

Table S1 Structural and electrical properties of synthesized mesoporous ATO thin films. Average thickness was determined by stylus profiler. *d*-spacing was calculated from GI-SAXS (in-plane) profile. Sheet resistance and resistivity were measured by four-probe method.

Sample	Average Thickness (nm)	Sheet Resistance (k Ω / \square)	Resistivity (Ω cm)	<i>d</i> -spacing (nm)
ATO_5_600	123.65	1.92	2.35×10^{-2}	—
ATO_10_600	254.57	4.23	1.02×10^{-1}	—
ATO_20_600	294.78	23.26	6.78×10^{-1}	—
ATO_30_600	276.91	41.68	1.11×10^0	—
ATO_40_600	217.93	17.53	3.70×10^{-1}	36.1
ATO_50_600	175.85	7.86	1.32×10^{-1}	30.7
ATO_60_600	179.35	6.34	1.08×10^{-1}	30.7
ATO_70_600	174.66	6.64	1.14×10^{-1}	29.2
ATO_5_800	117.59	1.19	1.29×10^{-2}	—
ATO_10_800	256.46	5.68	1.41×10^{-1}	—
ATO_20_800	284.44	21.02	5.97×10^{-1}	—
ATO_30_800	221.81	46.95	9.98×10^{-1}	—
ATO_40_800	201.33	16.65	3.32×10^{-1}	—
ATO_50_800	160.78	5.35	8.04×10^{-2}	34.1
ATO_60_800	170.22	4.91	7.66×10^{-2}	32.2
ATO_70_800	160.79	4.51	6.43×10^{-2}	32.2

Figure S1

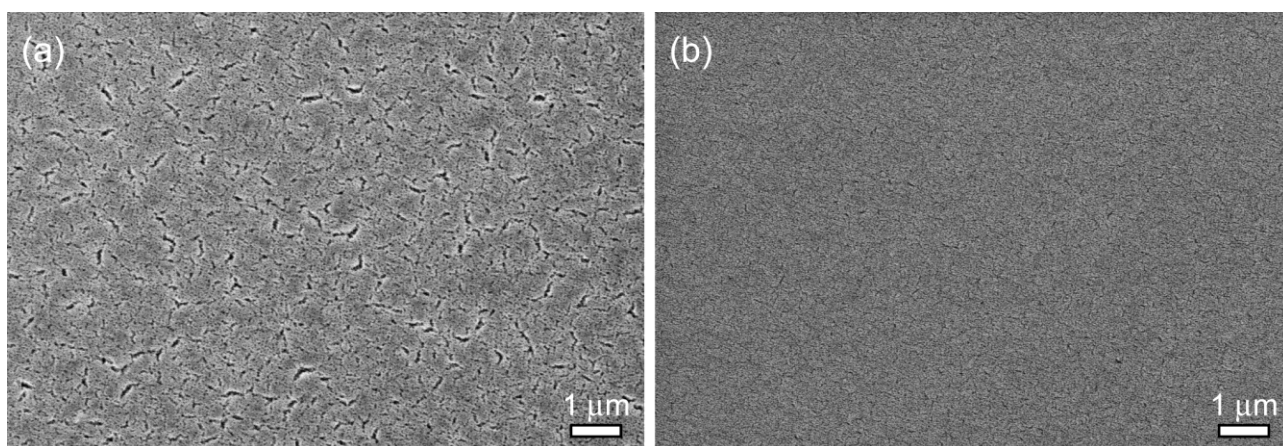


Figure S1 Low-magnified SEM images of (a) **ATO_5_600** and (b) **ATO_10_600**.

Figure S2

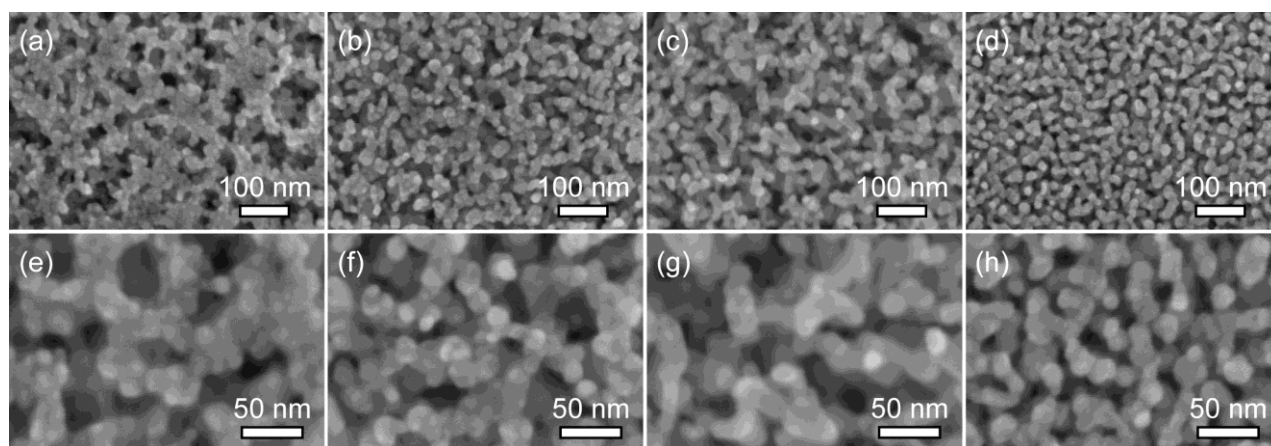


Figure S2 Top-view SEM images of (a) **ATO_5_800**, (b) **ATO_10_800**, (c) **ATO_30_800**, (d) **ATO_50_800** and magnified SEM images of (e) **ATO_5_800**, (f) **ATO_10_800**, (g) **ATO_30_800**, and (h) **ATO_50_800**.

Figure S3

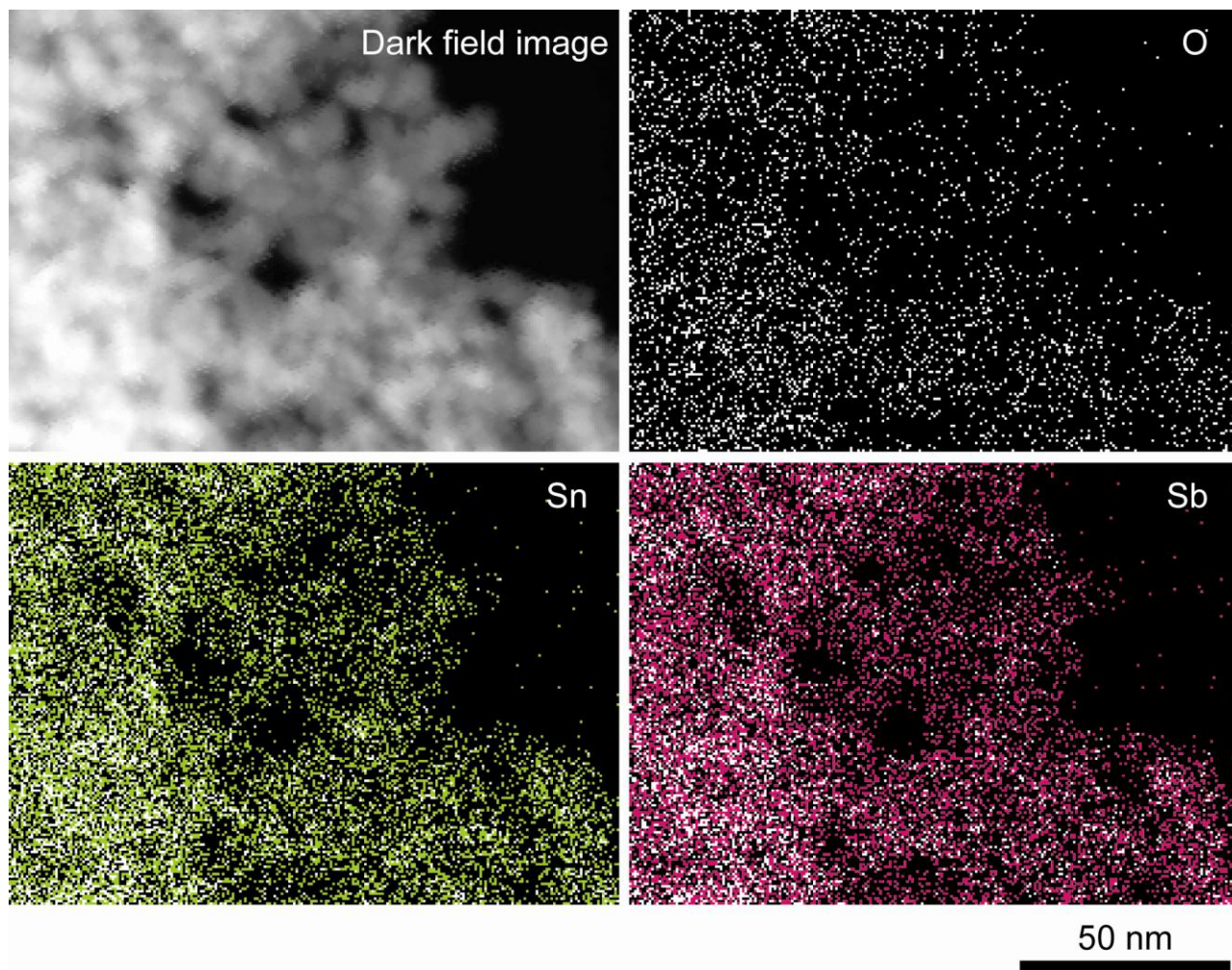


Figure S3. Dark field SEM image and EDS elemental mapping of **ATO_50_600**.

Figure S4

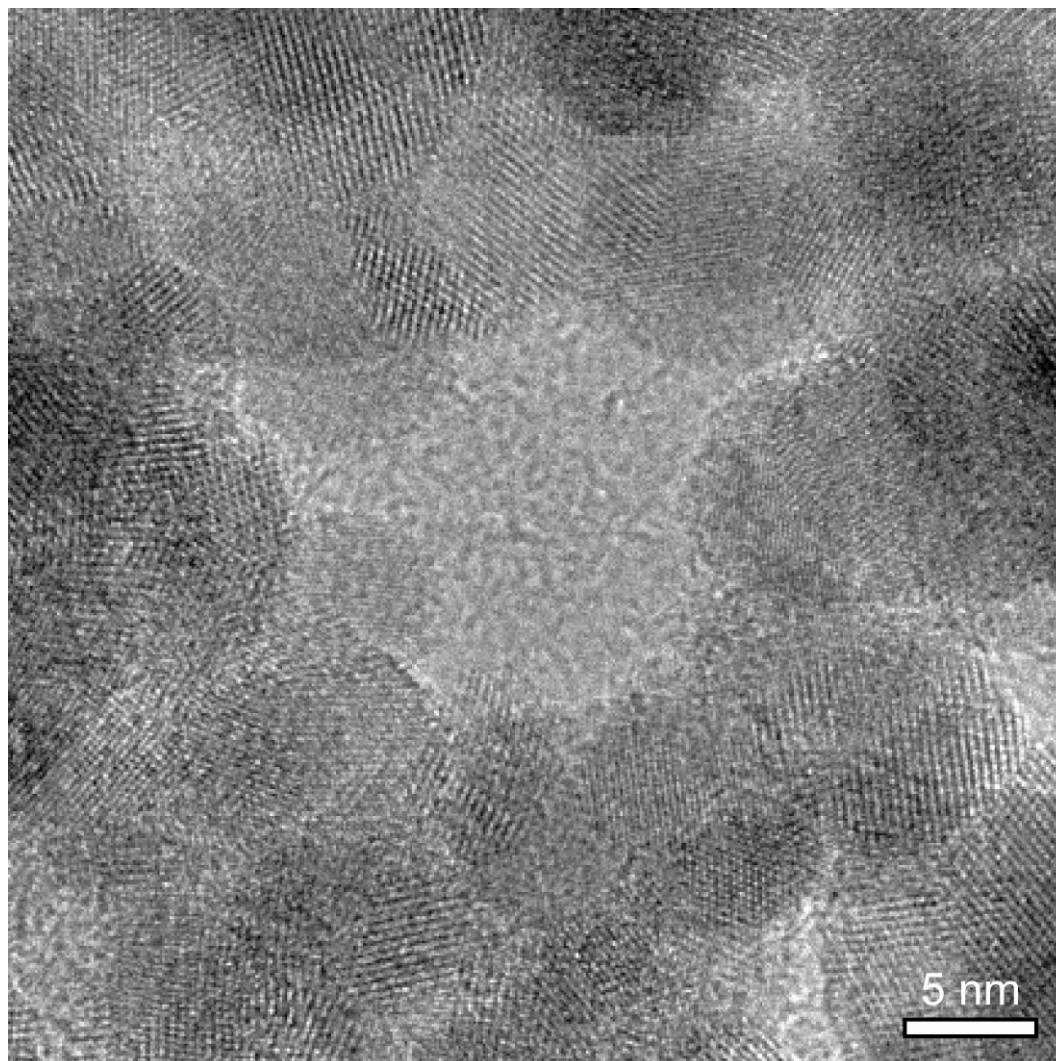


Figure S4. Enlarged image of high-magnified TEM image of **ATO_50_600** (Figure 2b).