

Supporting Information

Enhanced Optical Response of Hybridized VO₂/Graphene Films

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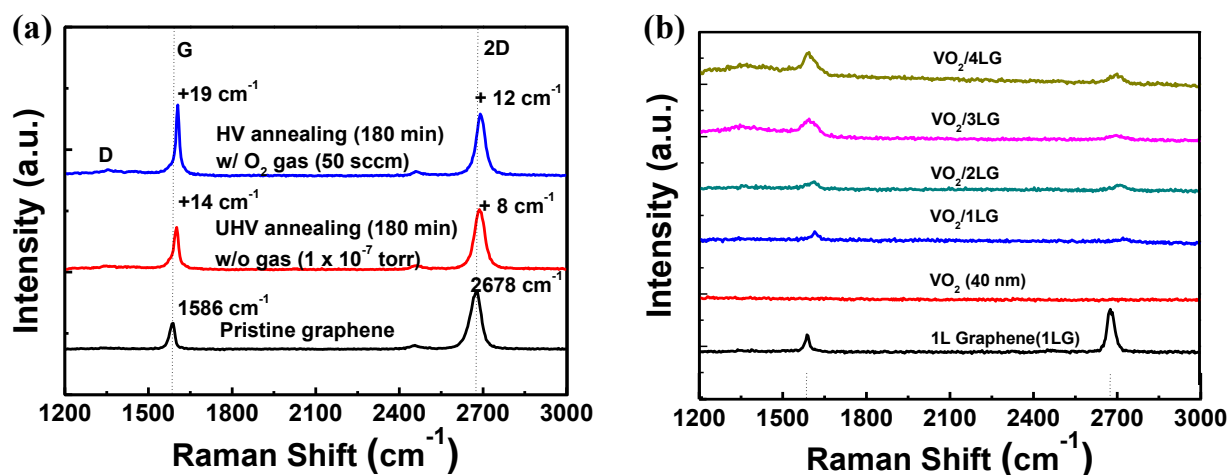


Fig. S1 Raman spectra of graphene films according to (a) annealing processes, (b) VO₂ growth.

Fig. S1 (a) shows raman spectra of graphene films under the different annealing conditions in ultra high vacuum (UHV) chamber. Eventhough, there is no D peak under the small amount of oxygen ambient and there is doping slightly because of the shifts of G and 2D peaks. (b) is raman spectras from the graphene and VO₂ thin film when it was on the graphene(0L~4L)/sapphire. As you can see here, the D peak can be seen almost invisible, simlilar with (a). One the other hand, The G and 2D peak of hybridize samples can be seen that an increase as increasing the number of graphene layers.

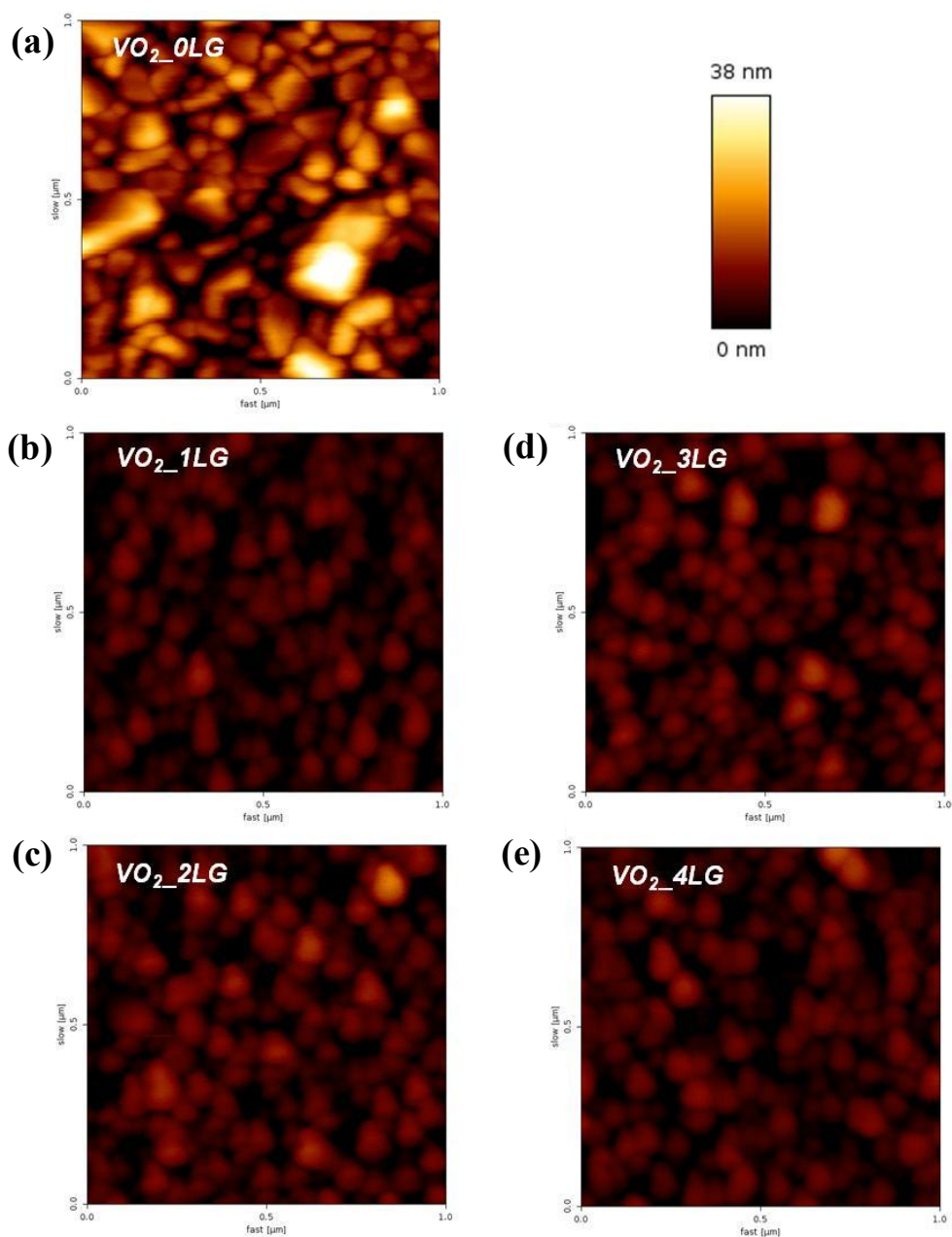


Fig. S2 AFM images of the graphene-supported VO_2 . (VO_2 / x N layer/Sapphire)

According to the AFM analysis, the morphology of VO_2 thin films are significantly different. In the case of the VO_2 thin film on graphene(1L~4L)/ sapphire is much better uniformity for the grain size and vertical-profile (height) than the VO_2 thin films deposited on bare sapphire.

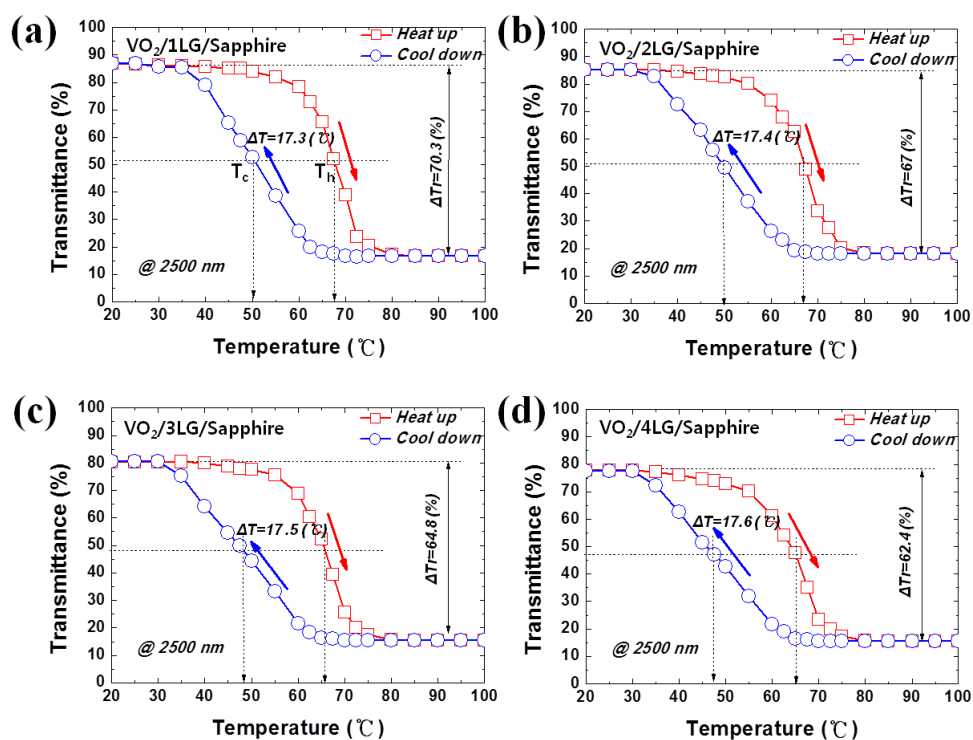


Fig. S3 Temperature dependence transmittance of the graphene-supported VO₂. (VO₂ / x N layer / Sapphire)

Fig. S3 is the temperature dependence IR transmittance of VO₂ thin film on graphene(1L~4L)/sapphire. According to the data, the critical phase transition temperature and the width of hysteresis are decreased as increasing the number of graphene-layers, respectively.

Tr_{max} : Transmittance of each sample at room temperature (20 °C), before phase transition.

Tr_{min} : Transmittance of each sample at high temperature(100 °C), after phase transition.

$Tr_{half} = [(Tr_{max} - Tr_{min})/2] + Tr_{min}$: Half point of transmittance-change, before and after phase transition (Reference transmittance for the estimation of T_c , T_h).

T_h : Phase transition temperature of hybridized VO₂/graphene samples for the heating process.

T_c : Phase transition temperature of hybridized VO₂/graphene samples for the cooling process.

Substrate	ΔTr (%)	T_h (°C)	T_m (°C)	T_c (°C)	ΔT (°C)	RMS (nm)
(Sapphire)						
VO ₂ /0LG	58	71.8	62.2	52.7	19.1	8.6
VO ₂ /1LG	70.3	67.5	58.9	50.4	17.3	2.9
VO ₂ /2LG	67.0	66.9	58.2	49.5	17.4	3.2
VO ₂ /3LG	65.3	65.9	57.1	48.2	17.5	3.2
VO ₂ /4LG	62.4	65.0	56.1	47.2	17.6	2.9

Table. S1 Various optical properties of the graphene-supported VO₂(VO₂ / x N layer / Sapphire)

Table S1 is from the analyzed values of Fig. S3 and S2 for each samples. According to the result, the phase transition temperature is decreased as increasing the number of graphene-layers, respectively. Regarding the mean phase transition temperature of VO₂ on 4L graphene sample is down to 56.1 °C and the surface morphology is also significantly different as there is graphene or not.

ΔTr (%): 100 Gap-value of maximum and minium transmittance for the sample.

$T_m = (T_h + T_c)/2$: Mean phase transition temperature of hybridized VO₂/graphene film on sapphire as a function of temperature.

$\Delta T = |T_h - T_c|$: hysteresis of phase transition temperature for hybridized VO₂/graphene film on sapphire depend on the heating and cooling process.

RMS: Relative values of surface morphology for each samples evaluated from Fig. S1.

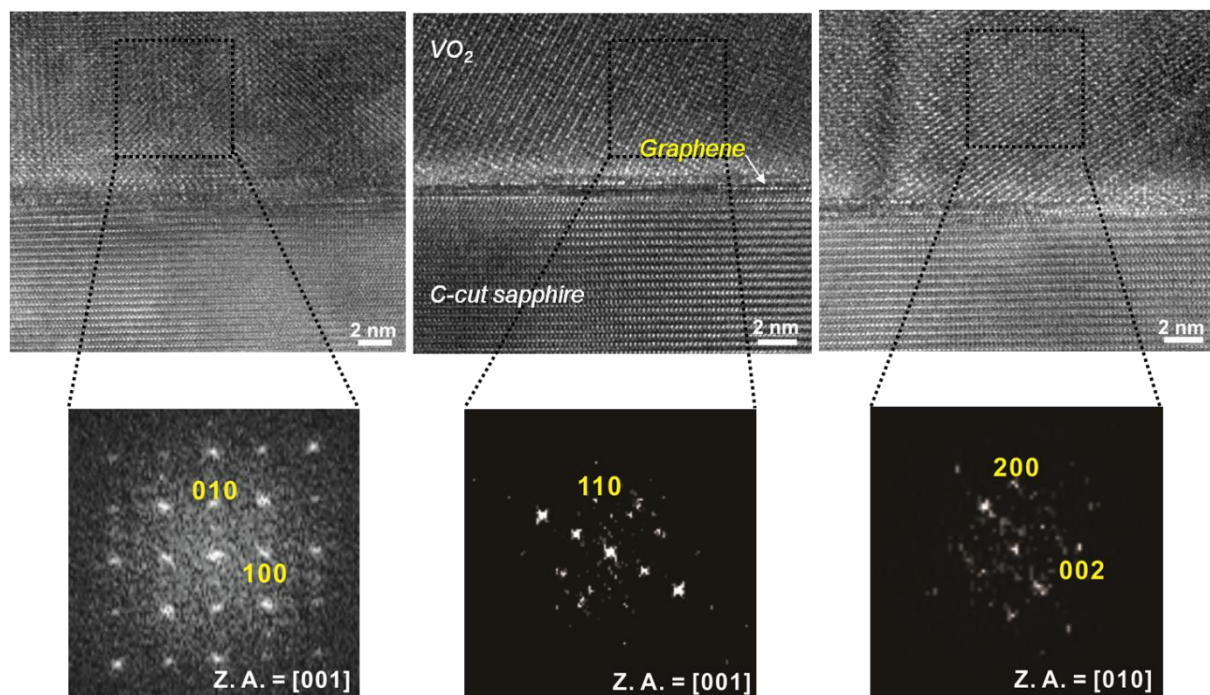


Fig. S4. High-resolution TEM images of the VO₂ films on graphene-supported sapphire substrate. (Various grains with different orientations could be observed)

VO₂ thin film on graphene-supported sapphire is no related with sapphire-orientation, as shown in above figure S4. The hybridized VO₂/graphene film on sapphire has a polycrystalline features, relatively.