Supplementary Information

VO_2 thermochromic smart window for energy savings and generation

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Calculations

The total internal reflection occurs when the light propagation into an optically thinner medium from an optically dense medium at the angle of incidence bigger than the total internal reflection angle. The corresponding formula is as follow:

$$\sin c = 1/n$$

in which n represents the refractive index of the optically dense medium and *c* represents the internal reflection angle. In our devices, n is 1.59, and *c* can be calculated to be 38.9^{o}.

To investigate the optical properties of the devices, the transmittances spectra (visible and solar) and the IR modulation abilities of three devices were characterised and further calculated according to the equation

$$T_i = \int \varphi_i T(\lambda) d\lambda / \int \varphi_i(\lambda) d\lambda$$

where T_λ denotes the transmittance at wavelength (λ), i denotes vis or sol for the calculations, is the standard luminous efficiency function for the photonic vision and is the solar irradiance spectrum for an air mass 1.5 corresponding to 37 ℃ above the horizon[1].

To investigate the properties of the devices, we characterised the solar cell by measuring the efficiency, open-circuit voltage (V_{oc}), fill factor (FF) and short-circuit current density (J_{sc}) under AM 1.5 illumination.

Discussion

Figures S1-a and S1-b show the XRD patterns of the VO_2 film and VO_2 nanoparticles, respectively. All of the peaks from Figures S1-a and S1-b can be indexed to VO_2 (M).

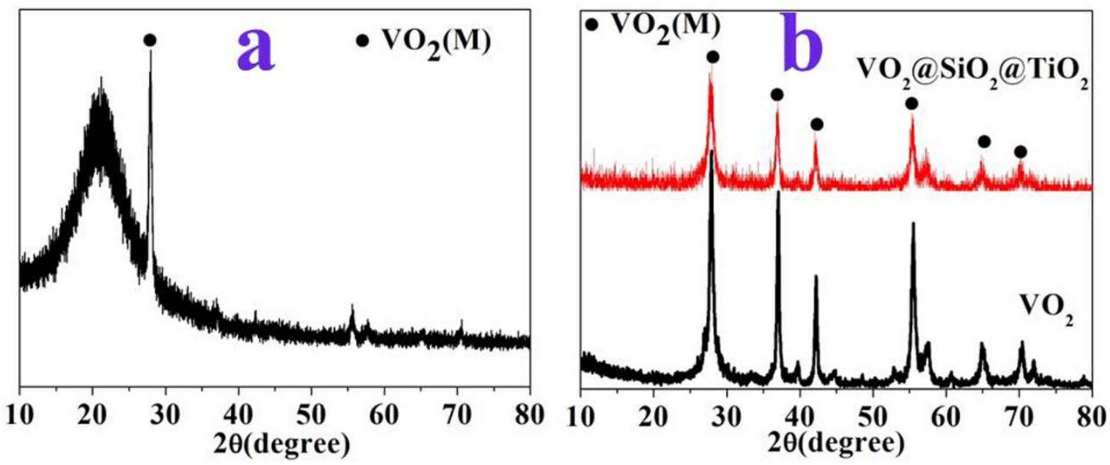

Figure S1|XRD result of VO_2 film and VO_2 nanoparticles. a, XRD pattern of the VO_2 film prepared by the solution method. b, XRD patterns of the VO_2 and VO_2@SiO_2@TiO_2 nanoparticles.

Figure S2 shows the SEM and TEM images of the VO_2 film and the VO_2, VO_2@SiO_2 and VO_2@SiO_2@TiO_2 nanoparticles. The VO_2 film is particulate with spherical VO_2 particles approximately 10 - 200 nm in diameter (Figures 2a, 2b). The SAED pattern in Figure S2c suggests that the film is highly crystalline. Figure S2d shows the morphology of the VO_2 nanoparticles, which are VO_2 (M) in crystalline phase and were prepared using the hydrothermal method. Figures S2e and S2f show the morphology of the VO_2@SiO_2 core-shell structure, and Figure S2i provides the EDS of the selected area of the red circle. The TEM image for the VO_2@SiO_2@TiO_2 nanoparticles is shown in Figure S2g. The corresponding EDS patterns of the k, j, and m points indicated in Figure S2g show three layers of the particle. The corresponding STEM of the green line in Figure S2g is shown in Figure S2h. From the EDS and the STEM, we can conclude that the three-layered structure of the VO_2@SiO_2@TiO_2

nanoparticles was successfully synthesised.

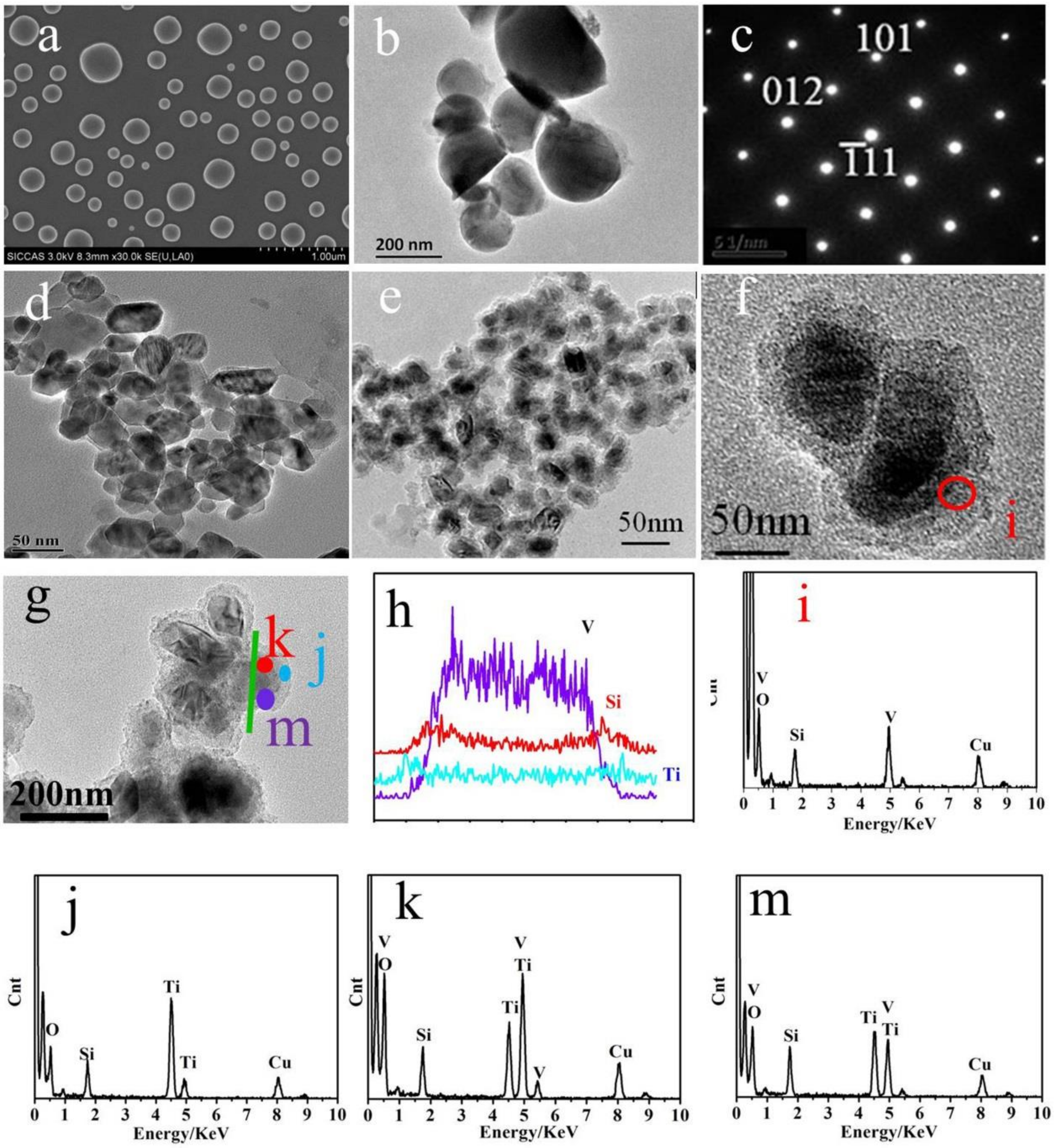

Figure S2|SEM and TEM characterisation of the VO_2 film and the particles. The SEM image of the VO_2 film is shown in a); the TEM image of the VO_2 film is shown in b); the SAED pattern of the film is shown in c); the TEM image of VO_2 particles is shown in d); the TEM image of VO_2@SiO_2 is shown in e); the magnification of e) is shown in f); the corresponding EDS is shown in i); the TEM image of VO_2@SiO_2@TiO_2 is shown in j); the corresponding EDS of the points j), k) and m) are shown in g), k) and m), respectively; the result of the STEM of the green line in g) is shown in h).