Supplementary Information (SI)

Epitaxial graphene growth on cubic silicon carbide on silicon with high temperature neutron reflectometry: an operando study

Aiswarya Pradeepkumar,[a,b] David Cortie,[c,d] Erin Smyth,[c] Anton P Le Brun,[c] and Francesca Iacopi*[a,b,d]

[a]School of Electrical and Data Engineering, Faculty of Engineering and Information Technology, University of Technology Sydney, Sydney, New South Wales, 2007, Australia

[b]ARC Centre of Excellence in Transformative Meta-Optical Systems, University of Technology Sydney, New South Wales, 2007, Australia.

[c]Australian Centre for Neutron Scattering, Australian Nuclear Science and Technology Organization, New Illawarra Road, Lucas Heights, New South Wales 2234, Australia

[d]ARC Centre of Excellence in Future Low-Energy Electronics Technologies, Melbourne, Victoria, 3800, Australia.

Fitted values	Ni/Cu bilayer on 3C-SiC(100)/Si(100) at RT				200 °C				400 °C			500 °C			600 °C			
	CuO	Cu	Ni	SiC	CuO	Cu	Ni	SiC	CuO	CuNi	SiC	CuO	CuNi	SiC	CuO	CuNi	NiSi$_2$	SiC
Thickness, Å	10.0±25.2	214.2±26.6	85.3±1.2	-	19.2±1.7	219.0±2.0	72.6±2.0	-	1.0±1.3	296.0±0.7	-	1.0±1.0	300.4±1.0	-	113±66	120.1±21.7	36.7±30.1	-
SLD x 10^{-6} Å^{-2}	3.6±1.5	6.2±0.01	7.0±0.1	5.2±0.1	5.5±0.3	6.2±0.0	7.02±0.2	5.1±0.0	4.0±0.0	6.6±0.0	5.1±0.0	4.1±0.0	6.5±0.0	5.2±0.0	4.9±0.6	6.6±0.4	4.3±1.8	5.1±0.0
Roughness, Å	26.0±4.6	11.8±5.7	1.6±2.2	2.0±0.2	38±0.4	1.7±1.4	28.0±1.7	4.6±0.0	50±1	5.9±0.4	17.6±0.7	50.0±0.6	2.5±1.3	17.7±0.4	101.0±0.0	36.8±4.3	1.5±7.1	14.7±5.6

*RT indicates room temperature

Table S1: Fitted neutron reflectivity parameters of thickness, scattering length density, SLD and roughness for the Ni/Cu on 3C-SiC during different annealing stages during the EG synthesis.

Fitted values	1100 °C				Cooled down to RT				After wet freckle etching		
	Molten Intermixed layer	C	SiOC	SiC	Intermixed layer	EG	SiOC	SiC	EG	SiOC	SiC
Thickness, Å	34.0±24.2	13.1±6.0	9.3±6.2	-	10.9±5.6	13.3±1.4	17.9±3.9	-	5.30±2.4	19.7±1.6	-
Scattering length density, SLD x 10^{-6} Å^{-2}	2.6±1.2	6.8±3.3	4.5±1.7	5.6±0.0	2.8±0.6	6.5±1.7	3.2±0.2	5.4±0.0	3.9±1.8	2.7±0.1	5.0±0.0
Roughness, Å	43.5±9.0	7.7±5.3	5.2±3.1	50±8.8	11.2±7.4	10.0±4.8	1.3±1.8	44.0±3.0	9.8±2.1	1.3±3.5	50.0±0.4

Table S2: Fitted neutron reflectivity parameters of thickness, scattering length density, SLD and roughness for the Ni/Cu on 3C-SiC at 1100 °C, after sample cooled down to room temperature and after wet freckle etching.

Fitted parameters	Pre-anneal				Post-anneal				After wet freckle etching		
	CuO	Cu	Ni	SiC	NiSi$_2$ Cu	EG	SiOC	SiC	EG	SiOC	SiC
Thickness, Å	12	270	20.7		100	15	30	-	15	70	
Scattering length density, SLD (x 10^{-6} Å^{-2})	13	62.4 (1.44 iSLD)	30.7	20	35	16	22	20	16	20	26
Roughness, Å	2.4	33	15.5	3	70	19	5	40	33	4	50

Table S3: Fitted X-ray reflectivity parameters of thickness, scattering length density, SLD, and roughness for the Ni/Cu on 3C-SiC before and after the furnace annealing for EG synthesis.
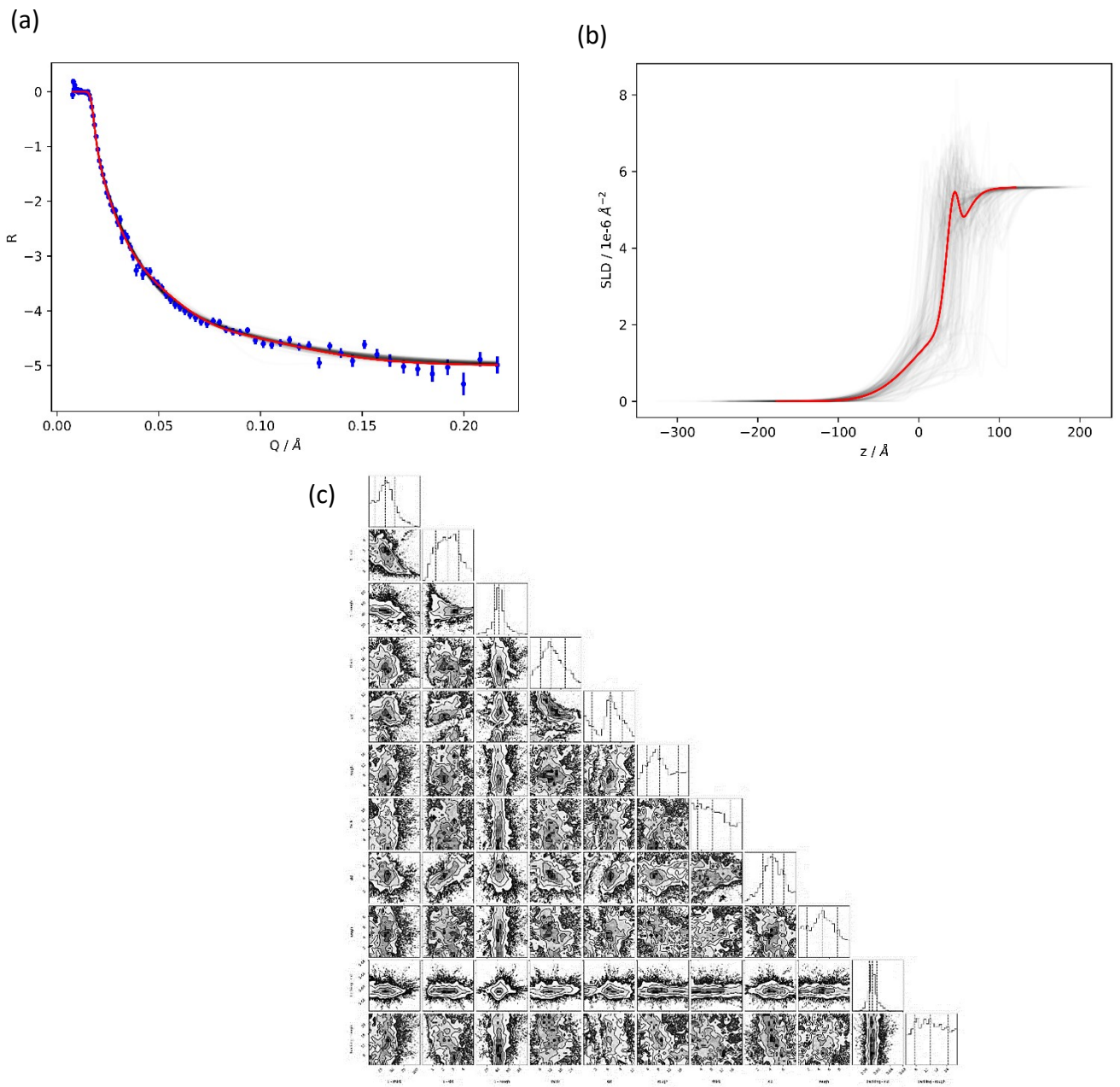
Figure S1. MCMC sampling neutron reflectivity data for the sample at 1100°C. (a) neutron reflectivity profile, (b) SLD profile, and (c) corner plot.
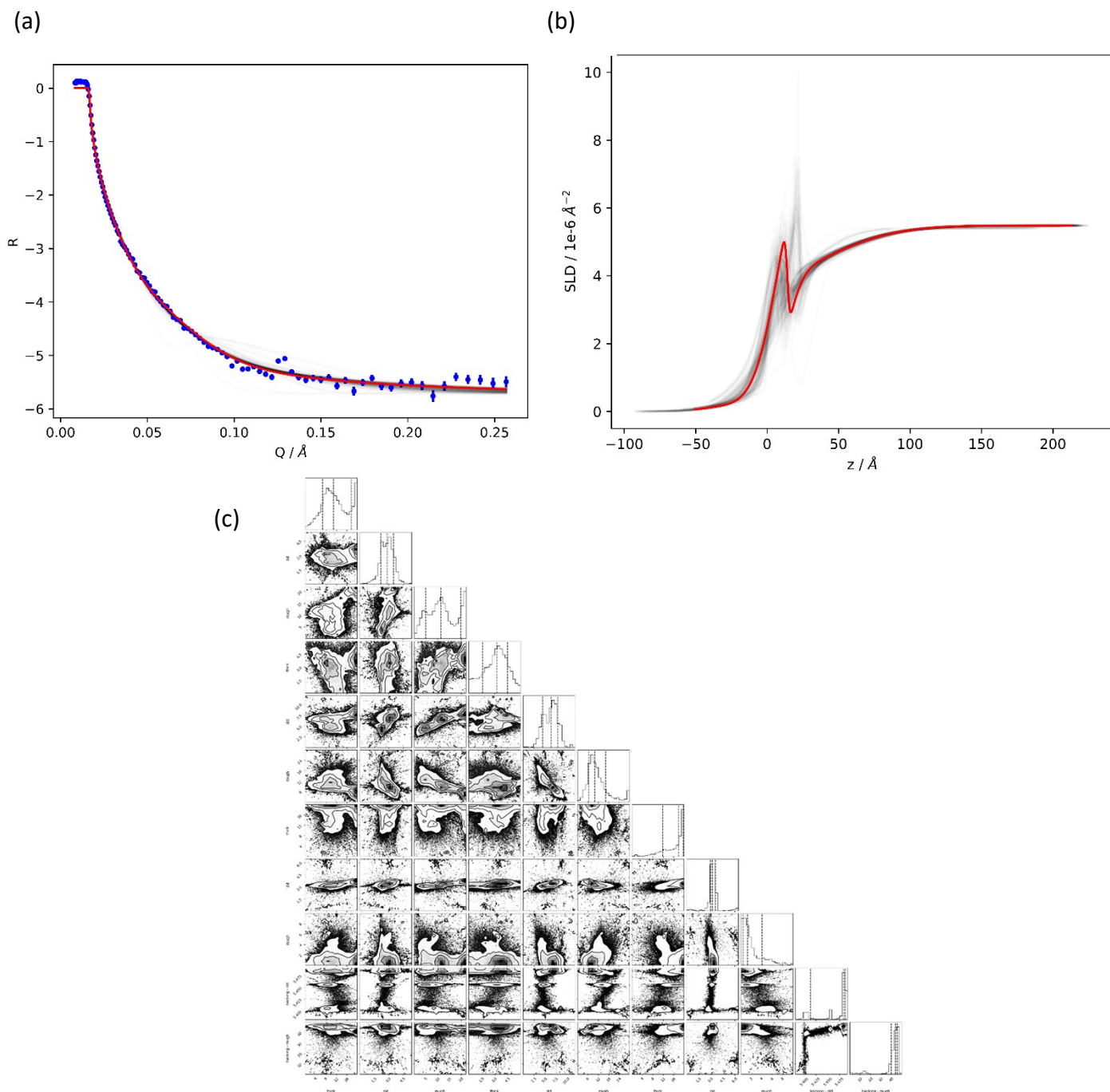
Figure S2. MCMC sampling neutron reflectivity data for sample cooled down to room temperature (a) neutron reflectivity profile, (b) SLD profile, and (c) corner plot.
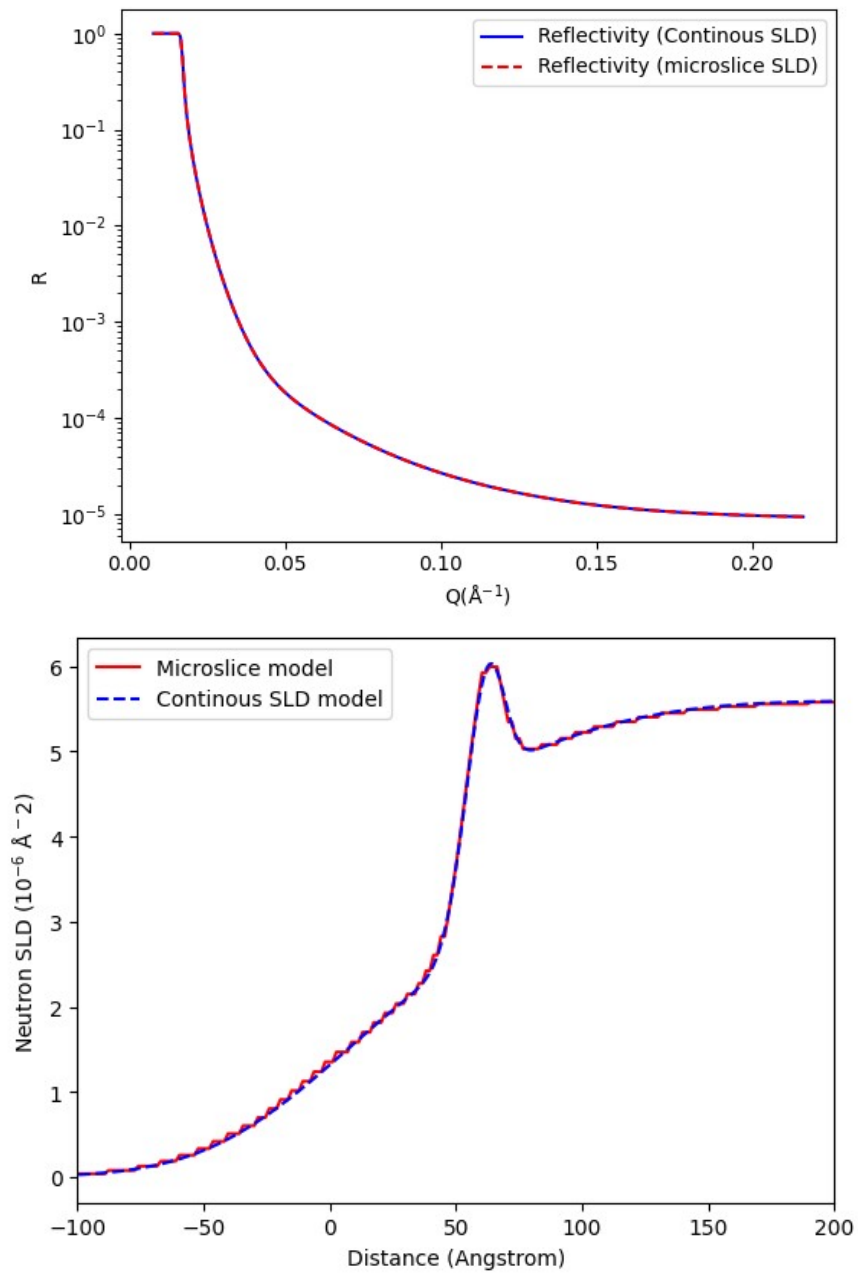
Figure S3: Alternate calculations using micro-slicing of the SLD profile of neutron reflectometry data at 1100 °C.
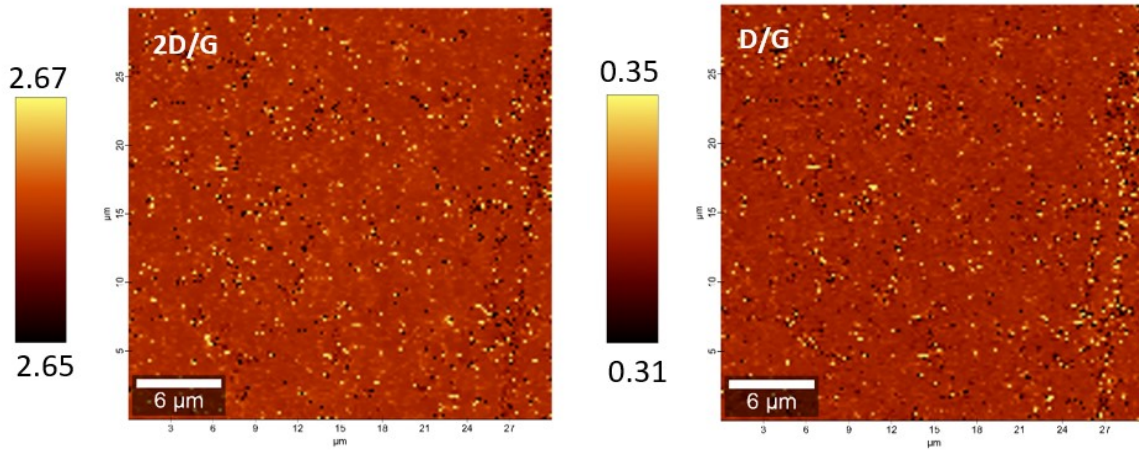
Figure S4: Raman maps for I_D/I_G and I_{2D}/I_G peak intensity ratios for the annealed sample after freckle etching
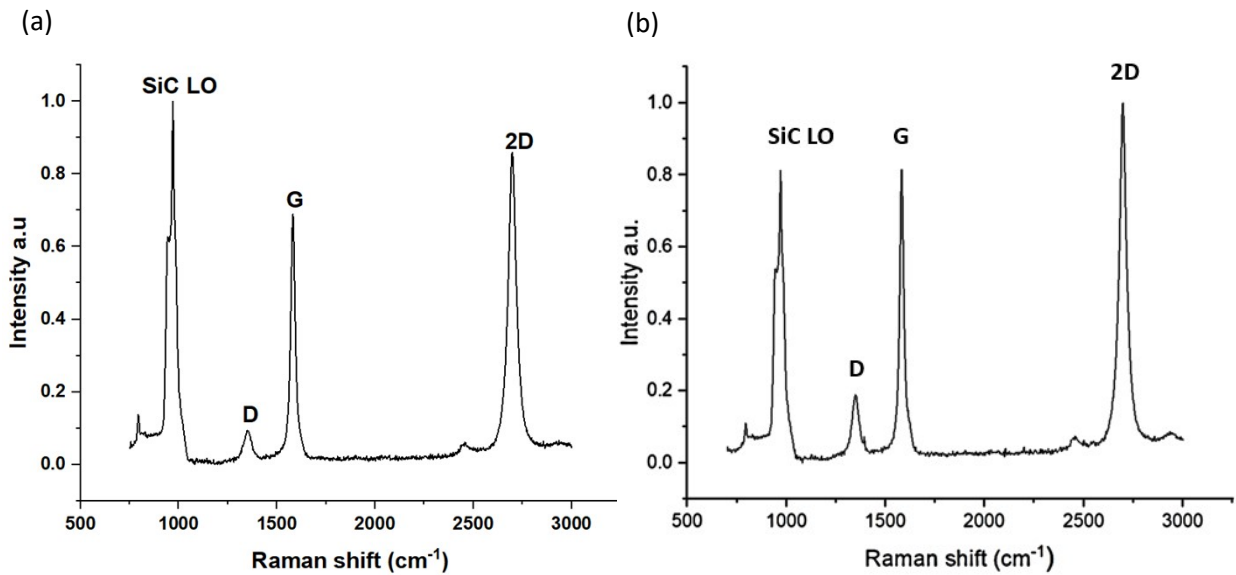

Figure S5: Comparison of average Raman maps (across 30 x 30 um² area) for graphene sample before (a) and after (b) freckle etching. Note that Figure S5 (b) is the same as Figure 13 in the manuscript.

	EG on 3C-SiC(100)/Si(100)
Carrier type	Holes
Sheet carrier concentration (±0.2) cm^{-2}	5.5 (±0.2) x 10^{12}
Mobility (±2) cm^{2}V^{-1}s^{-1}	331 (±1)
Sheet resistance (±1) k Ω/□	3.4k (±0.2) k

Table S4: van-der Pauw Hall effect measurements at room temperature. Error represents the variation across the current range of 1 to 10 μA.