Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting information

A new strategy of nanocompositing vanadium dioxide with excellent durability

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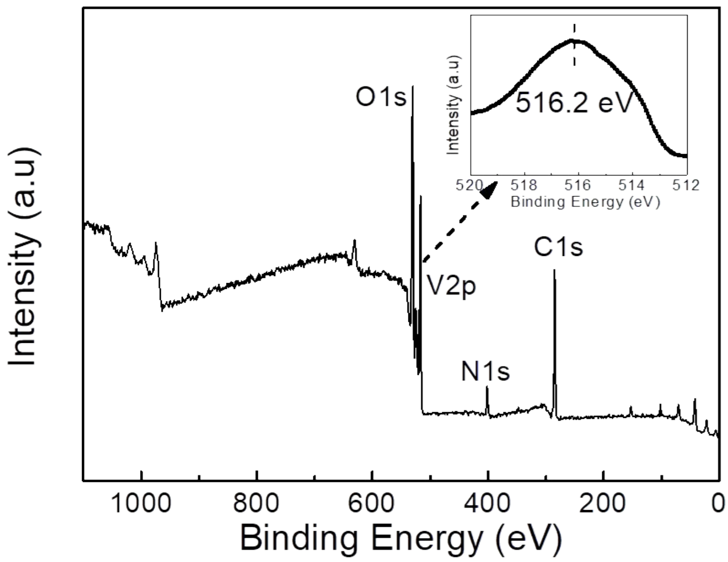

Figure S1. XPS spectrum of the as-deposited sample.

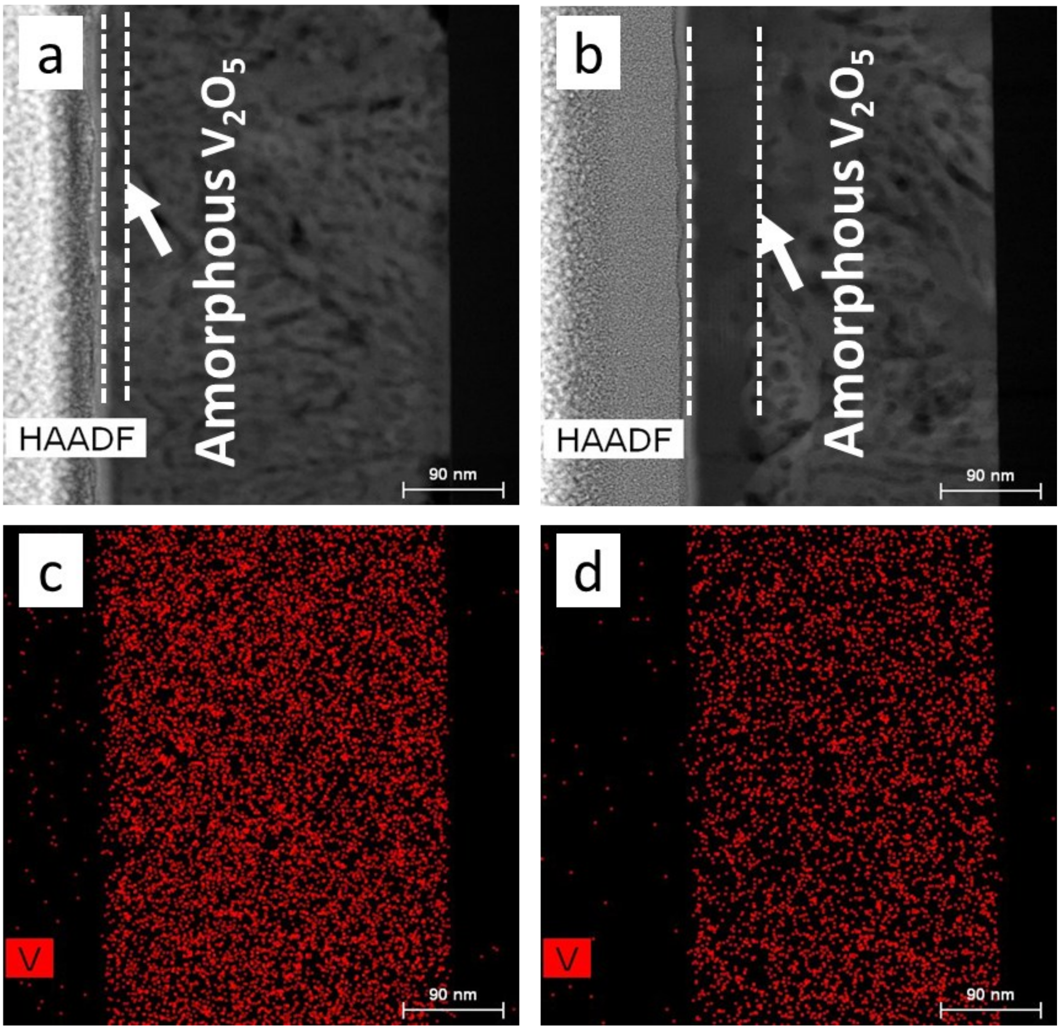

Figure S2. HAADF images of (a) 3 minutes RTA processed, and (b) 10 minutes RTA processed samples, (c) and (d) are the corresponding EDS maps of **Figure S2a** and **b**.

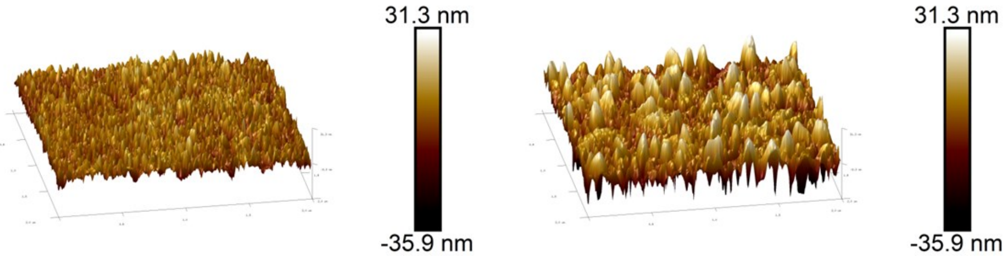

Figure S3. AFM images of the RTA sample and as-deposited VO_x film. The RMS roughness of the RTA sample and as-deposited VOx film is 4.65nm and 8.31nm, respectively.

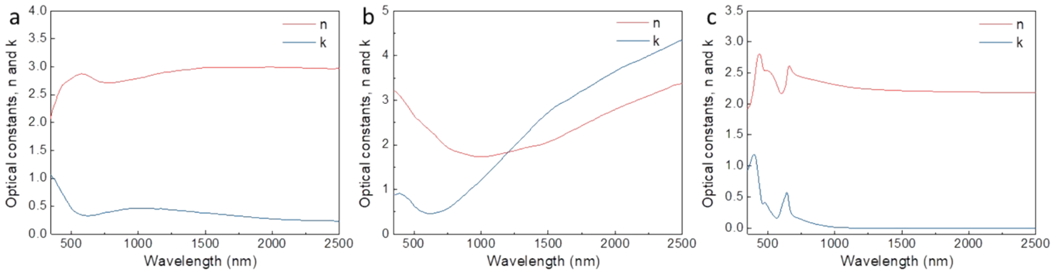

Figure S4. Spectral optical constants *n* and *k* for (a) VO_2 (M), (b) VO_2 (R), and (c) V_2O_5.

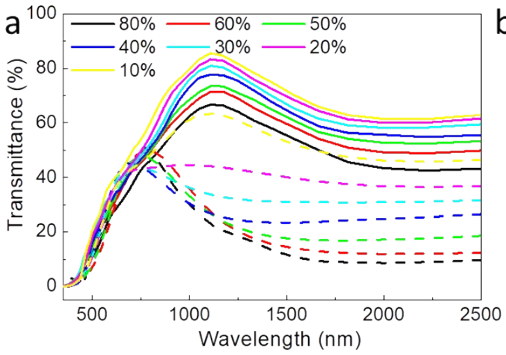

Figure S5. Simulated low and high temperatures transmittance spectra of the VO_2 NPs in V_2O_5 matrix structure with varying the concentration of the VO_2 NPs from 20% to 90%, the thickness of the film is fixed at 130 nm.

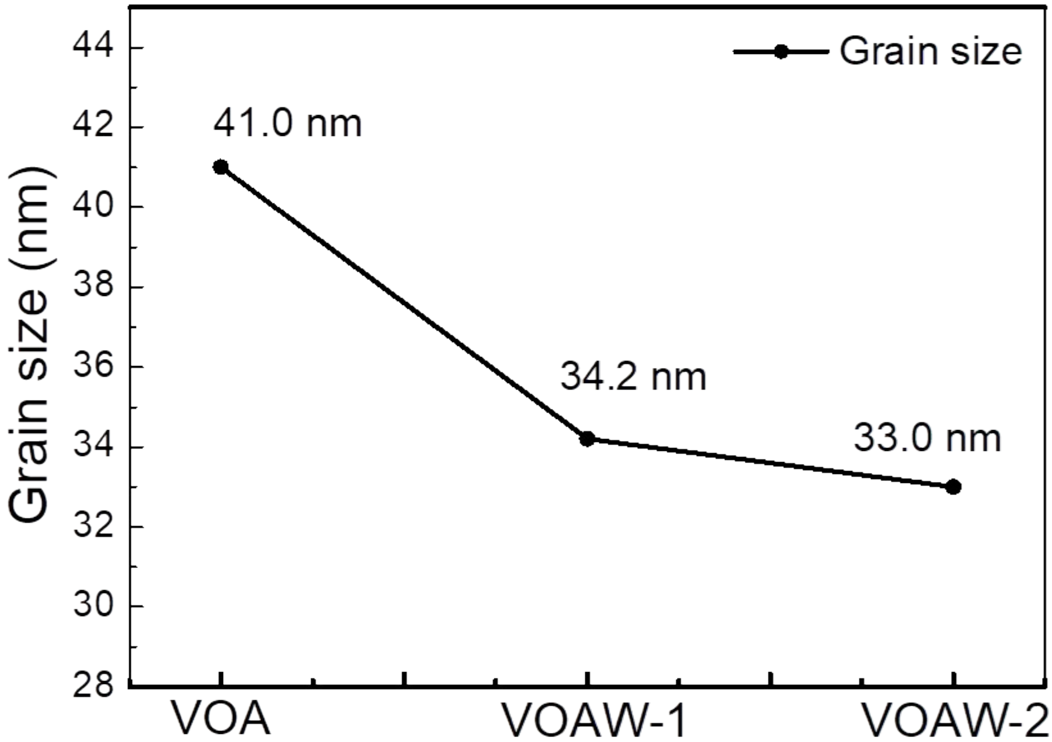

Figure S6. Calculated average grain size for the ($\bar{2}$11) facet of RTA processed samples.

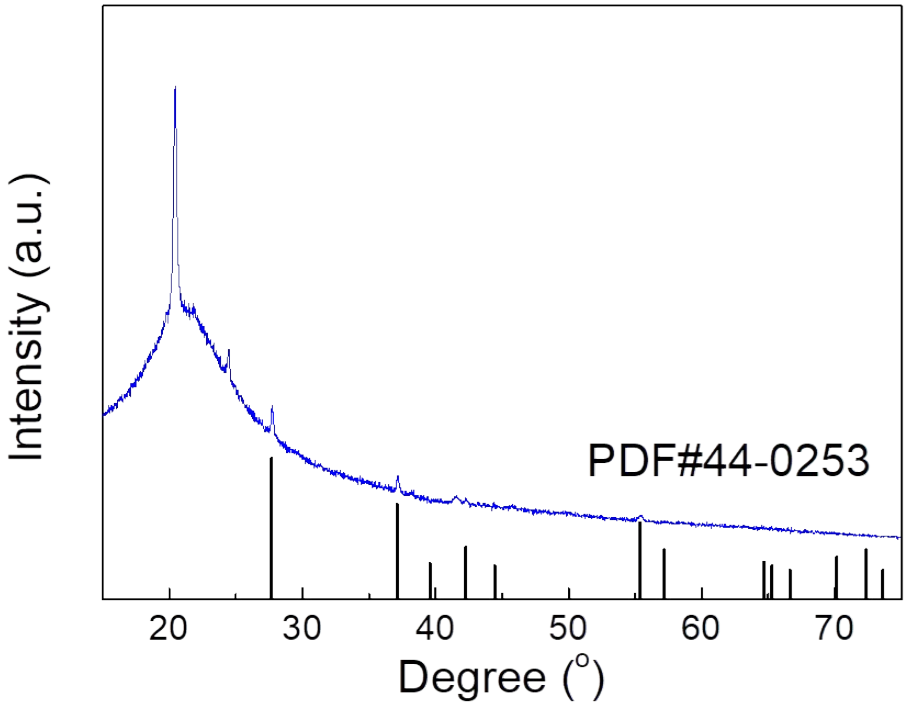

Figure S7. XRD patterns of the VOWA-3, the diffraction peaks that can well match the PDF No. 44-0253 are assigned to the diffraction information of tetragonal VO_2.

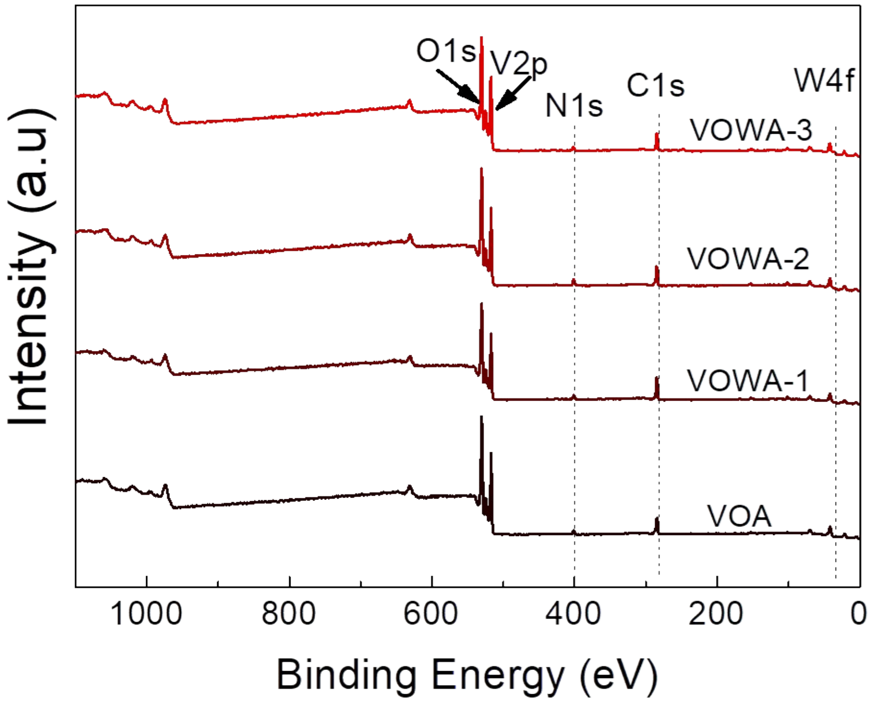

Figure S8. Survey XPS spectra of the RTA processed samples. The characteristic peaks assigned to N1s and C1s are due to the N_2 and CO_2 in the air. There are only V, W and O can be found in our samples.

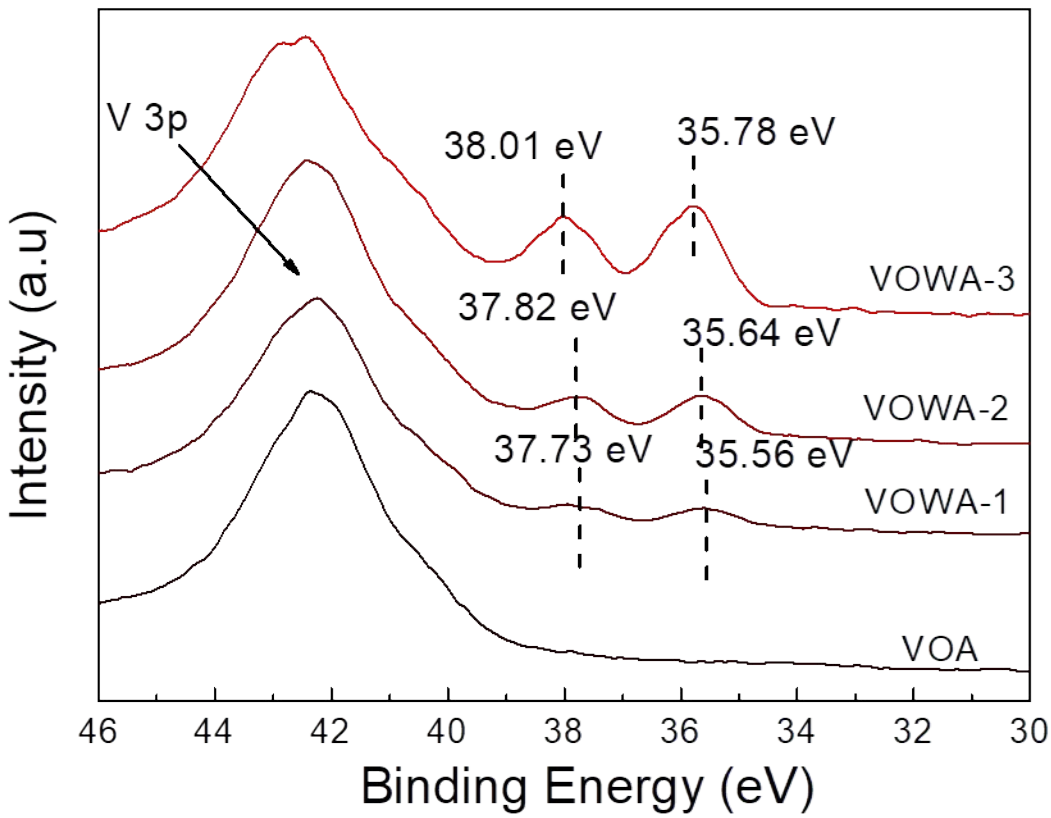

Figure S9. High-resolution XPS spectra of W 4f of all the samples.

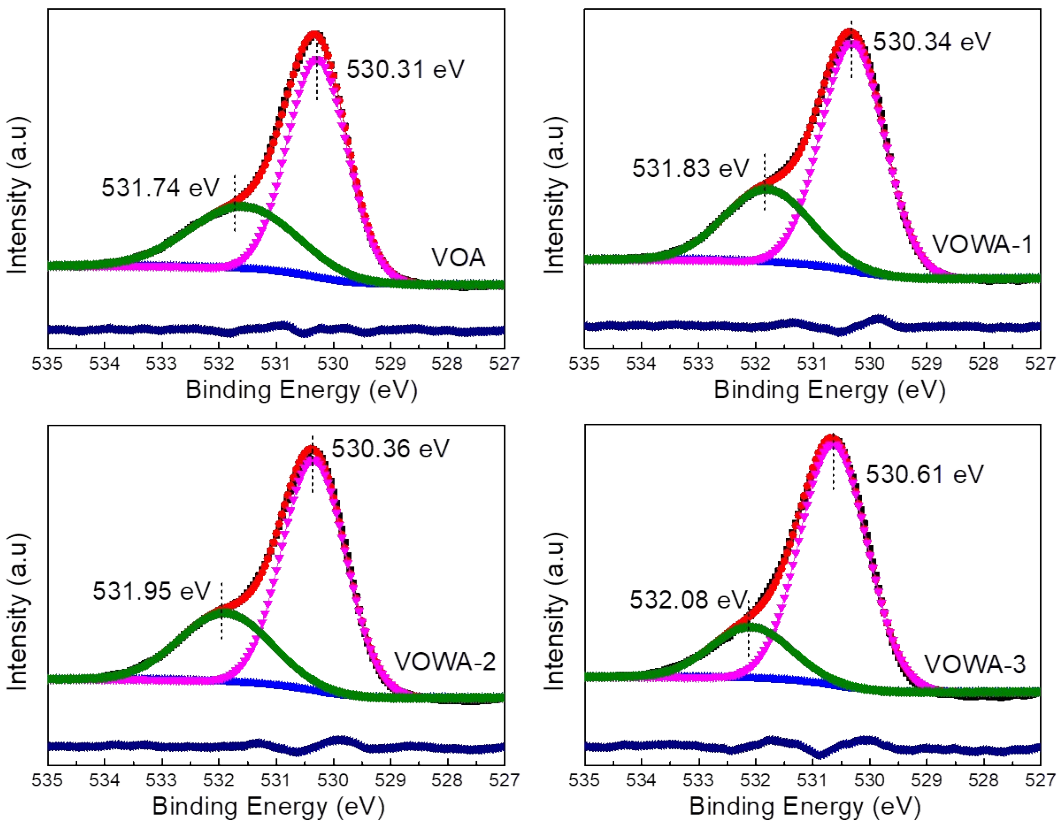

Figure S10. Deconvoluted O 1s peaks for VOA, VOWA-1, VOWA-2, and VOWA-3.

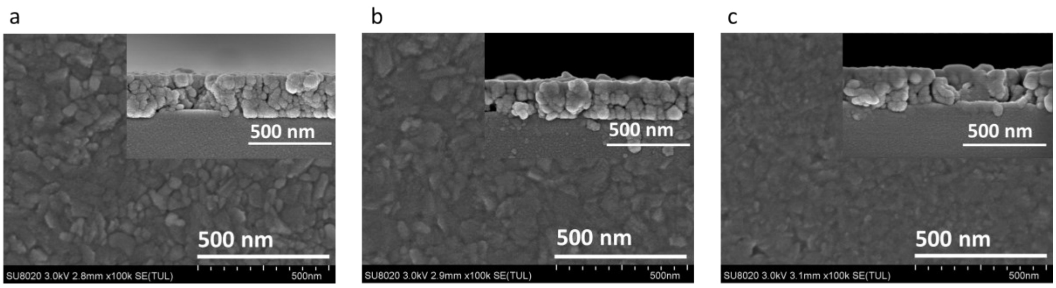

Figure S11. Surface and section morphologies of the VOA, VOWA-1, and VOWA-3.

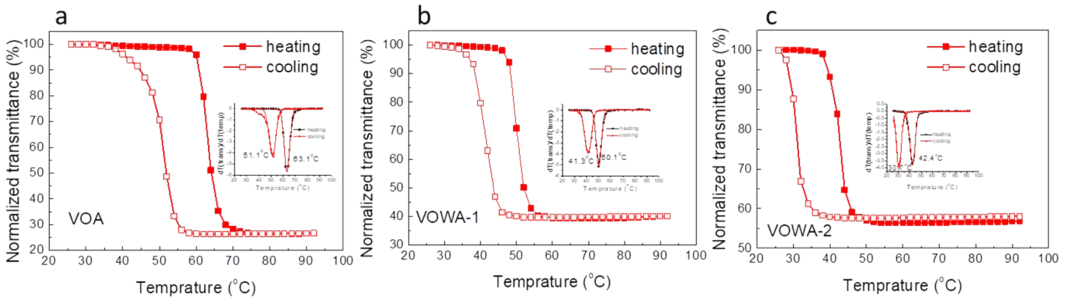

Figure S12. Temperature dependence of the transmittance at 1050 nm of VOA, VOWA-1, and VOWA-2.

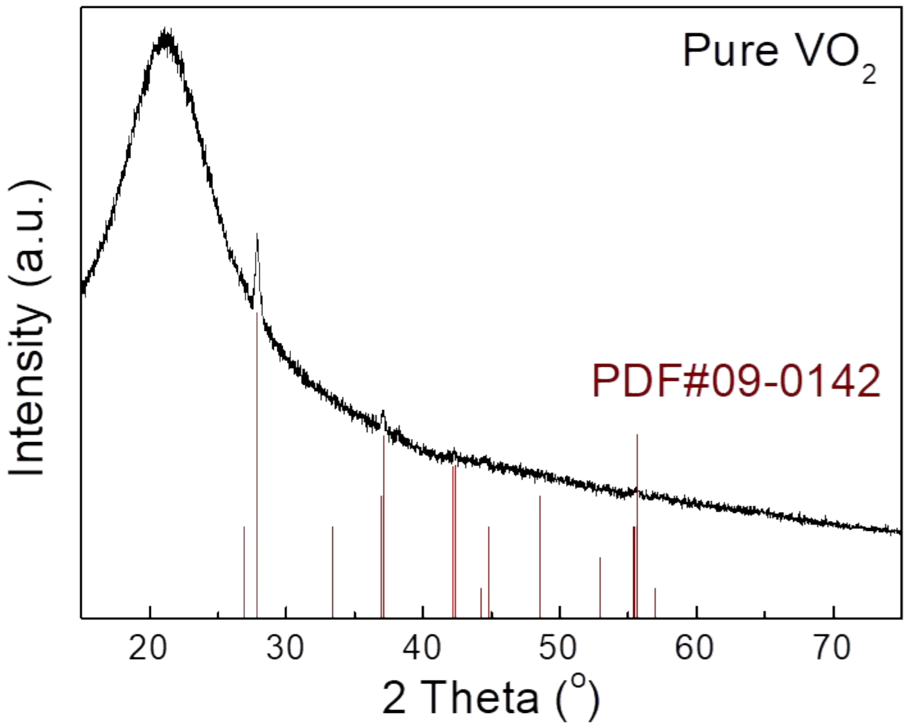

Figure S13. XRD pattern of the common polycrystalline VO_2 sample. The sample presents the polycrystalline feature of VO_2, which can be well-matched with PDF No. 09-0142.

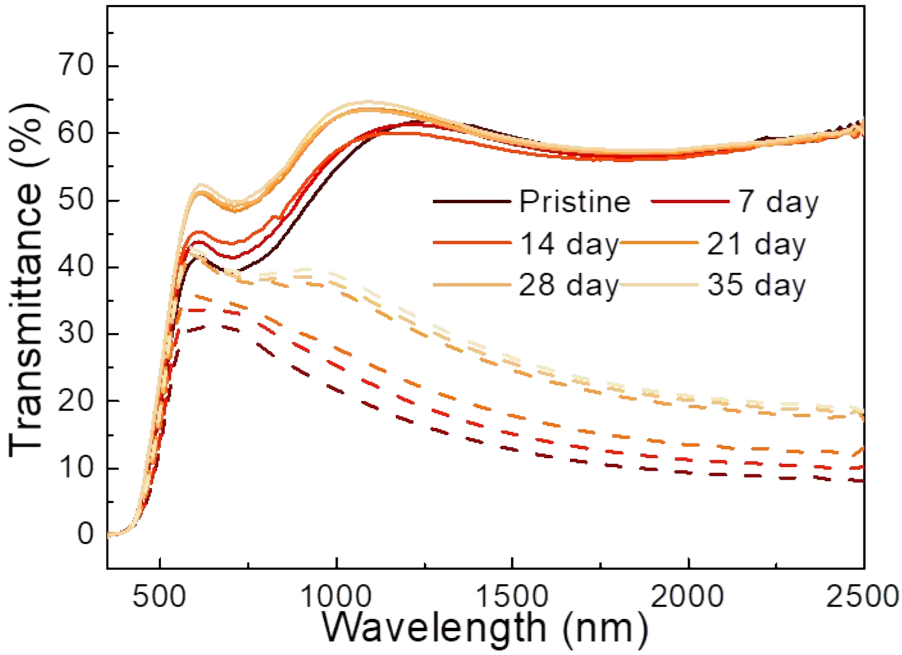

Figure S14. Transmittance spectra of VOA under acceleration testing model T_{test}= 100 ℃= 373 K and RH_{use}= 60%.

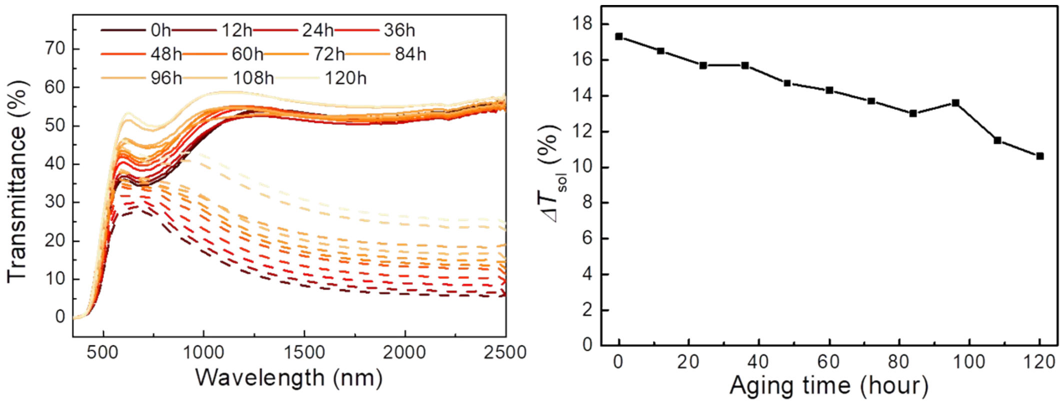

Figure S15. (a) Transmittance spectra of VOA under acceleration testing model T_{test}= 150 ℃= 423 K and RH_{use}= 60%. (b) Calculated ΔT_{sol} versus aging time at an acceleration temperature of 150 ℃ for undoped samples.

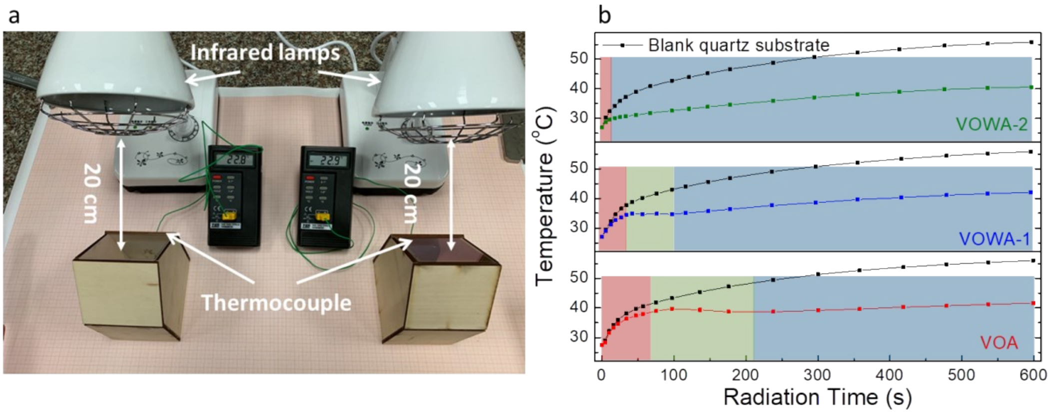

Figure S16. (a) Energy-saving efficiency test system. (b) Radiation time-dependent temperature curves of blank quartz glass, VOA, VOWA-1, and VOWA-2.

A wood house model was fabricated to quantitatively analyze the energy-saving efficiency of our samples. One side of the roof has been replaced by the blank quartz glass and our samples; the area of glass is 75 x 75 mm^2. Blank quartz glass is used to simulate room temperature changes under light duration without thermochromic coating. Two infrared lamps (150 W) have been used to simulate the sunlight source. The infrared lamp is symmetrically placed. The light source is perpendicular to the surface of the sample, with a distance of 20 cm. The real-time temperature is monitored by two thermocouples fixed in the center of the room. **Figure S16b** has compared the model's temperature changes with the coating of VOA, VOWA-1, and VOWA-2. The corresponding videos are given in the supporting information. For a model with blank quartz glass, the temperature increases from 27 ℃ to 55 ℃ in 600 s. The heating rate slows with the increase of light time. The temperature change of the model house equipped with a thermochromic coating can be divided into three stages. For VOA, the temperature rapidly increases from 27 ℃ to 40 ℃ in 90s (red area). The heating rate of the VOA coated model is lower than the model equipped with blank quartz glass, which is due to a lower transmittance of VOA. During this time, VOA is in an OFF state, the infrared radiation can enter to the house. With continuous radiation, the surface temperature of the VOA reaches a transition value, the VOA coating transforms to ON state, less infrared radiation can be incident into the house. As a result, a slight decrease in temperature is found in the green area of **Figure S16b**. Although the coating on an ON state can reduce the incidence of infrared radiation, other radiation still enters the model, which will cause the temperature to rise slowly again (blue area). The temperature of the house which equips VOA coating is 15 ℃ lower than that with blank quartz glass. The red area in the temperature curve of VOWA-1 is smaller than that of VOA and the temperature at the knee point of VOWA-1 is lower than that of VOA, which indicates the W doped sample present lower τ_c (heating) than that of the undoped sample. For VOWA-2, the τ_c (heating) furtherly decreases due to a higher concentration of W dopants.

Figure S17. Photograph of the as-deposited sample before and after the RTA process.

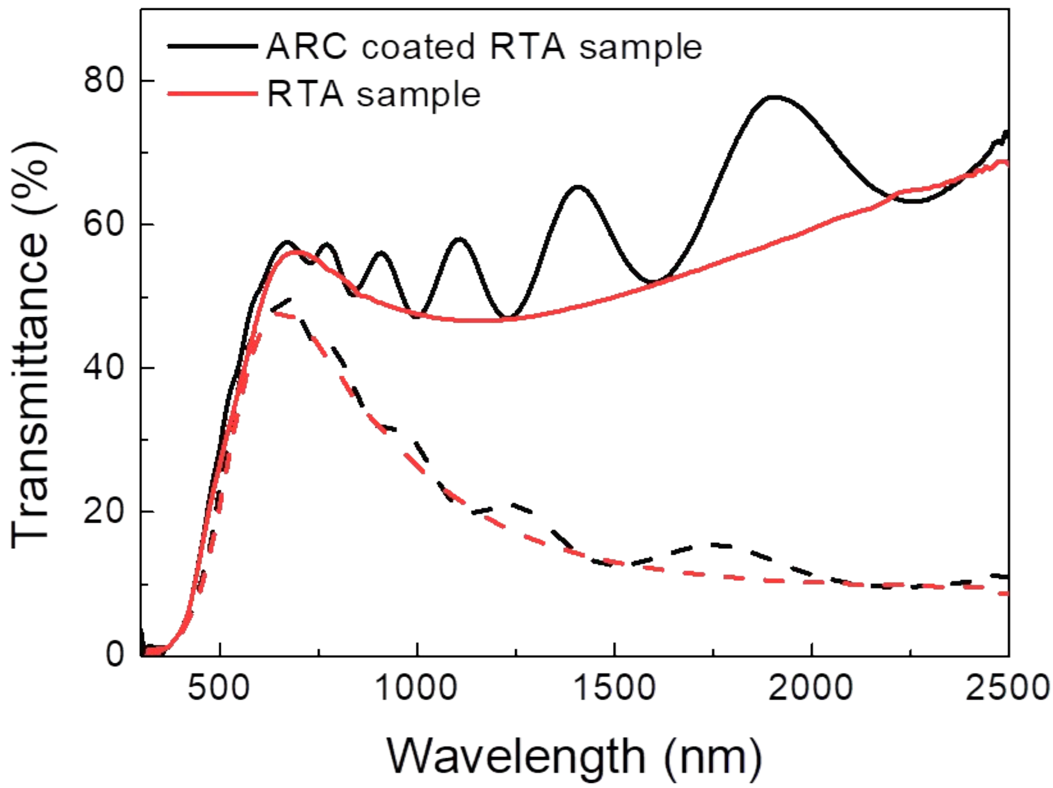

Figure S18. Transmittance spectra of the RTA sample and the anti-reflective coating coated RTA sample.

The smart windows with V_2O_5 will lead to a high risk for the user due to the poisonousness of V_2O_5. Adding a non-poisonous coating is the most effective way to protect the user from V_2O_5. The RTA sample with the V_2O_5 component is well compatible with the anti-reflective coatings (ARC). **Figure S18** shows the transmittance of the ARC coated RTA sample, the RTA sample can be overall covered by the ARC, and the ARC shows little influence on the thermochromic performance. The ARC is simply spin-coating on the surface of the RTA sample. The ARC used in this work is a kind of Si-Al gel, which has been reported in our previous work [*Journal of Alloys and Compounds 731 (2018) 1197-1207*].