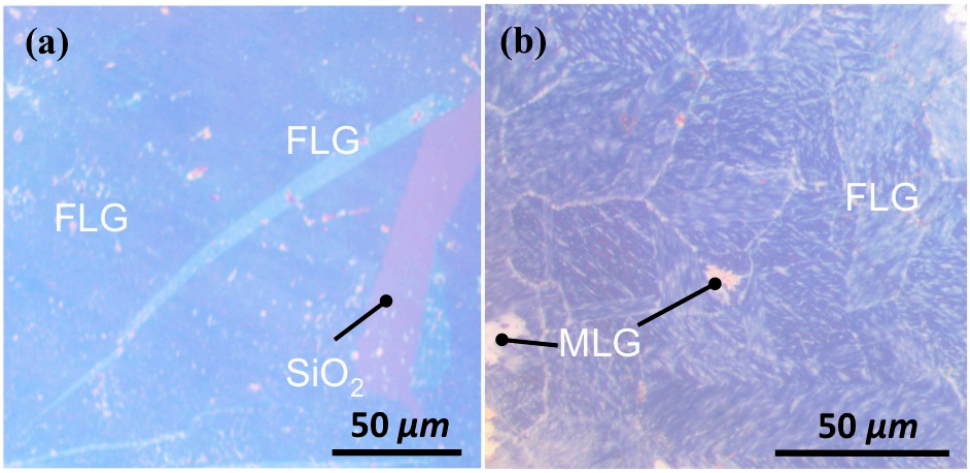

FIGURE S7. Optical microscope images of graphene films transferred on to SiO_2 substrate: (a) Cu-G using rapid heating/quenching (suggests formation of FLG) and (b) Ni-G using slow heating/quenching (suggests formation of FLG and multi layer graphitic islands).

TABLE S1. A summary of experimental details for various graphene specimen prepared in this study and their corresponding Raman peak ratios.

	specimen name	CH_4:H_2 (SCCM)	heating time (min)	growth time (min)	cooling time (min)	I_D/I_G	I_{2D}/I_G	2D peak FWHM (cm^{-1})
CVD/I	Cu-950-3-10-C	10:300	60	3	2	0.45	0.33	74.72
	Cu-950-10-10-C	10:300	60	10	2	0.5	0.39	59.27
	Cu-950-20-10-C	10:300	60	20	2	-	-	-
	Cu-950-10-20-C	20:300	60	10	2	0.3	0.25	78.04
	Cu-950-10-30-C	30:300	60	10	2	0.41	0.34	76.38
CVD/II	Cu-950-10-30-HC	30:300	2	10	2	0.24	0.24	73.06
	Cu-950-20-30-HC	30:300	2	20	2	0.51	0.66	58.80
	Cu-950-20-10-HC	10:300	2	20	2	0.55	0.29	78.05
	Cu-950-20-20-HC	20:300	2	20	2	0.63	0.39	66.42
CVD/I	Ni-950-10-120-C	120:300	60	10	2	0	1.03	69.74
	Ni-950-20-120-C	120:300	60	20	2	0	0.55	73.06
	Ni-950-30-120-C	120:300	60	30	2	0	0.78	78.04
	Ni-950-10-10-C	10:300	60	10	2	0	0.68	48.15
	Ni-950-10-50-C	50:300	60	10	2	0	0.87	46.49
CVD/II	Ni-950-10-120-HC	120:300	2	10	2	0	0.51	71.40
	Ni-950-20-120-HC	120:300	2	20	2	0	0.34	72.72
	Ni-950-30-120-HC	120:300	2	30	2	0	0.78	69.74
	Ni-950-10-10-HC	10:300	2	10	2	0	0.49	88.01
	Ni-950-10-50-HC	50:300	2	10	2	0	0.41	71.40
	Ni-950-10-80-HC	80:300	2	10	2	0	0.51	54.80

REFERENCES

1. David, L. Synthesis of large-area few layer graphene films by rapid heating and cooling in a modified apcvd furnace. M.S. Thesis, Kansas State University, Manhattan, KS, 2011.