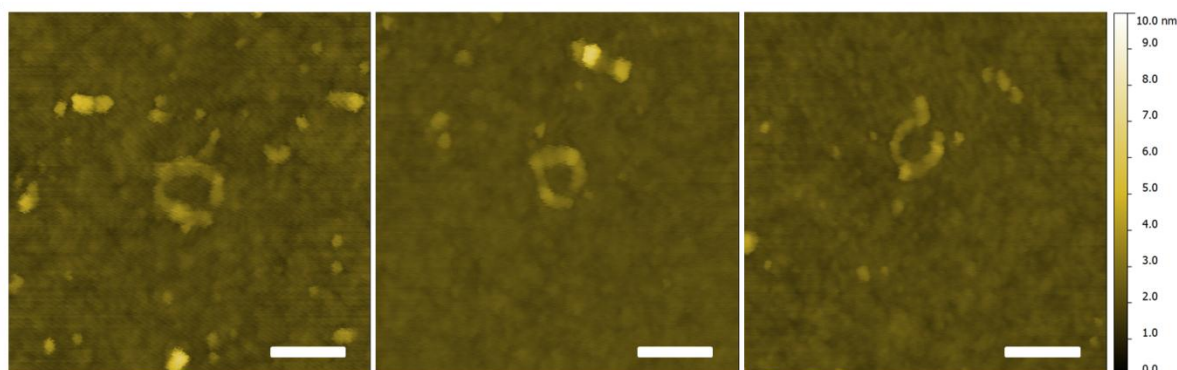


Supplementary Figure



Supplementary Figure 1 | C-shaped graphene or graphene arcs as by-products besides graphene nanorings. The scale bars are 100 nm.

Supplementary Tables

Specific shapes	Average value of dimensions	Lithography step 1: DNA templates on graphene	Lithography step 2: Metallized DNA masks on graphene	Lithography step 4: Graphene after etching and mask removal
ring-shape	height (nm)	2.9 ± 0.3	7.2 ± 1.4	1.2 ± 0.3
	width (nm)	16.1 ± 1.3	29.4 ± 3.2	19.0 ± 4.3
	outer diameter (nm)	75.7 ± 5.6	85.5 ± 8.9	81.7 ± 5.4
L-shape	height (nm)	2.1 ± 0.3	6.5 ± 1.1	1.1 ± 0.2
	width of long-arm (nm)	19.0 ± 2.5	29.7 ± 3.0	23.9 ± 2.4
	width of short-arm (nm)	25.6 ± 1.2	35.9 ± 3.8	29.1 ± 3.3
	length of long-arm (nm)	87.1 ± 2.7	102.4 ± 3.1	95.2 ± 2.5
	length of short-arm (nm)	61.5 ± 2.5	67.3 ± 6.1	64.4 ± 4.9
	angle of arms (degree)	93.3 ± 1.8	94.0 ± 5.2	94.4 ± 4.2
X-shape	height (nm)	1.9 ± 0.4	6.5 ± 1.0	1.2 ± 0.2
	width of arms (nm)	19.4 ± 2.0	31.8 ± 8.3	21.4 ± 3.7
	length of arms (nm)	37.4 ± 3.8	42.5 ± 5.2	38.6 ± 6.9
	acute angle of arms (degree)	72.9 ± 5.0	69.1 ± 4.4	75.0 ± 6.4

Y-shape	height (nm)	2.2 ± 0.2	6.3 ± 0.7	1.1 ± 0.1
	width of arms (nm)	22.4 ± 3.0	30.8 ± 4.1	24.2 ± 3.1
	length of long-arm (nm)	57.4 ± 3.0	67.9 ± 4.2	61.8 ± 3.1
	length of short-arm (nm)	36.4 ± 4.8	42.2 ± 5.2	41.2 ± 8.9
	obtuse angle of arms (degree)	141.1 ± 14.4	134.2 ± 16.6	139.9 ± 16.2
Z-shape	height (nm)	2.2 ± 0.3	7.1 ± 0.8	1.1 ± 0.1
	width of outer arms (nm)	21.9 ± 2.2	32.9 ± 3.0	24.2 ± 3.5
	width of inner-arm (nm)	18.3 ± 1.4	27.5 ± 2.1	20.3 ± 3.2
	length of outer-arm (nm)	60.1 ± 2.3	69.9 ± 3.8	57.5 ± 6.1
	length of inner-arm (nm)	95.8 ± 4.1	104.4 ± 6.7	95.5 ± 7.1
	angle of arms (degree)	48.9 ± 2.6	51.2 ± 3.8	52.9 ± 4.6

Supplementary Table S1 | The morphological changes of shape-specific nanostructures collected by AFM after different lithography steps. The average values of dimensions from ring-, L-, X-, Y- and Z-shapes collected on (lithography step 1) DNA templates immobilized on graphene, (lithography step 2) metallized DNA masks on graphene, (lithography step 4) graphene nanostructures after RIE etching and mask removal based on statistical analysis of more than 20 nanostructures for each shapes.

Average value of Raman signals	Lithography step 1: Graphene with DNA templates	Lithography step 2: Graphene with metallized DNA masks	Lithography step 3: After RIE etching	Lithography step 4: After mask removal
D band position (cm ⁻¹)	1322.59	1329.90	1329.79	1330.83
D band FWHM (cm ⁻¹)	29.47	36.63	34.72	24.31
D band height	65.39	515.19	2804.51	689.46
D band intensity	2957.93	27715.05	146604.46	26546.17
G ⁻ band position (cm ⁻¹)		1579.59	1577.61	
G ⁻ band FWHM (cm ⁻¹)		31.27	34.60	
G ⁻ band height		674.57	626.96	
G ⁻ band intensity		34449.66	33337.07	
G (or G ⁺) band position (cm ⁻¹)	1583.48	1592.45	1597.02	1586.86
G (or G ⁺) band FWHM (cm ⁻¹)	11.25	16.57	28.83	19.30
G (or G ⁺) band height	1341.86	2163.46	1564.66	899.84
G (or G ⁺) band intensity	23647.45	60503.27	70755.33	27120.03

D' band position (cm ⁻¹)		1619.71	1622.21	1623.29
D' band FWHM (cm ⁻¹)		18.94	19.44	11.86
D' band height		226.98	712.63	190.10
D' band intensity		7363.57	22029.37	3671.96
2D band position (cm ⁻¹)	2638.08	2644.14	2657.73	2647.44
2D band FWHM (cm ⁻¹)	26.76	37.49	48.93	34.30
2D band height	3484.82	4957.60	3143.93	1692.83
2D band intensity	146254.45	293134.70	236158.43	90372.39
Total G band intensity (including both G ⁻ and G ⁺)	23647.45	94952.93	104092.39	27120.03
I_{2D}/I_G intensity ratio	6.209	3.611	2.426	3.557
I_D/I_G intensity ratio	0.124	0.280	1.548	1.036

Supplementary Table S2 | Raman signals collected after each four lithography steps. The average values of Raman signals collected on (lithography step 1) graphene sheets with DNA nanostructures (including DNA nanorings and all letter-shapes), (lithography step 2) graphene sheets with metallized DNA nanostructures, (lithography step 3) after RIE etching and (lithography step 4) graphene nanostructures after mask removal based on statistical analysis of more than 200 Raman spectra. All the Raman peaks are fit to Lorentzians after background subtraction for statistical analysis. We observe that the samples derived from five different shapes (O-, X-, Y-, Z- and L-shapes) of DNA letter templates have almost the same Raman spectra after each lithography step due to their similar sizes. The statistical analysis in this Table included the experimental data of all five different DNA letter-shapes (roughly 40 spectra from each shape in each lithography step).