# **Supplementary Information for**

Adsorption and Ordering of Amphiphilic Rod-Coil Block Copolymers on Substrate: Conditions for Well-Aligned Stripe Nanopatterns

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#### 1. Simulation Method

**1.1 Dissipative Particle Dynamics Method** Dissipative particle dynamics (DPD), a simulation technique for hydrodynamics behavior, were employed for the present study. The DPD method was introduced by Hoogerbrugge and Koelman and was reformulated by Español and Warren as a proper statistical mechanics model.<sup>S1-S3</sup> In DPD simulation, a particle represents a block or cluster of atoms or molecules moving together coherently. The time evolution of the DPD beads is governed by the equations of motion

$$\frac{d\mathbf{r}_i}{dt} = \mathbf{v}_i, \quad m_i \frac{d\mathbf{v}_i}{dt} = \mathbf{F}_i \tag{S1}$$

where  $\mathbf{r}_i$ ,  $\mathbf{v}_i$ , and  $\mathbf{F}_i$  are the displacement, the velocity, and the total force acting on the *i*th bead, respectively. The total force exerting on the *i*th bead contains five types of forces,

$$\mathbf{F}_{i} = \sum_{i \neq j} \left( \mathbf{F}_{ij}^{\mathrm{C}} + \mathbf{F}_{ij}^{\mathrm{D}} + \mathbf{F}_{ij}^{\mathrm{R}} \right) + \mathbf{F}_{i}^{\mathrm{B}} + \mathbf{F}_{i}^{\mathrm{A}}$$
(S2)

where  $\mathbf{F}_{ij}^{C}$ ,  $\mathbf{F}_{ij}^{D}$ ,  $\mathbf{F}_{ij}^{R}$ ,  $\mathbf{F}_{i}^{B}$ , and  $\mathbf{F}_{i}^{A}$  are nonbonded conservation force, dissipative force, random force, harmonic spring force for bonds, and angle force, respectively. The nonbonded conservative force is a soft repulsion taking the form as

$$\mathbf{F}_{ij}^{\mathrm{C}} = a_{ij}\omega^{\mathrm{C}}\left(r_{ij}\right)\hat{\mathbf{r}}_{ij}$$
(S3)

where  $a_{ij}$  is the maximum repulsion between *i* and *j* beads,  $r_{ij} = |\mathbf{r}_i - \mathbf{r}_j|$  is the distance between these two beads,  $\hat{\mathbf{r}}_{ij} = (\mathbf{r}_i - \mathbf{r}_j)/r_{ij}$  is the unit vector. The dissipative force is a friction force, given by

$$\mathbf{F}_{ij}^{\mathrm{D}} = -\gamma \omega^{\mathrm{D}}(r_{ij})(\hat{\mathbf{r}}_{ij} \cdot \mathbf{v}_{ij})\hat{\mathbf{r}}_{ij}$$
(S4)

where  $\gamma$  is a friction coefficient, and  $\mathbf{v}_{ij} = \mathbf{v}_i \cdot \mathbf{v}_j$  is the relative velocity. The random force, acting as a heat source, is given by

$$\mathbf{F}_{ij}^{\mathrm{R}} = \sigma \omega^{\mathrm{R}}(r_{ij}) \xi_{ij} \Delta t^{-1/2} \hat{\mathbf{r}}_{ij}$$
(S5)

where  $\sigma$  is the noise amplitude, and  $\xi_{ij}$  is a random fluctuating variable with Gaussian statistics

$$\left\langle \xi_{ij}\left(t\right)\right\rangle = 0, \quad \left\langle \xi_{ij}\left(t\right)\xi_{kl}\left(t'\right)\right\rangle = \left(\delta_{ik}\delta_{jl} + \delta_{il}\delta_{jk}\right)\delta\left(t-t'\right)$$
(S6)

The parameters  $\gamma$  and  $\sigma$  are coupled by  $\sigma^2 = 2\gamma k_{\rm B}T\Delta t$ , where *T* is the absolute temperature and  $k_{\rm B}$  is the Boltzmann constant. We set  $\gamma = 4.5$  and  $\sigma/\Delta t^{1/2} = 3.0$ , respectively.<sup>S4, S5</sup> The  $\omega^{\rm C}(r_{ij})$ ,  $\omega^{\rm D}(r_{ij})$ , and  $\omega^{\rm R}(r_{ij})$  follows the relation

$$\omega^{\mathrm{D}}(r) = \left[\omega^{\mathrm{R}}(r)\right]^{2} = \left[\omega^{\mathrm{C}}(r)\right]^{2} = \begin{cases} \left(1-r\right)^{2} & r < 1\\ 0 & r \ge 1 \end{cases}$$
(S7)

The harmonic spring force for a bond is the derivative of the harmonic spring potential  $u_i^{\rm B}$  with respect to bond length  $r_{\rm B}$ , where  $u_i^{\rm B}$  is

$$u_{i}^{B} = \sum_{B} k_{B} \left( 1 - r_{B} / r_{eq} \right)^{2}$$
(S8)

Here, we choose the spring constant  $k_{\rm B}$  =100 and the equilibrium bond distance  $r_{\rm eq}$ =0.7. In addition, an angle force is applied for the rod blocks to ensure the rigidity of the blocks. The angle force is the derivative of the angle potential  $u_i^{\rm A}$  with respect to the angle  $\theta_i$ , where  $u_i^{\rm A}$  is

$$u_i^{\rm A} = k_{\rm A} \left( \cos \theta_i - \cos \theta_{\rm eq} \right)^2 \tag{S9}$$

Here, the equilibrium value  $\theta_{eq}$  of the angle is set to be  $\pi$ . Unless otherwise specified, the values of  $k_A$ = 20  $k_BT$  and  $k_A = 0$  were set for the rod blocks and coil blocks, respectively. To study the effect of the block rigidity on the adsorption and ordering behaviors, we varied the  $k_A$  value from 0 to 100. Note that  $u_i^A = 0$  and  $u_i^B = 0$  for the solvents since they are individual beads.

**1.2 Calculation of Order Parameter** To evaluate the order of the stripe patterns, we introduced an order parameter *S* to describe the order degree of stripe alignment.<sup>S6,S7</sup> The order parameter  $S_d$  relative to the orientation direction is defined as

$$S_{\rm d} = \left\langle \frac{3 \left[ \mathbf{u} \left( \mathbf{r} \right) \cdot \mathbf{u}_{\rm d} \right]^2 - 1}{2} \right\rangle \tag{S10}$$

where  $\mathbf{u}_i(\mathbf{r})$  is the *i*th normal vector of the domain surface<sup>S8</sup>, and  $\mathbf{u}_d$  is the normalized vector of orientation direction. By choosing different  $\mathbf{u}_d$ , we can get different values of  $S_d$ . The order parameter *S* for the domain is determined as the maximum value of  $S_d$ .

### 2. Experimental Method

**2.1 Synthesis and Characterization of PBLG-***b***-PEG Block Copolymers.** PBLG-*b*-PEG block copolymers were synthesized in an anhydrous 1,4-dioxane solution using ring-opening polymerization of BLG-NCA initiated by anhydrous mPEG-NH<sub>2</sub> macroinitiator.<sup>S9-S11</sup> The reaction was performed in a flame-dried reaction bottle under a dry nitrogen atmosphere at 15 °C. After three days, the reaction mixture was poured into a large volume of anhydrous ethanol. The precipitates were collected and dried under vacuum. Then, the products were purified twice by repeated precipitation from a chloroform solution into a large volume of anhydrous methanol.

We used <sup>1</sup>H NMR measurement (Avance 550, Nuclear, CDCl<sub>3</sub> as solvent) to characterize the number-average molecular weight ( $M_n$ ) of the synthesized block copolymers. A typical <sup>1</sup>H NMR spectrum is given in Figure S1a. Since the molecular weight of PEG is definite (5000 kg/mol), the molecular weight of PBLG can be obtained by calculating the ratio of the peak intensity of the methylene proton signal (5.1 ppm) of PBLG to that of the ethylene proton signal (3.6 ppm) of PEG in the <sup>1</sup>H NMR spectrum. The obtained molecular weight of PBLG blocks is *ca.* 12000 kg/mol. The polydispersity of the PBLG-*b*-PEG diblock copolymers was determined by gel permeation chromatography (PL-GPC, Varian, PBLG as standard) in dimethylformamide (DMF) at room temperature. The PDI of PBLG-*b*-PEG diblock copolymers in this work is 1.18. The typical GPC trace of PBLG-*b*-PEG is shown in Figure S1b.



**Figure S1.** (a) <sup>1</sup>H NMR spectra of PBLG-*b*-PEG block copolymers in CDCl<sub>3</sub>. (b) GPC trace of PBLG-*b*-PEG block copolymers, where the DMF used as eluent solvents.

**2.2 Preparation of Ultrathin PS Films on the Silicon Wafer.** We prepared polystyrene (PS) nanolayers irreversibly adsorbed on Si (100) substrates (PS substrate, insoluble in THF/DMF) according to literatures.<sup>S12,S13</sup> The Si (100) wafer was first immersed in a hot piranha solution (H<sub>2</sub>SO<sub>4</sub>: H<sub>2</sub>O<sub>2</sub> = 3:1) for 30 min, then rinsed with a vast amount of deionized water, and finally dried with a nitrogen gun. The PS with  $M_n = 537$  kg/mol and PDI = 1.03 was dissolved in toluene, and the solutions were spin-coated on the Si (100) wafers. The PS films with the thickness of *ca*. 140 nm were obtained on the Si wafers. The spin-cast PS films were annealed at *ca*. 160 °C for three days under vacuum below  $10^{-3}$  Torr and leached in baths of a good fresh solvent (toluene) at room temperature until the resultant film thickness remained constant. The resultant ultrathin PS films were dried in a vacuum oven at 50 °C for 24 h to remove the excess solvent trapped in the films.

We used a blade to make scratches on the substrate covered with PS. Note that the hardness of the blade is lower than that of the silicon wafer. Then, we determined the height of PS coatings by AFM measurement. Figure S2 shows the AFM phase image (the bottom shows the height profile) for PS films. As shown in Figure S2a, the thickness of PS films is *ca*. 14 nm before immersion into the THF/DMF (1/1) solvent mixture. After the immersion into the solvent mixture, the thickness of the PS film shows a slight decrease, which is *ca*. 12 nm (Figure S2b). However, we can not ascertain whether such a decrease results from the detachment of PS chains from the surface or not. This is because (i) the surface of the PS film can remain smooth after immersion (see Figure S2b), and (ii) the decreased value is within range of the measurement error from sampling.



**Figure S2** AFM images (the bottom shows the height profile) for the PS film (a) before and (b) after the immersion into the THF/DMF (1/1) solvent mixture. The scratches on the substrate are created using a blade.

**2.3** Assembly of PBLG-*b*-PEG on the Surface of PS-Silicon Wafer. The self-assembly of copolymers was conducted by a selective precipitation method according to our previous work<sup>S9</sup>. First, PBLG<sub>12000</sub>-*b*-PEG<sub>5000</sub> are dissolved in the mixture of tetrahydrofuran (THF) and N,N-dimethylformamide (DMF) (THF/DMF = 1/1 in volume, polymer concentration = 0.4 g·L<sup>-1</sup>) at 20 °C. Then, a piece of PS-silicon wafer was placed in 3 mL of block copolymer solutions in a sealed

beaker. Afterward, 1.2 mL of deionized water was added to 3 mL of polymer solution at a rate of *ca*. 1 mL/h with slightly stirring. The process of self-assembly is illustrated in Figure S3. After incubation for 2 hours, the wafer was taken out and rinsed with a great amount of deionized water to remove the remaining solution. The samples are dried in a vacuum for 30 min before characterizations.



**Figure S3.** Schematic of the self-assembly of PBLG-*b*-PEG on PS-silicon wafer. (a) The wafer and the block copolymer solutions are placed in a sealed beaker. (b) Aggregates are formed on the substrate after adding water. (c) Stripe patterns are formed as the water is further added.

**2.4 AFM Characterization.** Atomic force microscopy (AFM) is used to characterize the morphologies of thin films formed by  $PBLG_{12000}$ -*b*-PEG<sub>5000</sub>. The AFM images are obtained with the XE-100 AFM instrument (Park Systems), and the tapping mode was employed for the characterization.

**2.5 GISAXS Characterization.** The structures of the thin films were further characterized by grazing-incidence small-angle X-ray scattering (GISAXS) measurements. GISAXS measurements were performed at the Shanghai Synchrotron Radiation Facility (SSRF) 16B station. An incident X-

ray beam of energy of 10 keV ( $\lambda = 0.124$  nm) was used for the measurements. Two-dimensional GISAXS patterns are collected by a detector (2048 × 2048 pixels with a pixel size of 80 µm) placed at a distance of 1909 mm away from the sample. The in-plane period *d* is calculated from Bragg's Law, where  $d = 2\pi/q$ . The incident angle is 0.3°. Note that the critical incident angle for the PBLG-*b*-PEG film at 10 keV is about 0.15°. Because we aim to obtain the structure of the film rather than the film surface, the incident angle above the critical angle was adopted. Actually, we found that the GISAXS patterns measured from incident angles of 0.15° and 0.3° are similar, implying the structure of the film surface is consistent with the structure of the entire film. Because the film is ultrathin in this work, and ultrathin layers have lower total scattering intensity, the GISAXS measurement requires longer exposure times.<sup>S14</sup> In this work, the exposure time is 100s.

We used the correlation length to characterize the grain size in terms of 1D GISAXS spectra. The correlation length  $\xi$  is inversely proportional to the full width of half-maximum of the peak  $\Delta q_{xy}$ , that is,  $\xi = 2\pi k/\Delta q_{xy}$ . Here, k=1.03 is a constant related to the grain shape.<sup>S15,S16</sup> The  $\Delta q_{xy}$  is about 0.01 nm<sup>-1</sup> according to the 1D GISAXS spectra shown in Figure 9a, and therefore the correlation length  $\xi$  is about 650 nm, which is *ca*. 13 times of the periodicity.

#### **3. Effect of DPD Packings on the Simulation Result**

We examined the effect of DPD bead packing on the adsorption of polymers. For the sake of clarity, we considered a simple system consisting of polymers (C) and a substrate (P) with various DPD bead packings. The polymer (C) consists of 10 DPD beads and is hydrophilic by setting  $a_{CS}$ =25. The substrate (P) is hydrophobic and slightly repulsive to polymers by setting  $a_{PS}$ =200 and  $a_{PC}$ =30. Three kinds of packings were included, that is, FCC, BCC, and cubic arrangements.

Figure S4 shows the density distribution of flexible polymers as a function of the position *z* way from the substrate. As shown, the packing of DPD beads in a flat substrate can influence the adsorption of copolymers. Such influence is marked as the unit cell dimension is large (*e.g.*, 1.0  $r_c$ ), where the density distributions are different (Figure S4a). However, the influence becomes less pronounced as the DPD beads are arranged closer. For example, at the unit cell dimension of 0.6  $r_c$ , the distributions of polymers adsorbed on BCC- and FCC-packed substrates are almost the same (Figure S4b). Although the distribution of polymers adsorbed on the cubic-packed substrate is still different from those on BCC- and FCC-packed substrates, this difference can be minimized by decreasing the unit cell dimension to 0.5  $r_c$  (Figure S4b).

In this work, the minimum distance between DPD beads is 0.4  $r_c$  (the unit cell dimension is ca. 0.57  $r_c$ ), which is enough to eliminate the effect of packing fashion.



Figure S4. Density distributions of flexible polymers as a function of the position *z* way from the substrate with various DPD bead packings, where the polymer concentration is 0.3. The unit cell dimensions are (a) 1.0  $r_c$  and (b) 0.6  $r_c$ . In (b), the cubic packing with a unit cell dimension of 0.5  $r_c$  is also given for comparison. The polymer (C) consists of 10 DPD beads and is hydrophilic by setting  $a_{CS}=25$ . The substrate (P) is hydrophobic and slightly repulsive to polymers by setting  $a_{PS}=200$  and  $a_{PC}=30$ .

#### 4. Effect of Copolymer Concentration and Surface Affinity on the Morphologies

To direct view of the morphologies of the systems and gain an intuitive understanding of the self-assembly behavior, we provided top-view morphologies (Figure S5) and the snapshots of the structures formed on the substrate (Figure S6), respectively. As shown in the two figures, there are three kinds of primary morphologies. They are surface micelles, surface stripes, and surface stripes with micelles dispersed in solution. When the copolymer concentration is lower, the copolymers are almost absorbed by the substrate and form surface micelles of spherical shape. Surface stripes without micelles dispersed in solution were observed for the systems with intermediate concentration and high surface affinity. Note that for these two cases, there still exist free copolymers in the solutions. When the copolymer concentration is higher, the surface stripes with micelles dispersed in solution such that for these two cases, there still exist free copolymers in the solutions. When the copolymer concentration is higher, the surface stripes with micelles dispersed in solution such that for these two cases, there still exist free copolymers in the solutions. When the copolymer concentration is higher, the surface stripes with micelles dispersed in solution are formed. In particular, for the substrate with higher surface affinity, well-aligned stripes were found on the substrate.



**Figure S5.** Top view (from the top of the box to the bottom of the box) of the morphologies formed by rod-coil block copolymer solutions with a substrate positioned at the bottom of the simulation box. The morphologies are obtained at  $30000\tau$ . In these snapshots, both the micelles in the bulk solution and the films on the substrate are included.



**Figure S6.** Snapshots of the morphologies of the thin film formed by rod-coil block copolymers on the substrate. The morphologies are obtained at  $30000\tau$ . In these snapshots, the micelles in the bulk solution are excluded.

#### 5. Affinity Preference of the PBLG and PEG to the PS Surface

The affinity preference of the PBLG and PEG to the PS surface can be understood by Hansen solubility parameters (HSP). Hansen solubility parameters can be divided into two components, namely, a nonpolar component ( $\delta_d$ ) and a polar component ( $\delta_a$ ) ( $\delta_a^2 = \delta_P^2 + \delta_H^2$ , where  $\delta_P$  and  $\delta_H$  are the contributions from dipole-dipole interaction and hydrogen-bonding interaction, respectively).<sup>S17</sup> Table R1 shows the Hansen solubility parameters of the polymers. As shown, the PBLG can haves a  $\delta_d$  of *ca*. 17.7 (J/ml)<sup>0.5</sup> and a  $\delta_a$  of *ca*. 9.93 (J/ml)<sup>0.5</sup>. The  $\delta_d$  and  $\delta_a$  of PEG are *ca*. 17.0 (J/ml)<sup>0.5</sup> and 13.9 (J/ml)<sup>0.5</sup>, respectively. The  $\delta_d$  and  $\delta_a$  of PS are *ca*. 18.7 (J/ml)<sup>0.5</sup> and 6.86 (J/ml)<sup>0.5</sup>, respectively.

The distance ( $R_a$ ) between Hansen parameters can be calculated to determine if two polymers (1 and 2) are miscible, where  $R_a^2 = 4(\delta_{d1}-\delta_{d2})^2 + (\delta_{a1}-\delta_{a2})^2$ . If two polymers are miscible,  $R_a$  must not exceed  $R_0$  (the radius of the interaction of an HSP solubility sphere). The  $R_0$  depends on the chemical species of polymers and decreases with increasing the molecular weight of polymers. Sine PBLG, PS, and PEG have similar  $\delta_d$  but different  $\delta_a$ , the PBLG can be slightly incompatible with PS, while the PEG is more incompatible with PS.

In addition to the affinity preference of PBLG (and PEG) to PS, the interaction between PS and solvents can also affect the preference of PS surface to PBLG-*b*-PEG block copolymers. Because the PS is more incompatible with the solvents than hydrophilic PEG (and PBLG), the PS surface of the wafer has a preference for the PBLG-*b*-PEG block copolymers as compared with the solvents.

Polymer	Nonpolar Component δ <sub>d</sub> (J/ml) <sup>0.5</sup>	Polar Component δ <sub>a</sub> (J/ml) <sup>0.5</sup>	References and Notes
PBLG	17.7 <sup>a</sup>	9.93 <sup>b</sup>	a. Average value of 16.37 and 19.03;
			b. Average value of 2.05 and 17.8;
			J. Colloid Interf. Sci. 1978, 67, 118-
			126
PEG	17.0	13.9	Eur. Polym. J. 2007, 43, 3068-3093
PS	18.7	6.86	Allan F. M. Barton, CRC Handbook of
			Solubility Parameters and Other
			Cohesion Parameters, 2nd ed., 1991

## Table S1 Hansen solubility parameters of the polymers

#### 6. Bulk Morphology of PBLG-b-PEG Block Copolymer

We investigated the bulk phase morphology of the PBLG<sub>59</sub>-*b*-PEG<sub>113</sub> block copolymer used in the study. However, we found that it is difficult to prepare the bulk sample with ordered structures. Because the PBLG-*b*-PEG-*b*-PBLG with 25-64 mol% PBLG can form a lamellar microphase-separated morphology<sup>S18</sup>, it is inferred that the PBLG<sub>59</sub>-*b*-PEG<sub>113</sub> (*ca.* 34 mol%) can form lamellar structures in bulks. Therefore, the morphologies in bulk and on PS-silicon could be similar, but the immersion method can induce the ordering of structures.

### References

- S1. P. J. Hoogerbrugge and J. M. V. A. Koelman, Europhys. Lett., 1992, 19, 155.
- S2. J. M. V. A. Koelman and P. J. Hoogerbrugge, Europhys. Lett., 1993, 21, 363.
- S3. P. Espanol and P. Warren, *Europhys. Lett.*, 1995, **30**, 191.
- S4. C. Cai, L. Wang, J. Lin and X. Zhang, Langmuir, 2012, 28, 4515.
- S5. T. Jiang, L. Wang, S. Lin, J. Lin and Y. Li, Langmuir, 2011, 27, 6440.
- S6. X. Zhang, L. Wang, L. Zhang, J. Lin and T. Jiang, *Langmuir*, 2015, **31**, 2533.
- S7. L. Zhang, L. Wang and J. Lin, ACS Macro Lett., 2014, 3, 712.
- S8. X. Zhu, L. Wang and J. Lin, J. Phys. Chem. B, 2013, 117, 5748.
- S9. E. R. Blout and R. H. Karlson, J. Am. Chem. Soc., 1956, 78, 941.
- S10. C. Cai, L. Zhang, J. Lin and L. Wang, J. Phys. Chem. B, 2008, 112, 12666.
- S11. C. Cai, Y. Li, J. Lin, L. Wang, S. Lin, X.-S. Wang and T. Jiang, Angew. Chem. Int. Ed., 2013, 52, 7732.
- S12. C. Housmans, M. Sferrazza and S. Napolitano, Macromolecules, 2014, 47, 3390.
- S13. Y. Fujii, Z. Yang, J. Leach, H. Atarashi, K. Tanaka and O. K. C. Tsui, *Macromolecules*, 2009, 42, 7418.
- S14. D. Posselt, D.-M. Smilgies, P. Busch and C. M. Papadakis. Synchrotron Radiation News 2002, 15, 35.
- S15. T. J. Giammaria, F. F. Lupi, G. Seguini, M. Perego, F. Vita, O. Francescangeli, B. Wenning, C. K. Ober, K. Sparnacci, D. Antonioli, V. Gianotti and M. Laus. ACS Appl. Mater. Interfaces 2016, 8, 9897.
- S16. D. H. Kim, and S. Y. Kim. J. Phys. Chem. Lett. 2017, 8, 1865.
- S17. C. M. Hansen, Hansen Solubility Parameters: A User's Handbook, 2nd Edition, 2007.
- S18. H.-A. Klok and S. Lecommandoux. Adv. Polym. Sci. 2006, 202, 75.