Supplementary Information

Effect of microplate size on the semiconductor-metal transition in VO$_2$ thin films

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1. Room temperature resistivity of VO$_2$ film devices

![Figure S1](image)

Figure S1. The estimated average resistivity of VO$_2$ film devices D1 to D4 collected from four devices for each case at room temperature. The results show that the resistivity of VO$_2$ film devices D4 to D1 reduces as grain boundary density increases, indicating that grain boundaries can lower the electrical resistance of semiconductor states by introducing defect levels between the Fermi level and the conduction band edge in the VO$_2$ bandgap.
2. The first derivative of the temperature curves

![First derivative of temperature curves](image)

**Figure S2.** The first derivative of the temperature curves \(\left|\frac{d\log(\rho)}{dT}\right|\) extracted from Figure 4(a) for a clear view of the \(T_{SMT}\) of VO\(_2\) films with different microstructures. The results show that the \(T_{SMT}\) (~340 K) is not considerably different during the SMT process for VO\(_2\) thin films with different microstructures.

3. The current variation before and after transition

![Current variation before and after transition](image)

**Figure S3.** \(I_{ds}-V_{ds}\) curves of D4 device measured at 300 K and 350 K, i.e. before and after phase transition. The current variation also changes by more than four orders of magnitude during the SMT process.

4. The morphology and phase transition properties of Mo\(^{6+}\)-doped VO\(_2\) film

Doping heterogeneous ions (such as W\(^{6+}\), Mo\(^{6+}\), and Nb\(^{6+}\)) is the commonly
adopted approach to reduce the $T_{\text{SMT}}$. Here we have further carried out Mo$^{6+}$ doping during the growth of S4 film sample by using MoO$_3$ powder as doping agent (5 mg). Limited by our own instrument conditions, EDS instead of XPS has been employed to detect elements in the doped film, and confirms the existence of Mo element. The test result shows that the $T_{\text{SMT}}$ of doped VO$_2$ film is lowered to 335 K, as shown in Figure S4(a). Meanwhile, it should be noted that the amplitude of the transition is decreased to 3 decades. However, with increasing the amount of MoO$_3$ powder, the VO$_2$ film becomes very discontinuous, making it difficult to fabricate device for phase transition measurements (In fact, the porous structures have appeared in the doped film), as shown in Figure S4(c) and (d). In current work, we emphasize on the effect of microplate size on the semiconductor-metal transition in VO$_2$ thin films by adjusting the amounts of precursors, more systematic investigations for the modulation of $T_{\text{SMT}}$ of VO$_2$ thin films by heterogeneous ions doping will be studied in the future work.

Figure S4. (a) Temperature-dependent resistance measurements of Mo$^{6+}$-doped VO$_2$ thin film, the inset is the first derivative of the temperature curves ($|d[\log (R)]/dT|$) for a clear view of the $T_{\text{SMT}}$ of the doped film. (b) XRD pattern of pure and doped VO$_2$ thin films, no significant differences on crystal structures can be observed in the film after Mo atoms are introduced, which is in agreement with results reported for Mo-doped VO$_2$ films. (c) The EDS pattern of the doped VO$_2$ thin films. (d) SEM image of VO$_2$ thin films under 10 mg MoO$_3$ powder as doping agent.

5. IR response characteristics of VO$_2$ film device
Figure S5. (a) $I_{ds}$-$V_{ds}$ curves of the VO$_2$ film photodetector under dark and different IR radiation intensities, the inset is a typical SEM image of the device and scale bar is 20 µm. (b) Photo-switching characteristics of the photodetector under varying light power. (c) Photocurrent versus light power plot at bias of 5.0 V. (d) A single on/off cycle for estimating the rise and fall times.