Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Fabrication of nanowires in micropatterns using block copolymers

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1. **Phase behavior of PS-b-P2VP 44-b-18.5 k thin films**

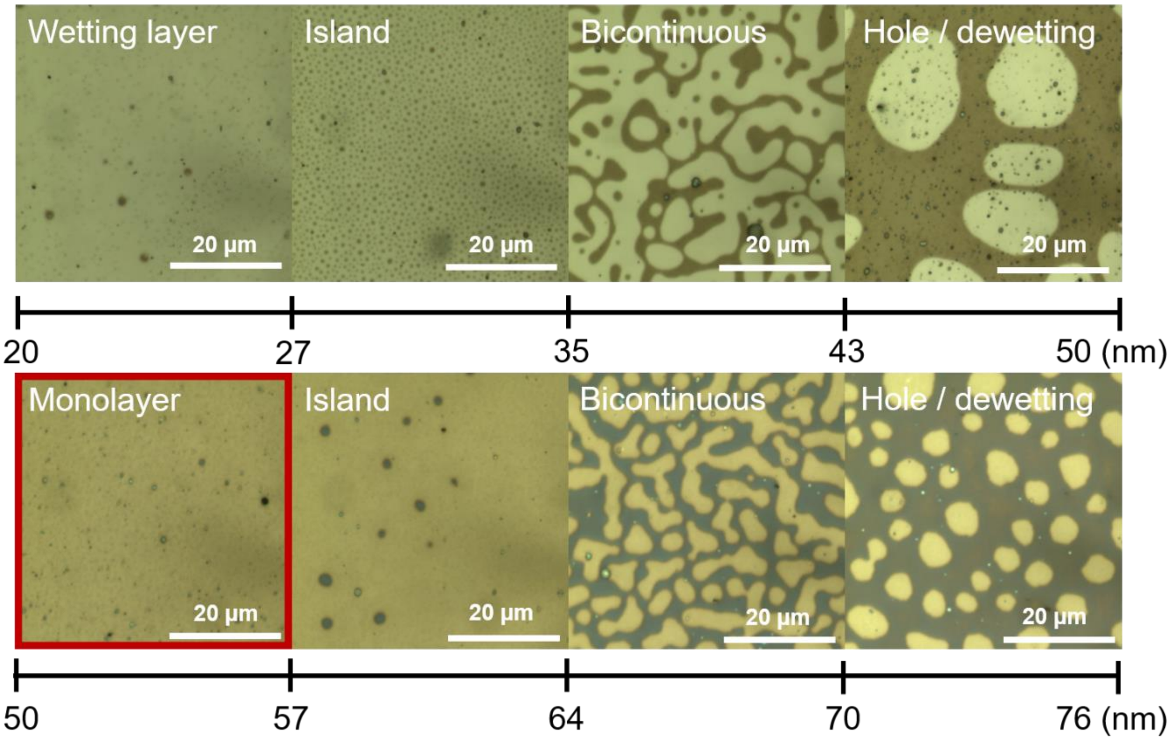

Fig.S1. Macroscopic phase behavior of PS-b-P2VP 44-b-18.5 k thin films. All of optical microscope (OM) images were obtained after thermal annealing at 170 ℃ for 24 h under vacuum.

2. Investigation of optimal shear condition with varying film thickness

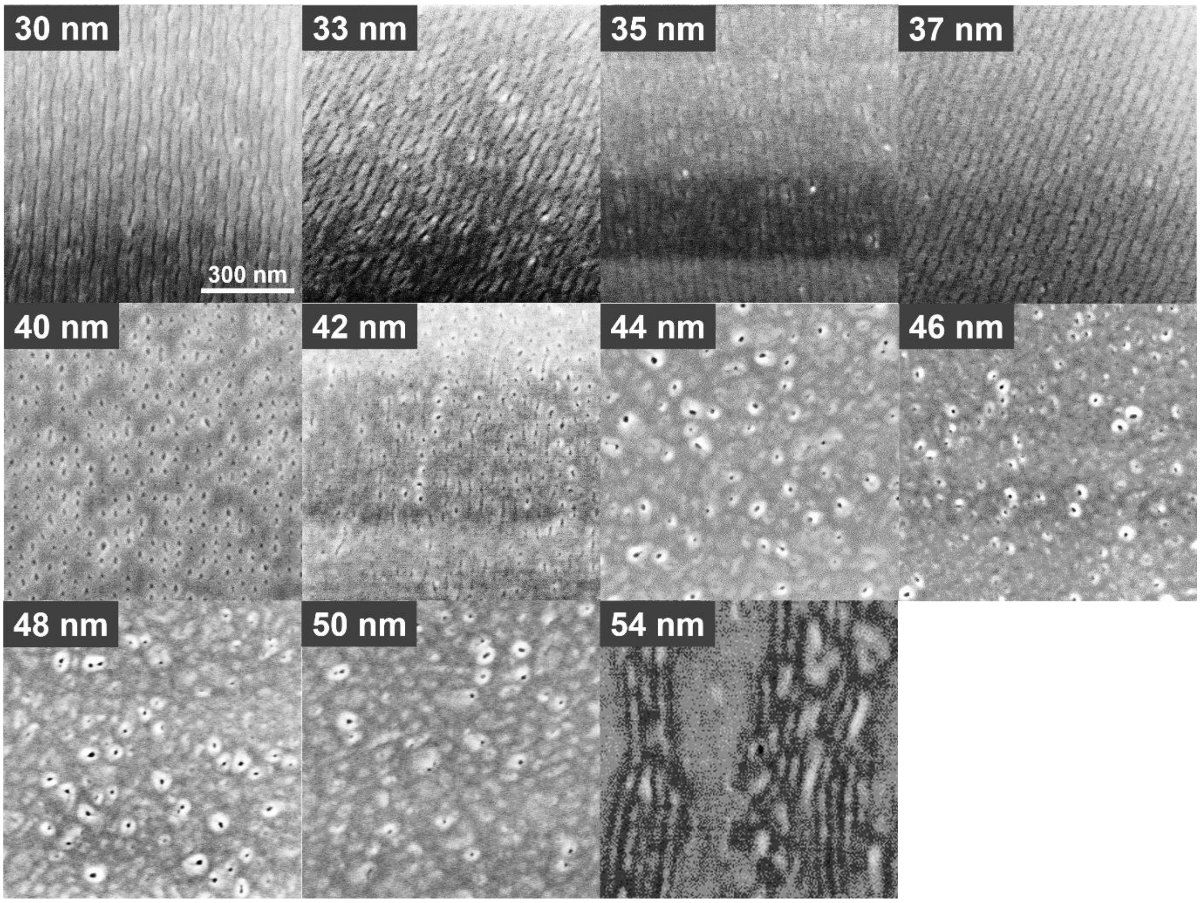

Fig.S2. SEM images of PS-b-P2VP 44-b-18.5 k thin films after applying shear stress. Shear stress was given at 150 ℃, 27 kPa for 30 min. All of images were obtained after soaking in ethanol for 20 min.

3. Calculation detail of Hermans orientation factor

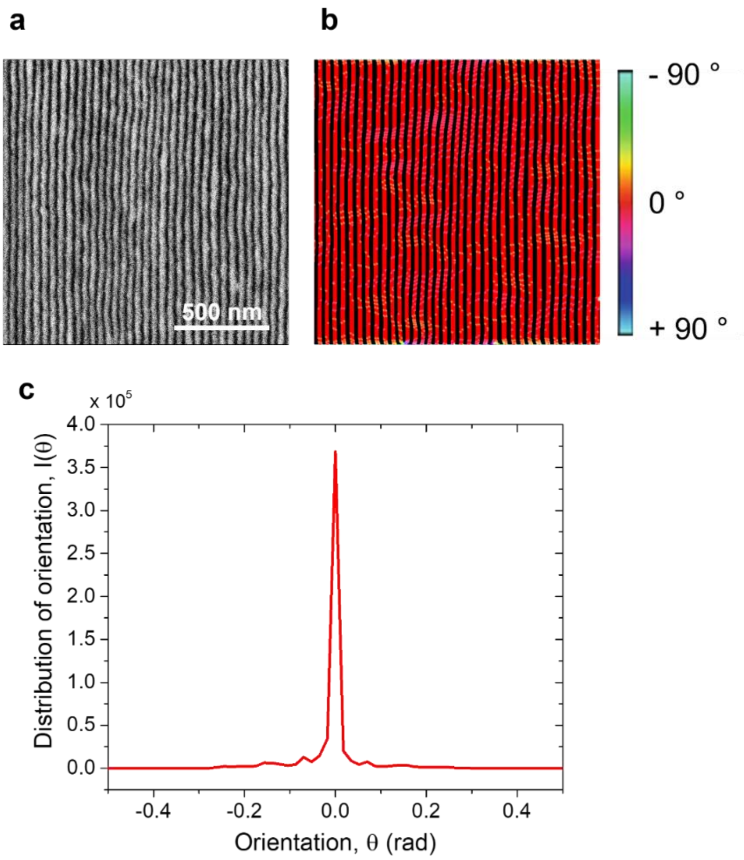

Fig.S3. Procedure for calculation of Hermans orientation parameter. (a) Original SEM image of BCP thin films sheared at 170 'C, 24 kPa for 30 min. (b) Color map image of (a) after orientation analysis. (c) Plot of distribution of orientation obtained from (b).

$$S = \frac{3\langle \cos^2 \theta \rangle - 1}{2} \qquad [S1]$$

$$\langle \cos^2 \theta \rangle = \frac{\int_0^{90} I(\theta) sin\theta \cos^2 \theta d\theta}{\int_0^{90} I(\theta) sin\theta d\theta} \qquad [S2]$$

Orientation parameter (S) can be calculated with Eq.S1 and S2. First, color survey was done by employing image J software to show the distribution of orientation in the entire image. Then, orientation distribution obtained from Fig.S3b is plotted in Fig. S3c. S value was calculated with Eq. S1 and S2, where θ is an orientation angle and $I(\theta)$ is intensity value at θ.

4. Direct photolithography process using negative tone PR (AZ-nLof)

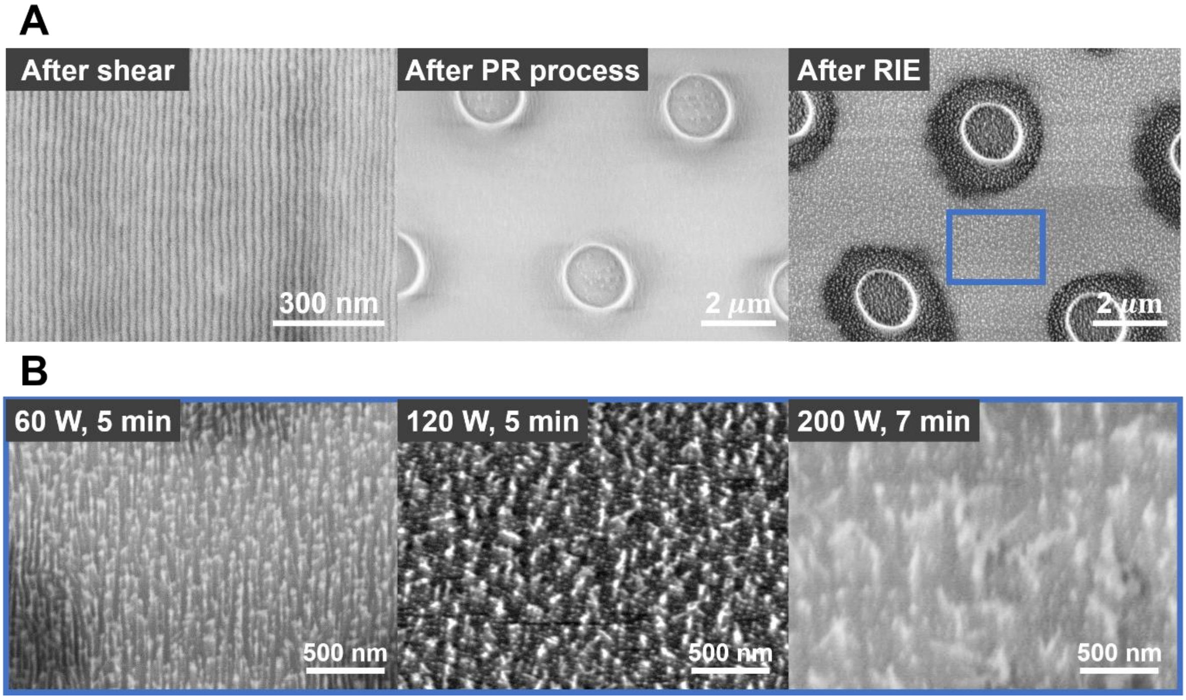

Fig.S4. Photolithography process with negative tone PR (AZ-nLof) on shear aligned PS-b-P2VP thin films. 38 nm thick film was firstly shear aligned at 170 ℃, 24 kPa for 30 min (a, left). After gold loading on P2VP domain, negative tone PR was used to create micropattern on shear aligned PS-b-P2VP thin films (a, middle). Subsequent RIE process was conducted for creating gold nanopatterns in uncovered region (a, right, blue rectangular region represents uncovered region where gold nanostructure is expected to appear). Enlarged images of blue rectangular area show negative tone PR messed up the final structures (b).

5. **Optimizing RIE condition – calculated from homopolymer thin film etching test**

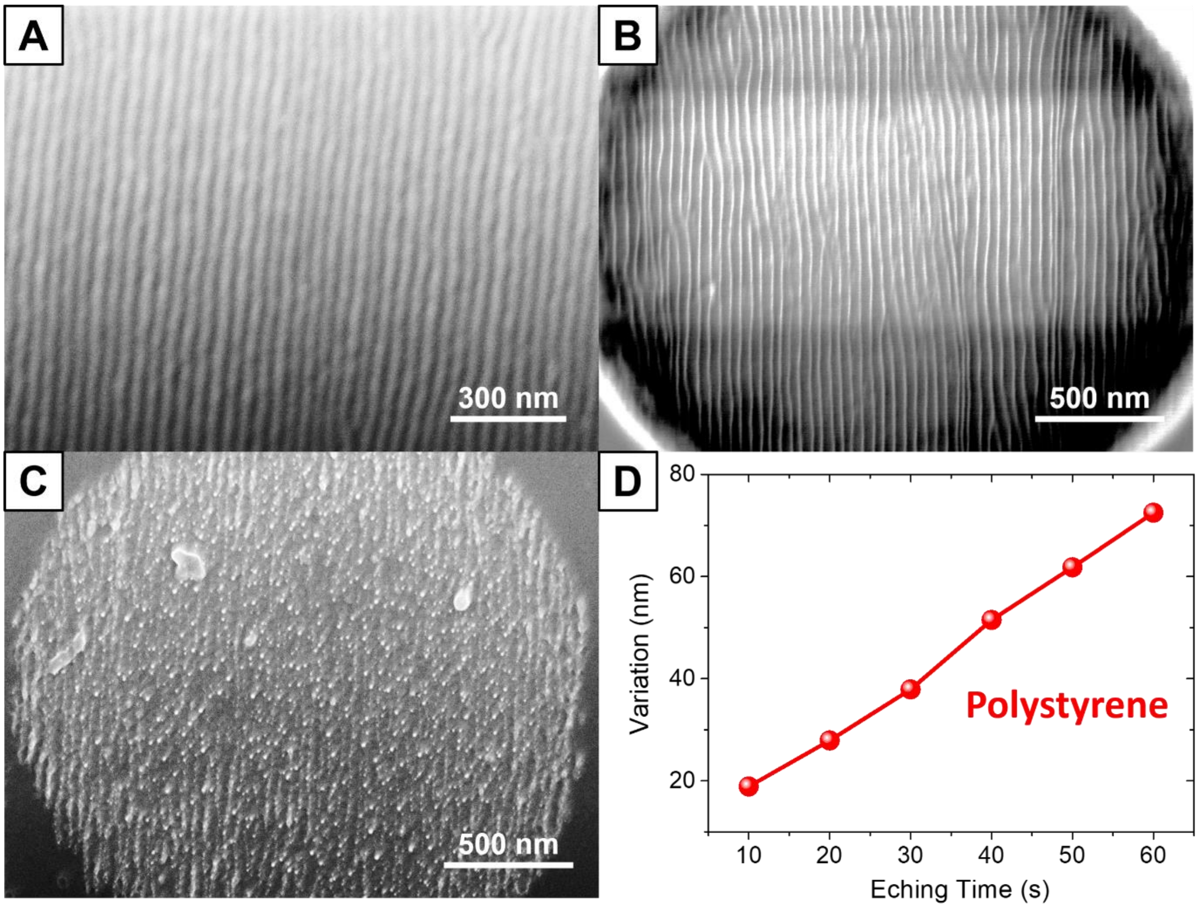

Fig.S5. The entire process under the conditions obtained from the PS homopolymer thin film etching test. (a) 38 nm thick film was shear aligned at 170 ℃, 24 kPa for 30 min and then gold loading was performed. (b) Direct photolithography was performed with positive tone PR and clear metal nanopattern was obtained through a RIE process at 60 W, 10 mTorr, 10 sccm for 30 s, which is expected to remove all PS layer. (c) Collapsed gold nanostructures were observed after the lift-off process by ultrasonication with toluene for 15 min. (d) Etching rate test at 60 W, 10 mTorr, 10 sccm with PS homopolymer thin films. 30 s was chosen for creating final structures, which is expected to remove all PS layer (~ 40 nm).

6. Effect of RIE condition on gold line quality

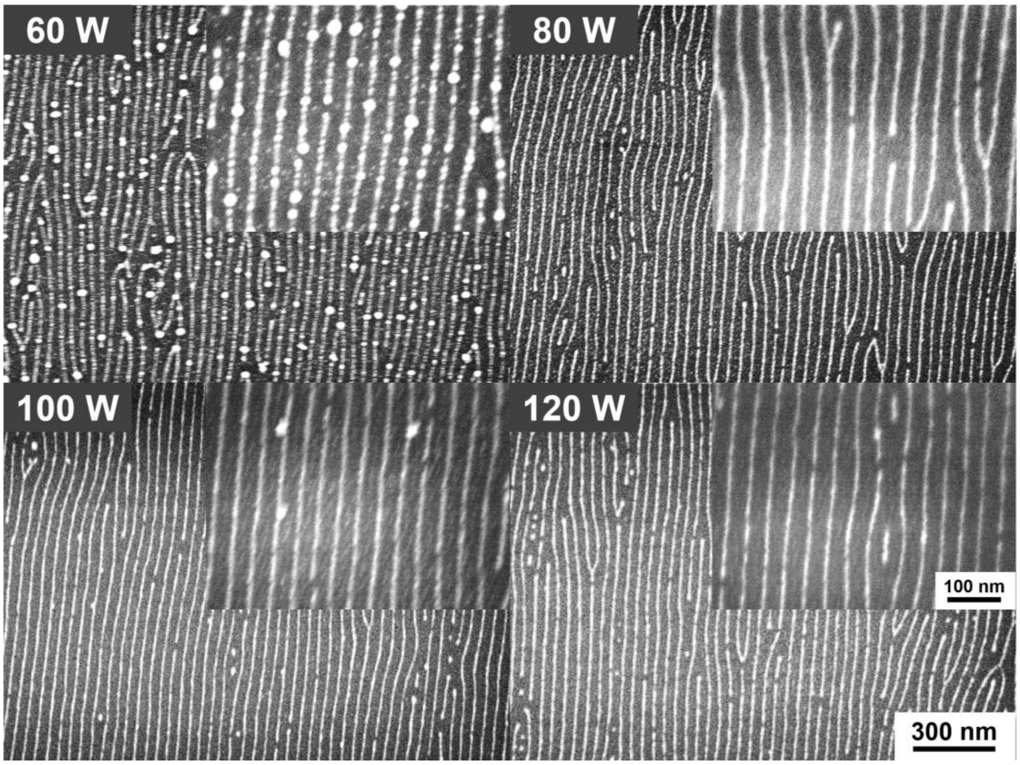

Fig.S6a. Investigation of effect of RIE power on gold line quality. All O_2 RIE experiments were performed with varying RIE power a range from 60 W to 120 W. Other condition was fixed at 10 mTorr, 10 sccm for 90 s.

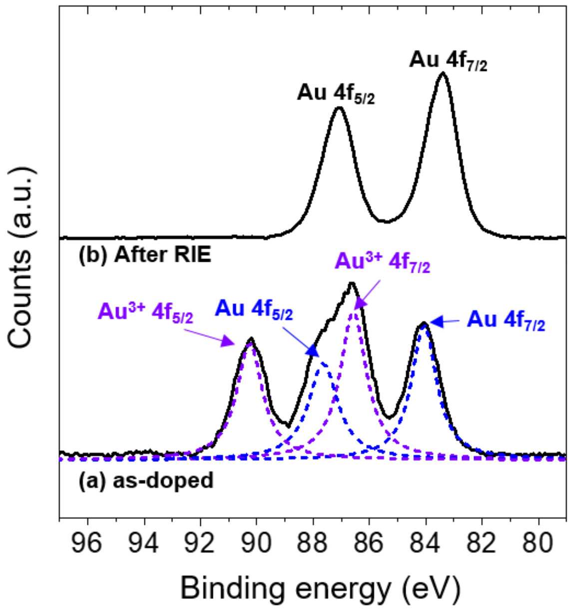

Fig.S6b. XPS spectra (a) after metal-ion loading and (b) RIE of gold nanolines. The dashed lines in (a) show the Lorentz fit results at each peak position (purple: Au^{3+} 4f, blue: Au 4f). Each plot was vertically shifted for clarity.

7. Evaluation of micro- and nano -structure quality

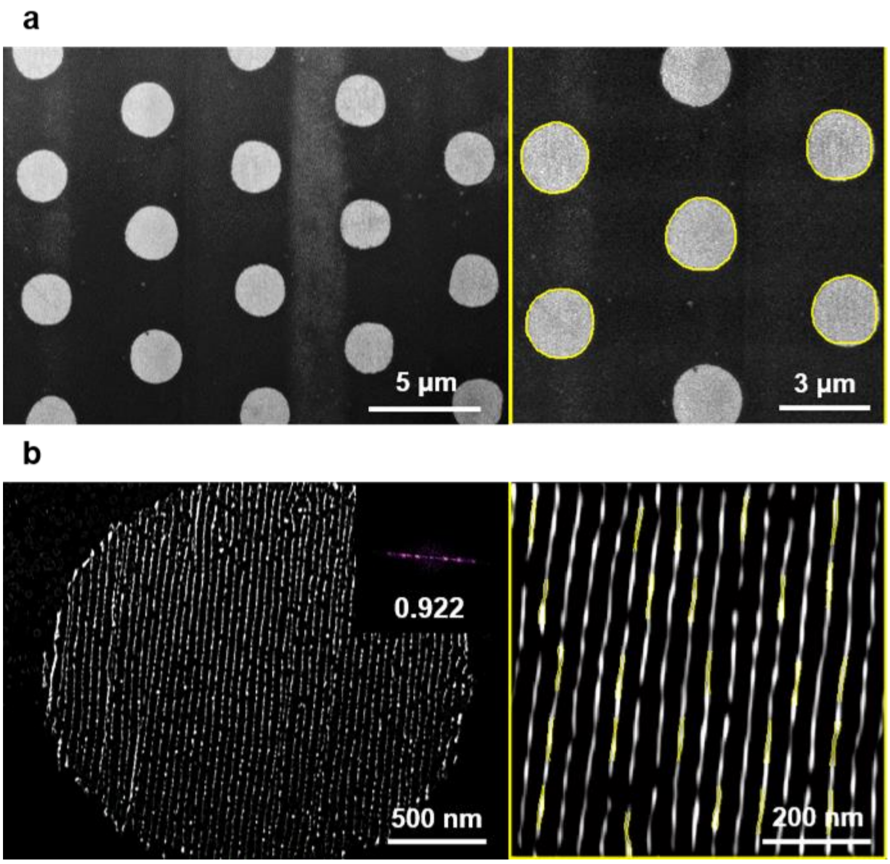

Fig.S7. Marked SEM images for structural quality quantification from Fig. 6. CD, CWR, CER, LWR, and CER were calculated with SuMMIT software.