Electronic Supplementary Information

Realization of High-Quality Optical Nanoporous Gradient-Index Filters by Optimal Combination of Anodization Conditions

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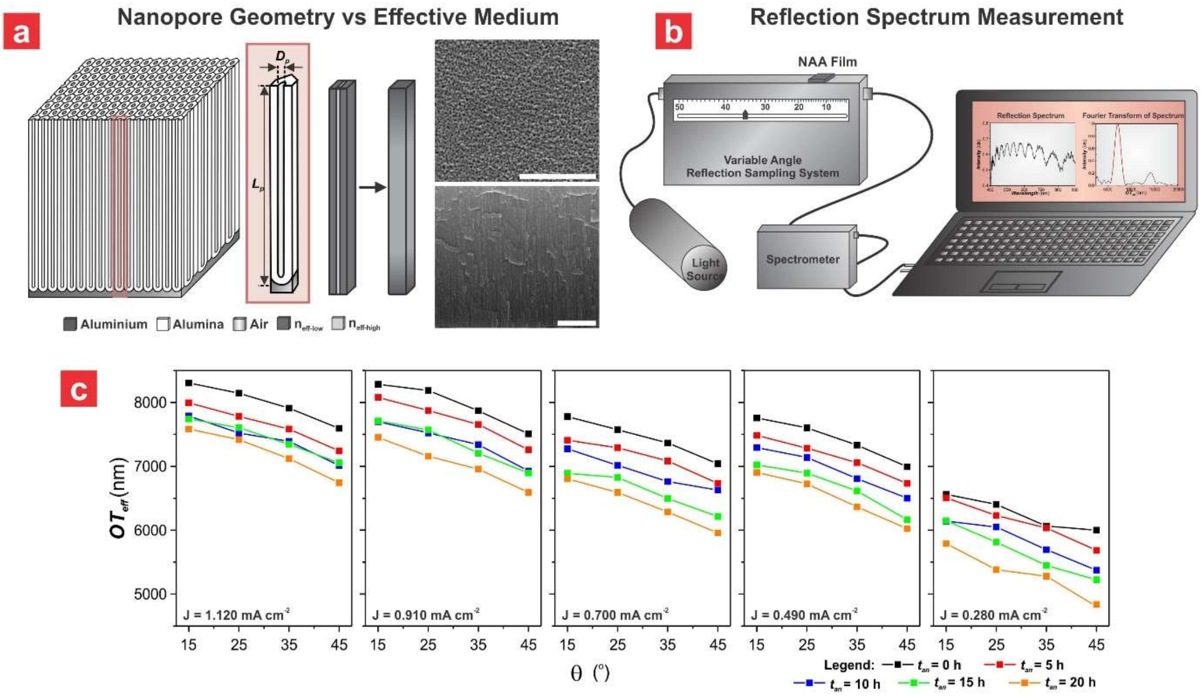

Fig. S1. Assessment of effective medium of NAA films produced with varying J and t_{an}. (a) Schematic illustration showing the correlation between nanopore geometry and effective medium in NAA films, with FEG-SEM images showing top and cross-sectional views of a representative NAA film (scale bar = 500 nm – top and scale bar = 1 µm – cross-section). (b) Schematic of set-up used to acquire the reflection spectrum of NAA films. (c) Effective optical thickness (OT_{eff}) of NAA films produced with varying J = 0.280–1.120 mA cm^{-2} and t_{an} = 0–20 h at varying angle of incidence (ϑ = 15°, 25°, 35° and 45°).

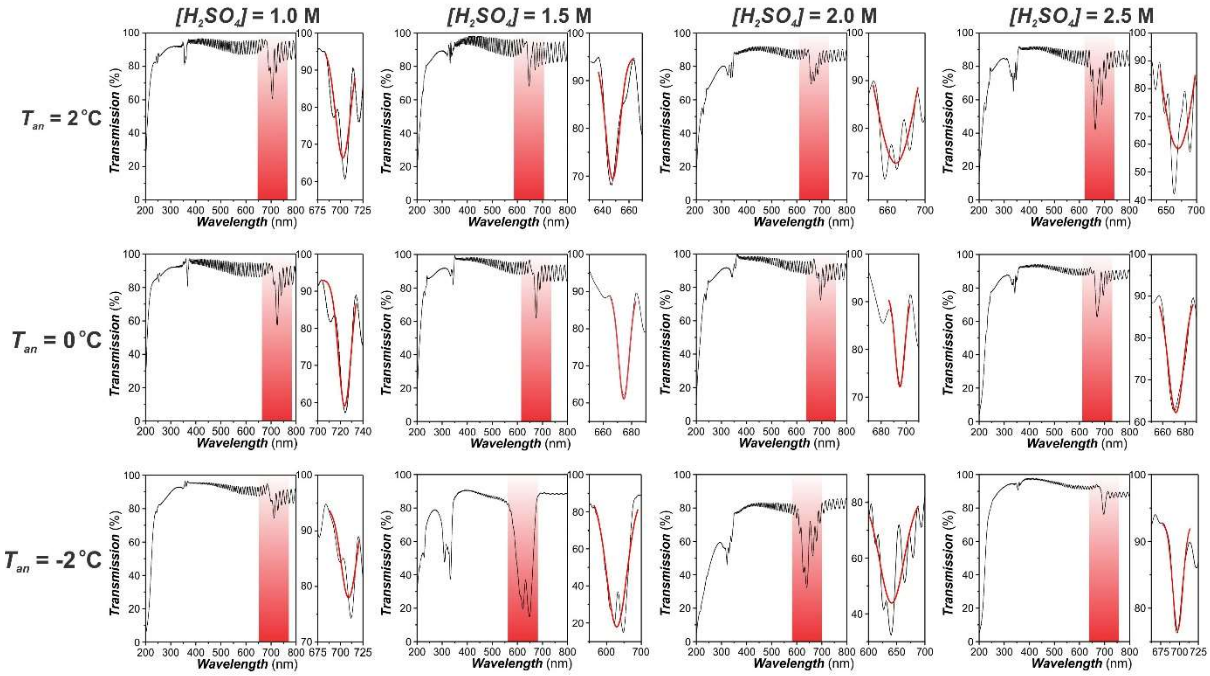

Fig. S2. Full transmission spectra and magnified views of the characteristic photonic stopband (PSB) of NAA-GIFs produced by SPA with varying T_{an} = –2–2 °C and $[H_2SO_4]$ = 1.0–2.5 M for t_{an} = 10 h.

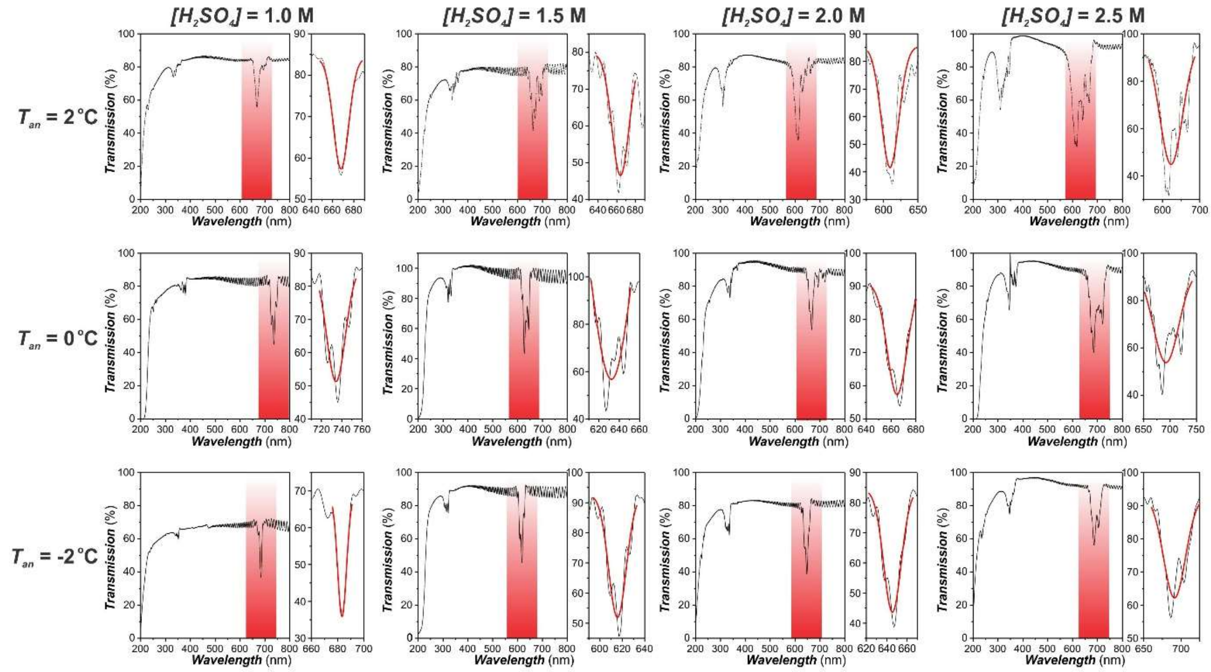

Fig. S3. Full transmission spectra and magnified views of the characteristic photonic stop band (PSB) of NAA-GIFs produced by SPA with varying T_{an} = –2–2 °C and $[H_2SO_4]$ = 1.0–2.5 M for t_{an} = 15 h.

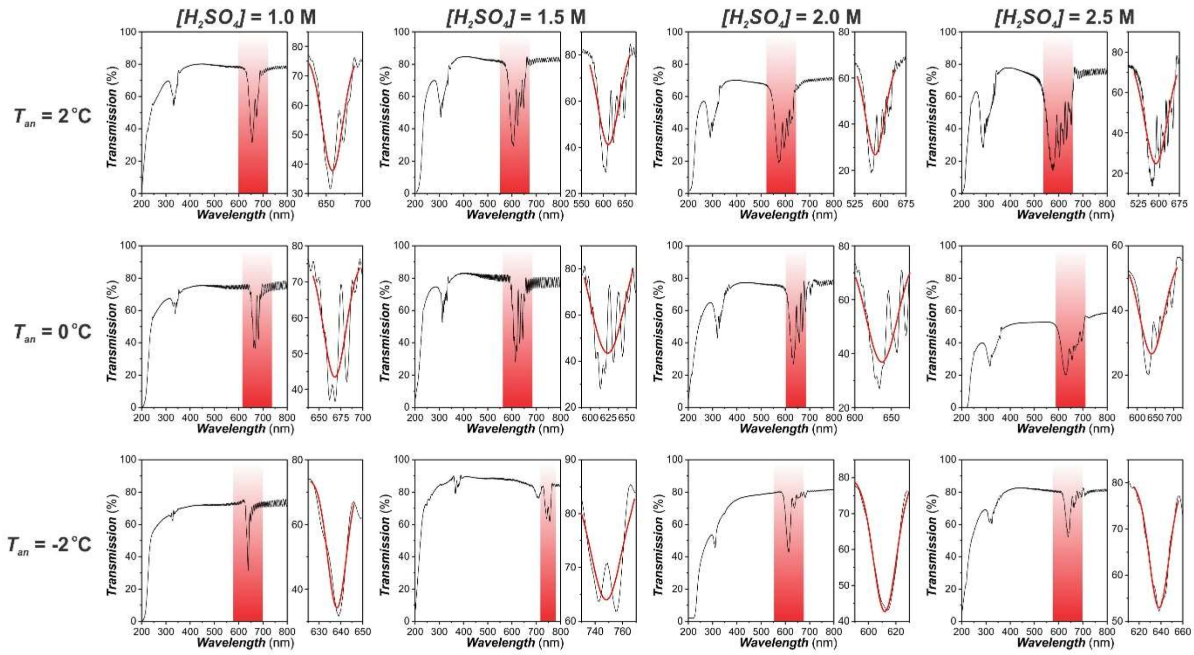

Fig. S4. Full transmission spectra and magnified views of the characteristic photonic stop band (PSB) of NAA-GIFs produced by SPA with varying T_{an} = –2–2 °C and $[H_2SO_4]$ = 1.0–2.5 M for t_{an} = 20 h.

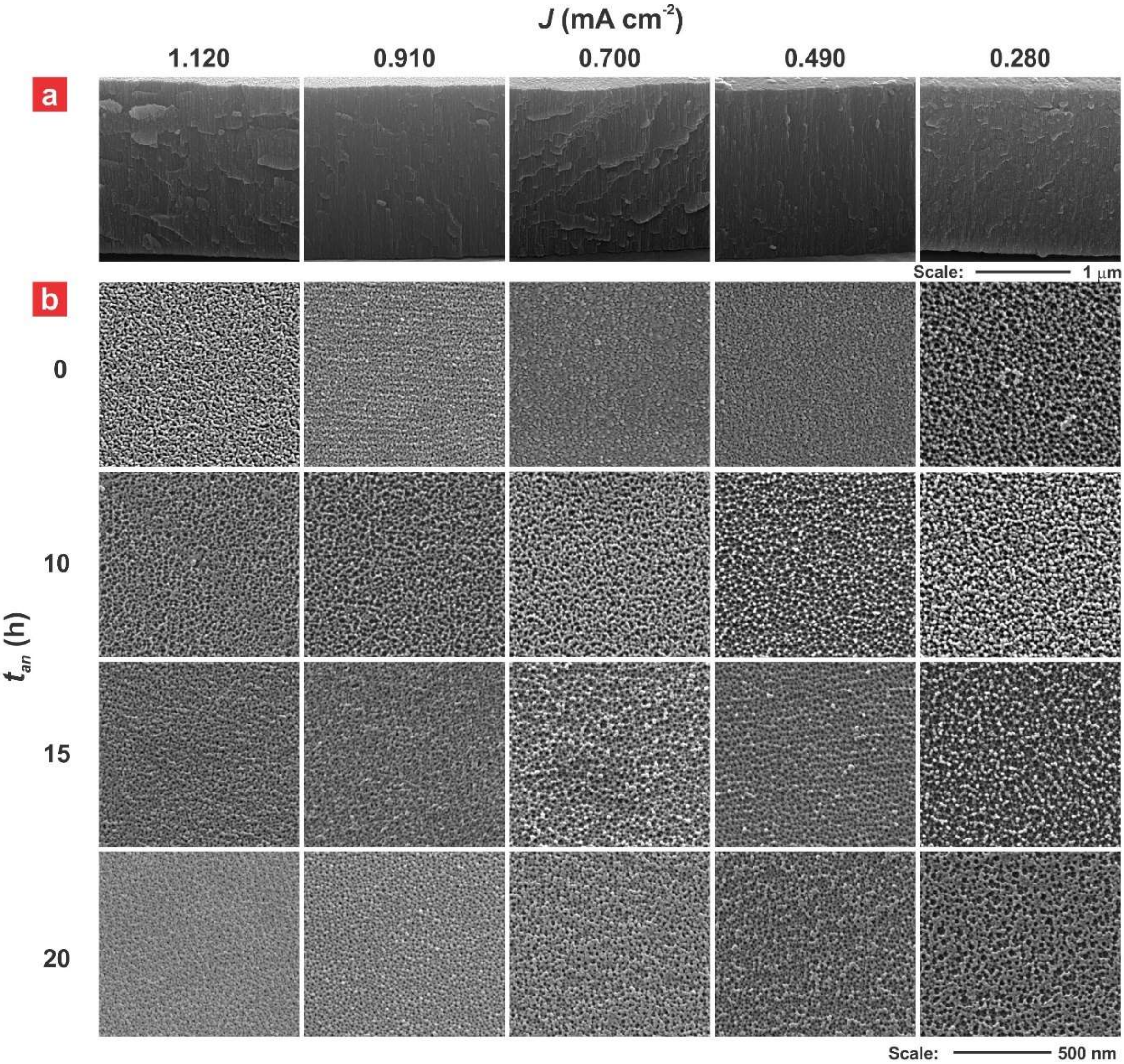

Fig. S5. SEM images of NAA films produced with varying anodization current density (J) and anodization time (t_{an}). (a) Cross-sectional view of NAA films showing the length of pore grown at different J (0.280–1.120 mA cm^{-2}) (scale bar = 1 μm) (b) Top view of NAA films produced as a function of J and t_{an} (0–20 h) (scale bar = 500 nm).

The ANOVA table (**Table 3**) was calculated using the equations outlined in **Table S1**, where *SS* is the sum of squares of the corresponding source, *DF* is the degree of freedom of such source, *MS* is the mean square of corresponding source, F_0 is the test statistic of that source, a, b and c are the total number of levels corresponding to t_{an}, T_{an} and $[H_2SO_4]$, respectively, and n is the total number of replications.

The hypotheses H_0, H_1, H_2, H_3, H_4, H_5 and H_6 were evaluated based on the comparison between F_0 value calculated from ANOVA table and the value of F-distribution for a significance level of 95% (i.e. 0.05) with the correspoding value of *DF* (Source) and *DF* (Error) (i.e. $F_{(0.05,\ DF\ (Source),\ DF\ (Error))}$). In this way, the tested null hypothese (i.e. H_0, H_1, H_2, H_3, H_4, H_5 and H_6) associated with cases i–vii were rejected if:

i) H_0: $F_{0\text{-}tan} \geqslant F_{(0.05,\ DF\ (tan),\ DF\ (Error))}$

ii) H_1: $F_{0\text{-}Tan} \geqslant F_{(0.05,\ DF\ (Tan),\ DF\ (Error))}$

iii) H_2: $F_{0\text{-}[H2SO4]} \geq F_{(0.05,\ DF\ ([H2SO4]),\ DF\ (Error))}$

iv) H_3: $F_{0\text{-}tan.Tan} \geq F_{(0.05,\ DF\ (tan \cdot Tan),\ DF\ (Error))}$

v) H_4: $F_{0\text{-}tan.[H2SO4]} \geq F_{(0.05,\ DF\ (tan \cdot [H2SO4]),\ DF\ (Error))}$

vi) H_5: $F_{0\text{-}\ Tan.[H2SO4]} \geq F_{(0.05,\ DF\ (Tan \cdot [H2SO4]),\ DF\ (Error))}$

vii) H_6: $F_{0\text{-}tan.Tan.[H2SO4]} \geq F_{(0.05,\ DF\ (tan \cdot Tan \cdot [H2SO4]),\ DF\ (Error))}$

Considering three-factor analysis of variance model in general form:

$$y_{ijkl} = \mu + \alpha_i + \beta_j + \gamma_k + (\alpha\beta)_{ij} + (\alpha\gamma)_{ik} + (\beta\gamma)_{jk} + (\alpha\beta\gamma)_{ijk} + \epsilon_{ijkl} \quad \begin{cases} i = 1, 2, \dots, a \\ j = 1, 2, \dots, b \\ k = 1, 2, \dots, c \\ l = 1, 2, \dots, n \end{cases}$$

In this study, α, β and γ represent t_{an}, T_{an}, $[H_2SO_4]$, respectively.

Table S1. Equations of different parameters for ANOVA table.

Source	SS	DF	MS	F_0
t_{an}	$SS_{t_{an}} = \frac{1}{bcn}\sum_{i=1}^{a} y_{i\dots}^2 - \frac{y_{\dots\dots}^2}{abcn}$	$a-1$	$MS_{t_{an}} = \frac{SS_{t_{an}}}{a-1}$	$F_{0-t_{an}} = \frac{MS_{t_{an}}}{MS_E}$
T_{an}	$SS_{T_{an}} = \frac{1}{acn}\sum_{j=1}^{b} y_{.j..}^2 - \frac{y_{\dots\dots}^2}{abcn}$	$b-1$	$MS_{T_{an}} = \frac{SS_{T_{an}}}{b-1}$	$F_{0-T_{an}} = \frac{MS_{T_{an}}}{MS_E}$
$[H_2SO_4]$	$SS_{[H_2SO_4]} = \frac{1}{abn}\sum_{k=1}^{c} y_{..k.}^2 - \frac{y_{\dots\dots}^2}{abcn}$	$c-1$	$MS_{[H_2SO_4]} = \frac{SS_{[H_2SO_4]}}{c-1}$	$F_{0-[H_2SO_4]} = \frac{MS_{[H_2SO_4]}}{MS_E}$
$t_{an}.T_{an}$	$SS_{t_{an}.T_{an}}$ $= \frac{1}{cn}\sum_{i=1}^{a}\sum_{j=1}^{b} y_{ij\dots}^2 - \frac{y_{\dots\dots}^2}{abcn} - SS_{t_{an}} - SS_{T_{an}}$ $= SS_{Subtotals\,(t_{an}.T_{an})} - SS_{t_{an}} - SS_{T_{an}}$	$(a-1)(b-1)$	$MS_{t_{an}.T_{an}} = \frac{SS_{t_{an}.T_{an}}}{(a-1)(b-1)}$	$F_{0-t_{an}.T_{an}} = \frac{MS_{t_{an}.T_{an}}}{MS_E}$

t_{an}.[H_2SO_4]	$SS_{t_{an}\cdot[H_2SO_4]} = \frac{1}{bn}\sum_{i=1}^{a}\sum_{k=1}^{c} y_{i.k.}^2 - \frac{y_{....}^2}{abcn} - SS_{t_{an}} - SS_{[H_2SO_4]} = SS_{Subtotals\,(t_{an}\cdot[H_2SO_4])} - SS_{t_{an}} - SS_{[H_2SO_4]}$	$(a-1)(c-1)$	$MS_{t_{an}\cdot[H_2SO_4]} = \frac{SS_{t_{an}\cdot[H_2SO_4]}}{(a-1)(c-1)}$	$F_{0-t_{an}\cdot[H_2SO_4]} = \frac{MS_{t_{an}\cdot[H_2SO_4]}}{MS_E}$
T_{an}.[H_2SO_4]	$SS_{T_{an}\cdot[H_2SO_4]} = \frac{1}{an}\sum_{j=1}^{b}\sum_{k=1}^{c} y_{.jk.}^2 - \frac{y_{....}^2}{abcn} - SS_{T_{an}} - SS_{[H_2SO_4]} = SS_{Subtotals\,(T_{an}\cdot[H_2SO_4])} - SS_{T_{an}} - SS_{[H_2SO_4]}$	$(b-1)(c-1)$	$MS_{T_{an}\cdot[H_2SO_4]} = \frac{SS_{T_{an}\cdot[H_2SO_4]}}{(b-1)(c-1)}$	$F_{0-T_{an}\cdot[H_2SO_4]} = \frac{MS_{T_{an}\cdot[H_2SO_4]}}{MS_E}$
t_{an}.T_{an}.[H_2SO_4]	$SS_{t_{an}.T_{an}\cdot[H_2SO_4]} = \frac{1}{n}\sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{c} y_{ijk.}^2 - \frac{y_{....}^2}{abcn} - SS_{t_{an}} - SS_{T_{an}} - SS_{[H_2SO_4]} - SS_{t_{an}.T_{an}} - SS_{t_{an}\cdot[H_2SO_4]} - SS_{T_{an}\cdot[H_2SO_4]} = SS_{Subtotals\,(t_{an}.T_{an}\cdot[H_2SO_4])} - SS_{t_{an}} - SS_{T_{an}} - SS_{[H_2SO_4]} - SS_{t_{an}.T_{an}} - SS_{t_{an}\cdot[H_2SO_4]} - SS_{T_{an}\cdot[H_2SO_4]}$	$(a-1)(b-1)(c-1)$	$MS_{t_{an}.T_{an}\cdot[H_2SO_4]} = \frac{SS_{t_{an}.T_{an}\cdot[H_2SO_4]}}{(a-1)(b-1)(c-1)}$	$F_{0-t_{an}.T_{an}\cdot[H_2SO_4]} = \frac{MS_{t_{an}.T_{an}\cdot[H_2SO_4]}}{MS_E}$
Total	$SS_T = \sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{c}\sum_{l=1}^{n} y_{ijkl}^2 - \frac{y_{....}^2}{abcn}$	$abcn-1$		
Error	$SS_E = SS_T - SS_{Subtotals\,(t_{an}.T_{an}\cdot[H_2SO_4])}$	$abc\,(n-1)$	$MS_E = \frac{SS_E}{abc(n-1)}$	