Supporting Information
Broadband Antireflection Coating Covering from Visible to Near Infra-red Wavelengths by Using Multi-layered Porous Block Copolymer Films

*Wonchul Joo, Hye Jeong Kim, and Jin Kon Kim**

Single and double layer with PS-*b*-PMMAs

According to the design principle for zero reflectance,[1] a single-layered AR film with n = 1.23 exhibits zero (or less than 0.1 wt%) reflectance at a target wavelength (λ =4nt). We fabricated a single-layered porous film by spin-coated of **SMMA69** in toluene on a glass substrate. PMMA was removed by using UV irradiation followed by rinsing with acetic acid.

Figure S1a gives the reflectance curve (square symbol) of a single-layered porous film prepared **SMMA69**. Almost zero value of reflectance (lower than 0.1%) is observed at 520 nm. Comparing with a reflectance curve of bare glass (~ 4.3%), this porous film shows a good AR at a specific wavelength. This is similar to the result in our previous paper.[2] Based on the CMT, n and t are calculated to be 1.20 and 112 nm, respectively. The predicted thickness is consistent with the measured one (110 nm) by cross-sectional SEM image. Also, the n is consistent with the calculated value by eq. (1). From a tilted SEM image as shown in Figure S1b, a sponge-like porous structure with high porosity was fabricated. However, the reflectance curve becomes a V-shaped curve, namely, the reflectance at larger wavelengths becomes larger (2 % or more at wavelengths larger than 1000 nm).

To avoid typical a V-shaped curve, many researchers[3-5] introduced double-layered AR films. A double-layered film exhibits a broad band AR when the following two requirements are met:[1]

$$\frac{n_{top}^{2} n_{sub}}{n_{bottom}^{2}} = 1 \qquad \text{(A1)}$$

Here, n_{top}, n_{bottom}, and n_{sub} are the refractive indices of the top layer, bottom layer and a substrate, respectively. The thickness of each layer should be.[1]

$$n_{top} t_{top} = n_{bottom} t_{bottom} = \frac{\lambda}{4} \qquad \text{(A2)}$$

When *n* of the top layer is lower than the bottom layer, the thickness of top layer must be larger than the bottom layer. To achieve a broadband AR by using a double-layered porous film based on PS-*b*-PMMAs, we chose **SMMA69** as the top layer and **SMMA30** as the bottom layer. **SMMA69** was spin-coated on the pre-made **SMMA30** layer which was treated by ozone, and PMMA blocks in both layers were completely removed by UV irradiation. From the cross-sectional SEM image in Figure S1c, the double-layered porous film with the top layer having higher porosity and the bottom layer having smaller porosity was successfully fabricated. Figure S1a (circle symbol) gives the reflectance curve of the double-layered porous film, which shows a broadband AR (less than 0.5%) at visible light wavelengths (400 ~ 800 nm). Based on the CMT, the values of *n* and *t* of the top **SMMA69** layer and the bottom **SMMA30** layer are 1.22 and 115 nm, and 1.42 and 100nm, respectively. The thicknesses are consistent with measured ones by SEM images and the *n* is also consistent with eq (1). However, the reflectance was significantly increased from 1000 nm to 2000nm. Namely, the reflectance was increased up to 2 % at 2000 nm. Thus, the double-layered porous film is not effective for broadband AR covering visible light and NIR wavelength simultaneously.

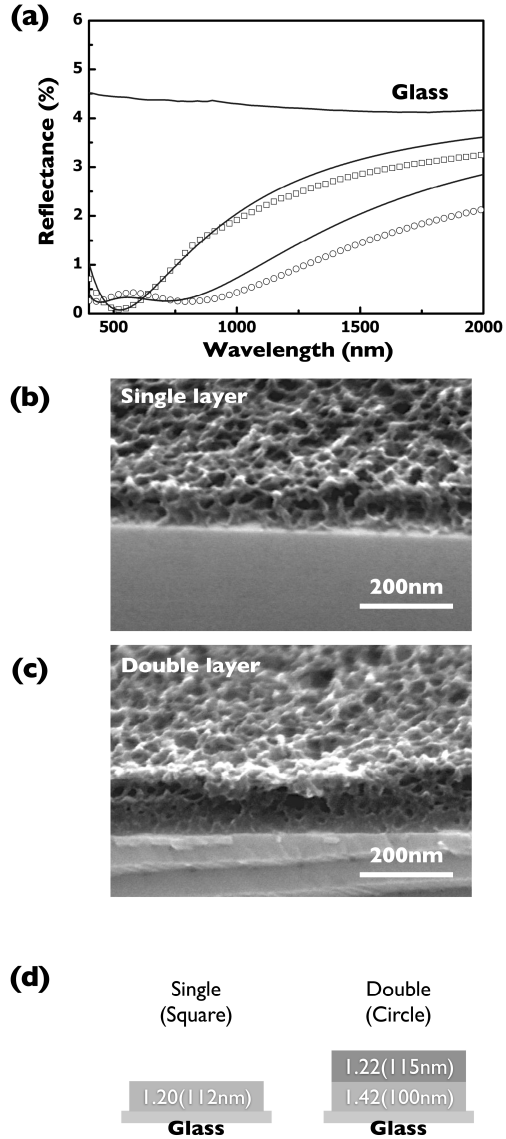

Figure S1. (a) Reflectance curves for **SMMA69** single-layered (□) and **SMMA69/SMMA30** double-layered (○) porous films. Solid lines in (a) represent the calculated curves based on the CMT. Cross-sectional SEM images for (b) **SMMA69** single-layer and (c) **SMMA69/SMMA30** double-layer porous films. (d) The characterized values of *n* and *t* of each layer based on the CMT.

References

(1) Macleod, H. A. *Thin-Film Optical Filters*; Hilger: Bristol, 1986.

(2) Joo, W.; Park, M. S.; Kim, J. K. *Langmuir* **2006**, *22*, 7960.

(3) Koo, H. Y.; Yi, D. K.; Yoo, S. J.; Kim, D. Y. *Adv. Mater.* **2004**, *16*, 274.

(4) Schäffer, W. E.; Mlynek, J.; Steiner, U. *Science* **1999**, *283*, 520.

(5) Kim, S.; Cho, J.; Char, K. *Langmuir* **2007**, *23*, 6737.