Electronic Supplementary Material (ESI) for Soft Matter.

Tuning Phase Structures of a Symmetrical Diblock Copolymer with a Patterned Electric Field

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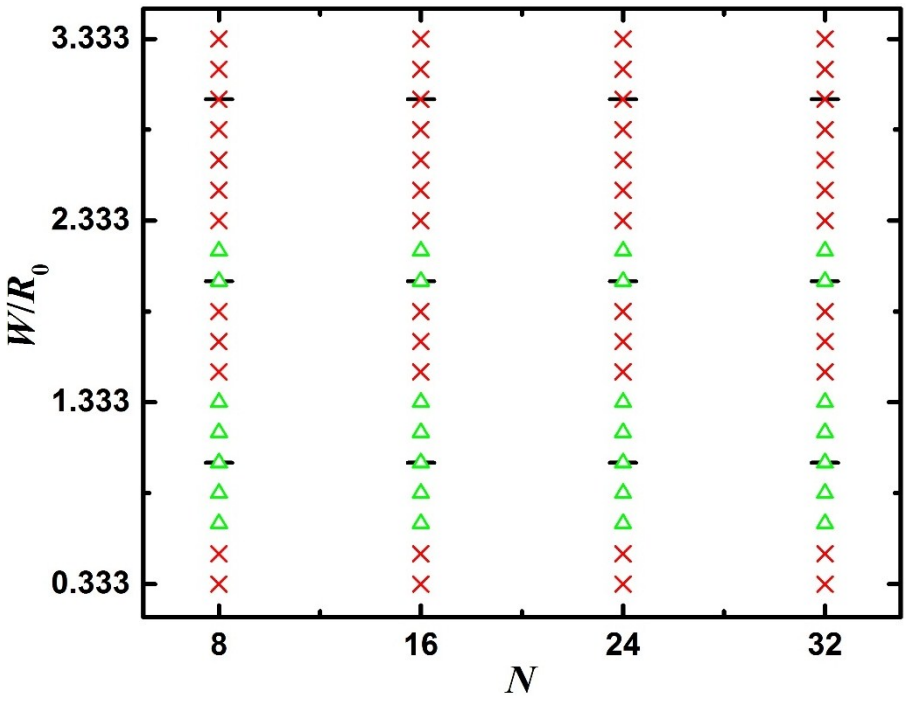
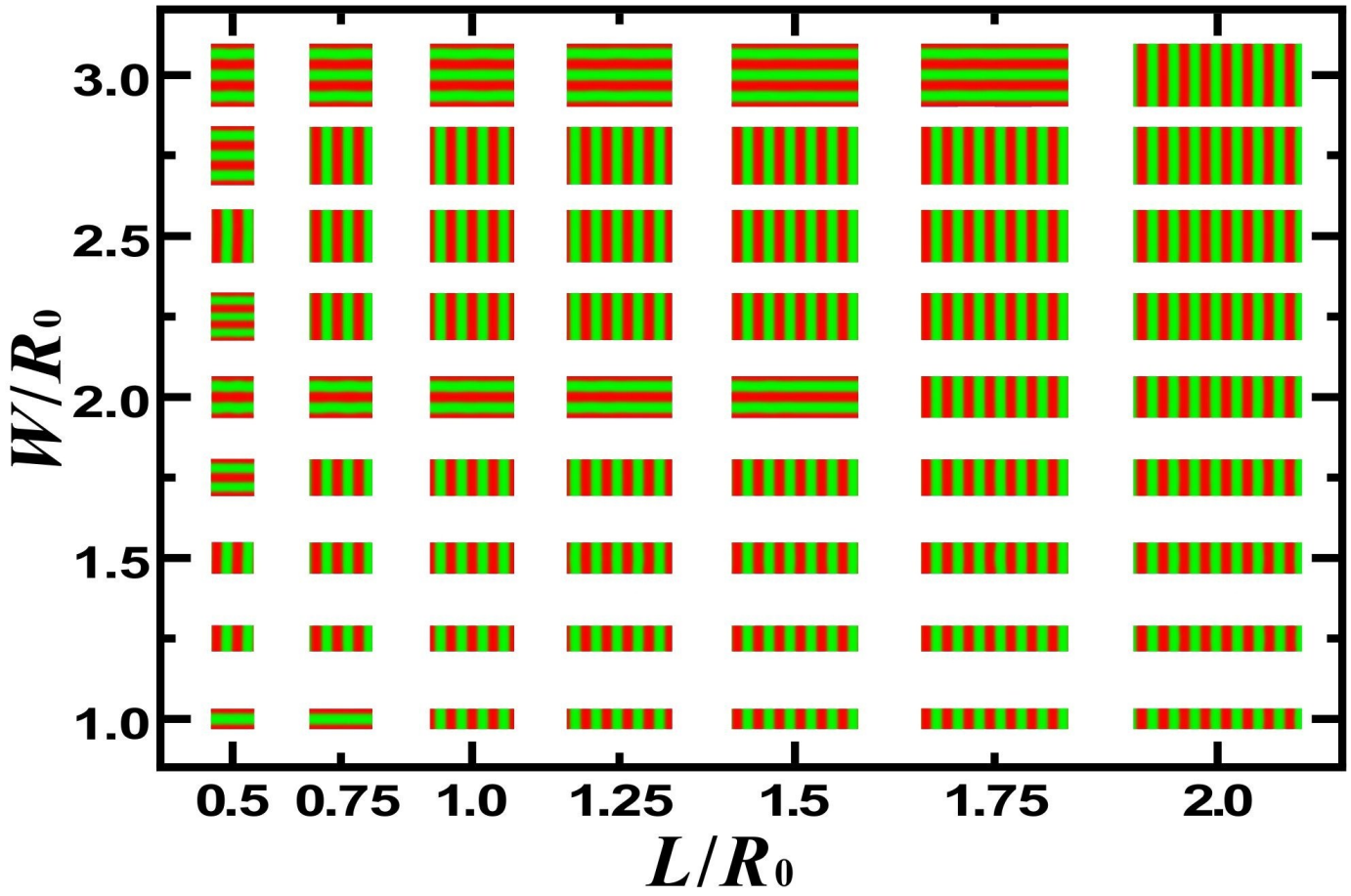
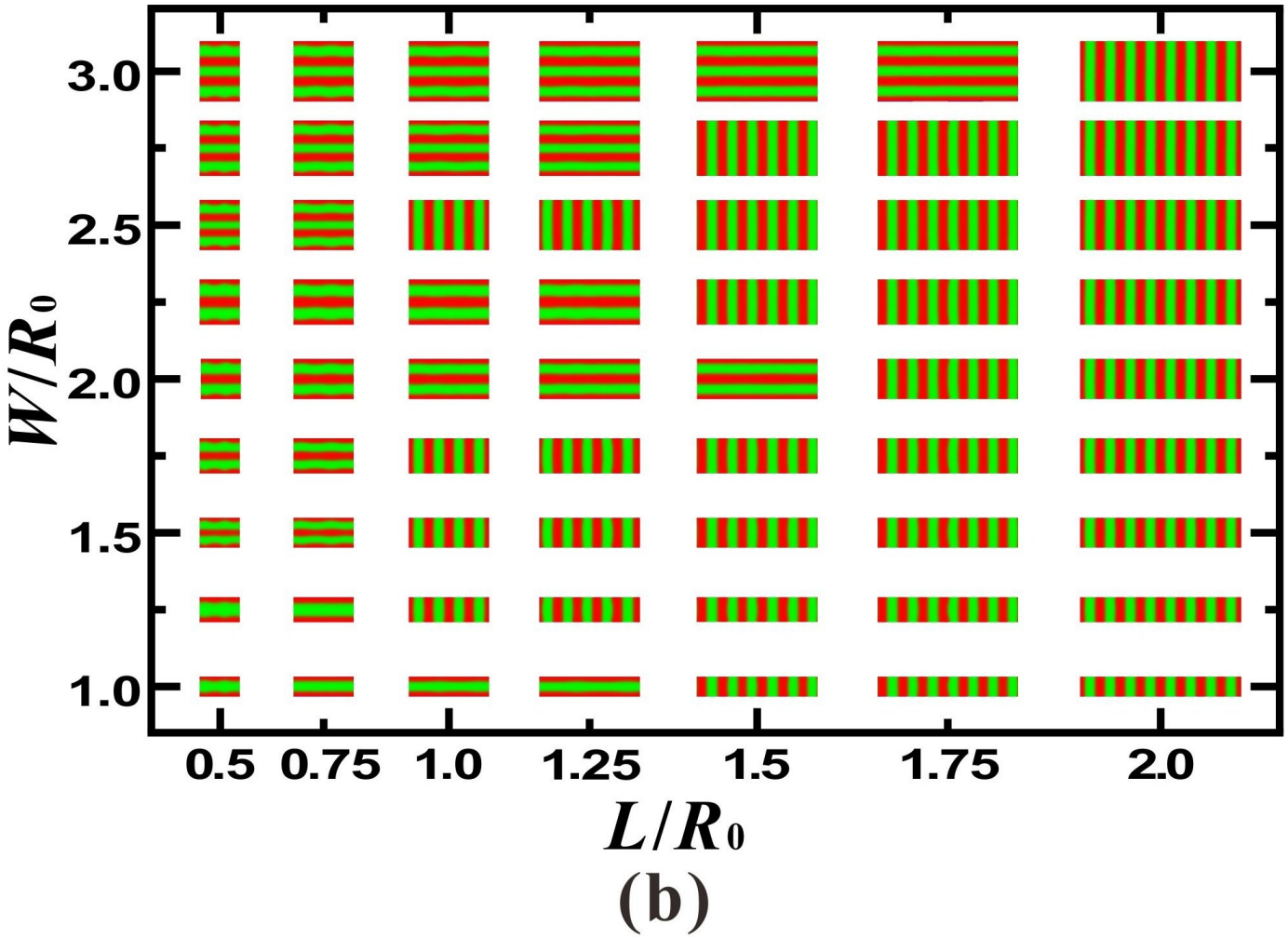
Supporting information



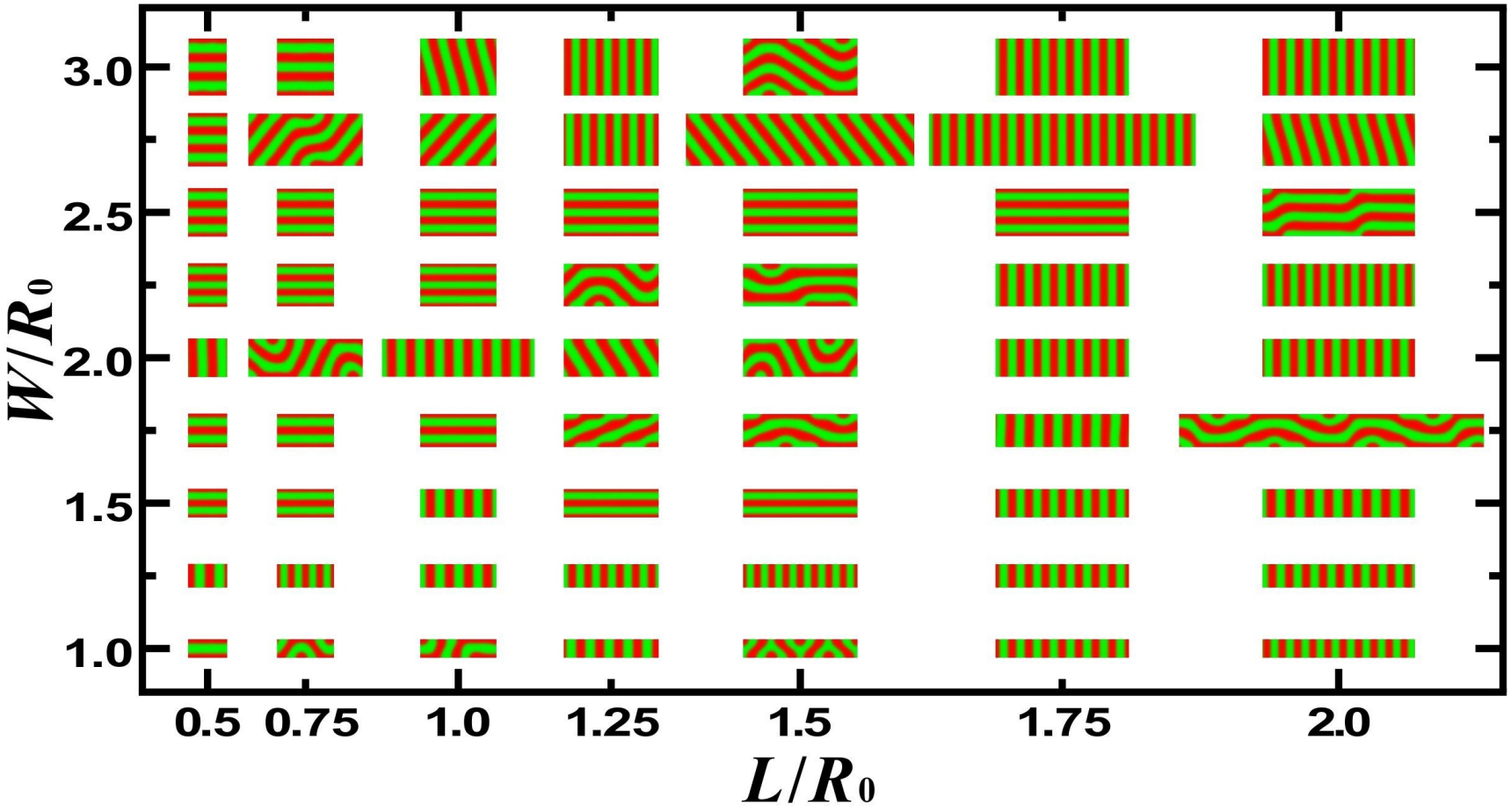
S1 Morphology diagram of a diblock copolymer thin film with $f = 0.5$, $\chi_{AB}N = 29.1$ and Kuhn length $b_B = 1.4b_A$. The diagram shows the equilibrium configuration in the confined space without electric field as a function of a diblock copolymer length N and film thickness W. Integer multiples of equilibrium phase period R_0 are indicated with horizontal black bars ($R_0 \approx 5.25R_g$ for N = 8, 16, 24, 32). Red crosses and green triangles indicate perpendicular phase structures and parallel configurations, respectively.



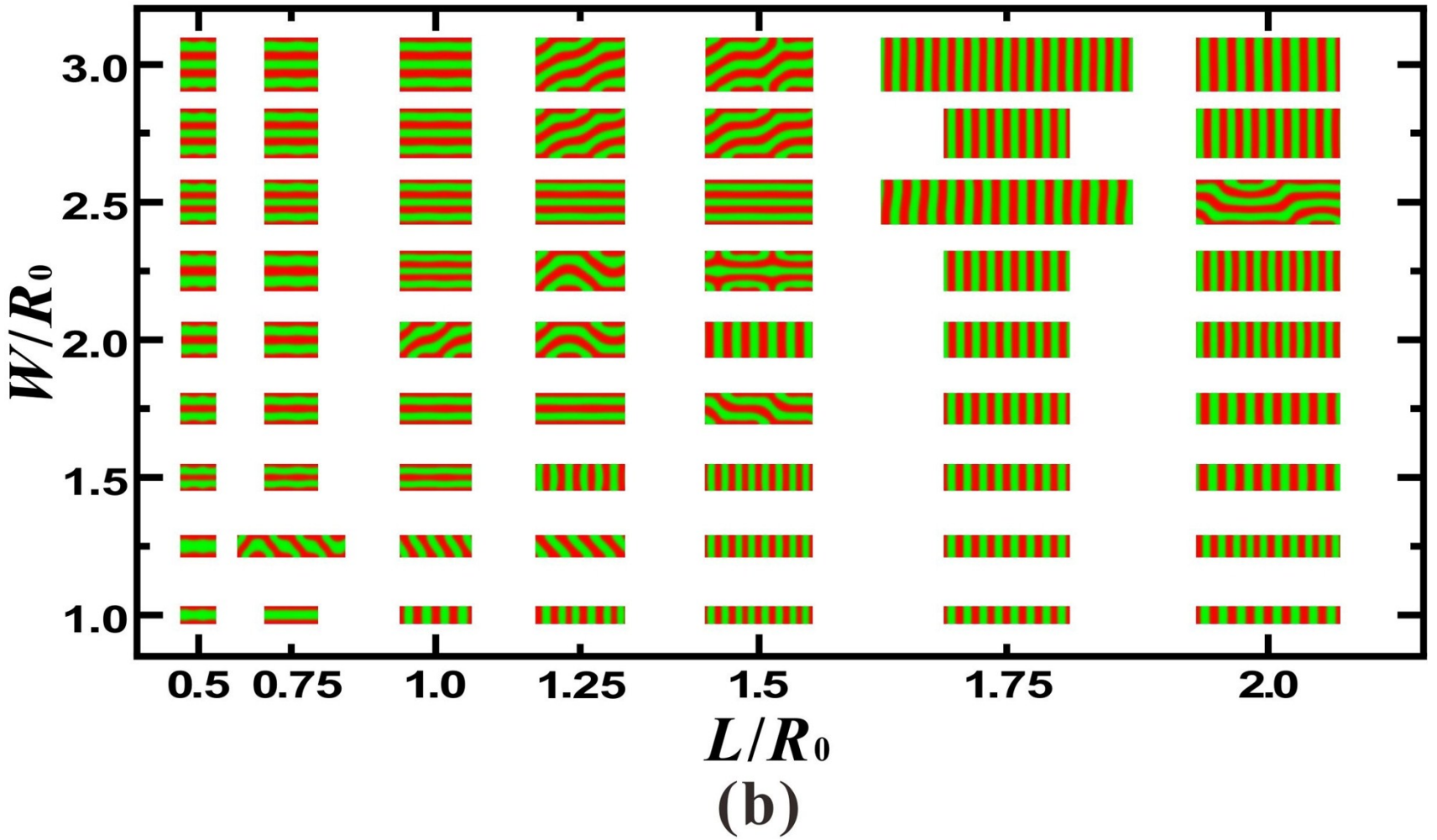
(a)



S2 Phase diagram of AB diblock copolymer melts depending on the film thickness (W) and the size of electrode (L) under alternatively distributed electric field. (a) U_{high} = 20.0 V, (b) U_{high} = 40.0 V. Here, U_{low} = 10.0 V, κ_A = 6.0 and κ_B = 2.5.



(a)



S3 The phase structures are achieved using annealing algorithm when varying the film thickness (W) and the size of electrode (L) under the alternatively distributed electric field. (a) U_{high} = 20.0 V, (b) U_{high} = 40.0 V. Here, U_{low} = 10.0 V, κ_A = 6.0 and κ_B = 2.5. Some of these phase structures in the X-direction with two periods are also examined.

TABLE Ⅰ. The free energy of phase structures under alternatively distributed electric field (U_{high} = 20.0 V).

L/R_0	W/R_0	A	P	V	S	L/R_0	W/R_0	A	P	V	S
0.50						1.50					
	1.00	0.408915	0.408886	0.413614	P		1.00	0.431580	0.423068	0.422690	V
	1.25	0.382348	0.383140	0.382193	V		1.25	0.400457	0.396400	0.390142	V
	1.50	0.368323	0.368298	0.360656	V		1.50	0.378436	0.378418	0.367874	V
	1.75	0.344561	0.344548	0.345021	P		1.75	0.355226	0.354172	0.351540	V
	2.00	0.333181	0.330088	0.333181	P		2.00	0.342868	0.339121	0.339158	P
	2.25	0.332216	0.322299	0.323885	P		2.25	0.332945	0.330836	0.329425	V
	2.50	0.318820	0.318823	0.316442	V		2.50	0.326041	0.326219	0.321571	V
	2.75	0.309376	0.309416	0.310330	A		2.75	0.316267	0.316258	0.315101	V
	3.00	0.303140	0.303135	0.305222	P		3.00	0.312313	0.309589	0.309684	P
0.75						1.75					
	1.00	0.425382	0.416951	0.419237	P		1.00	0.425420	0.423681	0.423094	V
	1.25	0.396586	0.390507	0.386727	V		1.25	0.392927	0.397017	0.390524	V
	1.50	0.374029	0.374002	0.364531	V		1.50	0.370613	0.378865	0.368201	V
	1.75	0.349878	0.349900	0.348407	V		1.75	0.355205	0.354617	0.351866	V
	2.00	0.339402	0.335048	0.336184	P		2.00	0.342113	0.339555	0.339480	V
	2.25	0.336330	0.326859	0.326609	V		2.25	0.332353	0.331266	0.329725	V
	2.50	0.322666	0.322673	0.318916	V		2.50	0.323540	0.326594	0.321862	V
	2.75	0.314226	0.313019	0.312598	V		2.75	0.317585	0.316624	0.315397	V
	3.00	0.317191	0.306518	0.307322	P		3.00	0.312561	0.309952	0.309963	P
1.00						2.00					
	1.00	0.423529	0.420365	0.420233	V		1.00	0.429859	0.424086	0.423557	V
	1.25	0.389320	0.393734	0.388013	V		1.25	0.392801	0.397415	0.390896	V
	1.50	0.366821	0.376455	0.365891	V		1.50	0.368526	0.379162	0.368511	V
	1.75	0.352233	0.352226	0.349756	V		1.75	0.355793	0.354911	0.352178	V
	2.00	0.338178	0.337262	0.337491	P		2.00	0.341741	0.339868	0.339758	V
	2.25	0.338228	0.329000	0.327870	V		2.25	0.333436	0.331536	0.329990	V
	2.50	0.324471	0.324483	0.320096	V		2.50	0.323571	0.326684	0.322115	V
	2.75	0.314822	0.314704	0.313713	V		2.75	0.316655	0.316877	0.315633	V
	3.00	0.308980	0.308153	0.308379	P		3.00	0.312205	0.310204	0.310178	V
1.25											
	1.00	0.422192	0.422162	0.422102	V						
	1.25	0.394154	0.395428	0.389608	V						
	1.50	0.377721	0.377701	0.367288	V						
	1.75	0.354867	0.353462	0.351000	V						
	2.00	0.341313	0.338434	0.338626	P						
	2.25	0.331753	0.330143	0.328906	V						
	2.50	0.325452	0.325637	0.321075	V						
	2.75	0.319134	0.315691	0.314630	V						
	3.00	0.313769	0.309048	0.309223	P						

A represents the annealing result, P represents the parallel lamellar phase structure, V represents the vertical layered phase structure, and S represents the phase structure with the lowest free energy (red).

TABLE Ⅱ. The free energy of phase structures under alternatively distributed electric field (U_{high} = 40.0 V).

L/R_0	W/R_0	A	P	V	S	L/R_0	W/R_0	A	P	V	S
0.50						1.50					
	1.00	0.172391	0.172386	0.198704	P		1.00	0.292201	0.284346	0.282561	V
	1.25	0.196451	0.196452	0.222225	A		1.25	0.304789	0.300659	0.295150	V
	1.50	0.228062	0.228197	0.233666	A		1.50	0.307678	0.309819	0.298014	V
	1.75	0.224076	0.224090	0.239387	A		1.75	0.301554	0.300233	0.297227	V
	2.00	0.223644	0.223629	0.242376	P		2.00	0.295084	0.294762	0.295067	P
	2.25	0.226654	0.226663	0.244105	A		2.25	0.296892	0.293064	0.292457	V
	2.50	0.236765	0.236779	0.245203	A		2.50	0.293929	0.293943	0.289790	V
	2.75	0.234094	0.234122	0.245943	A		2.75	0.289311	0.287803	0.287222	V
	3.00	0.233436	0.233574	0.246474	A		3.00	0.287784	0.283961	0.284841	P
0.75						1.75					
	1.00	0.232599	0.232590	0.249900	P		1.00	0.287587	0.289903	0.286628	V
	1.25	0.259606	0.250691	0.264514	P		1.25	0.300115	0.306148	0.298639	V
	1.50	0.271623	0.271618	0.269194	P		1.50	0.302941	0.313889	0.301196	V
	1.75	0.263780	0.263735	0.270061	P		1.75	0.302129	0.304072	0.300211	V
	2.00	0.259898	0.259893	0.269440	P		2.00	0.301143	0.298655	0.297902	V
	2.25	0.259753	0.259751	0.268284	P		2.25	0.298316	0.296977	0.295169	V
	2.50	0.265263	0.265261	0.267014	P		2.50	0.293789	0.297300	0.292386	V
	2.75	0.260471	0.260511	0.265781	A		2.75	0.291957	0.291036	0.289737	V
	3.00	0.257953	0.257987	0.264632	A		3.00	0.290756	0.287179	0.287252	P
1.00						2.00					
	1.00	0.261072	0.260689	0.261067	P		1.00	0.287214	0.293595	0.287197	V
	1.25	0.285426	0.277487	0.276503	V		1.25	0.307410	0.309887	0.299667	V
	1.50	0.292331	0.292301	0.281211	V		1.50	0.304366	0.316599	0.302459	V
	1.75	0.283399	0.283399	0.281756	V		1.75	0.303151	0.306924	0.301609	V
	2.00	0.283363	0.278584	0.280651	P		2.00	0.306382	0.301310	0.299380	V
	2.25	0.288617	0.277346	0.278935	P		2.25	0.303585	0.299462	0.296687	V
	2.50	0.280270	0.280291	0.277055	V		2.50	0.297208	0.299600	0.293925	V
	2.75	0.274642	0.274642	0.275210	A/P		2.75	0.293626	0.293332	0.291266	V
	3.00	0.271358	0.271358	0.273479	A/P		3.00	0.288786	0.289383	0.288786	A/V
1.25											
	1.00	0.281406	0.275646	0.277064	P						
	1.25	0.293392	0.292000	0.290074	V						
	1.50	0.297003	0.303370	0.293036	V						
	1.75	0.293987	0.293987	0.292386	V						
	2.00	0.291289	0.288779	0.290377	P						
	2.25	0.288001	0.287227	0.287909	P						
	2.50	0.288754	0.288754	0.285414	V						
	2.75	0.284296	0.282790	0.283022	P						
	3.00	0.281580	0.279162	0.280809	P						

A represents the annealing result, P represents the parallel lamellar phase structure, V represents the vertical layered phase structure, and S represents the phase structure with the lowest free energy (red).