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Supporting Information

Morphology-controlled epitaxial VO_2 low-dimensional structures: The delicate effects of substrates and structures on the phase transition behaviors

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Fig. S1. Large-area SEM images of nanowires, nanorods and nanoplatelets.

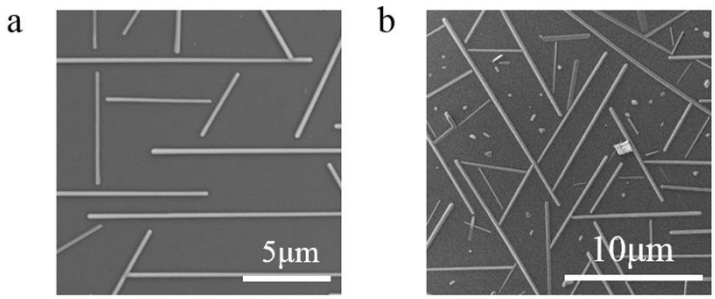

Fig. S2. Influence of frequency of pulsed laser on the SEM morphologies of VO_2 nanowires. (a) 1 Hz, (b) 4 Hz.

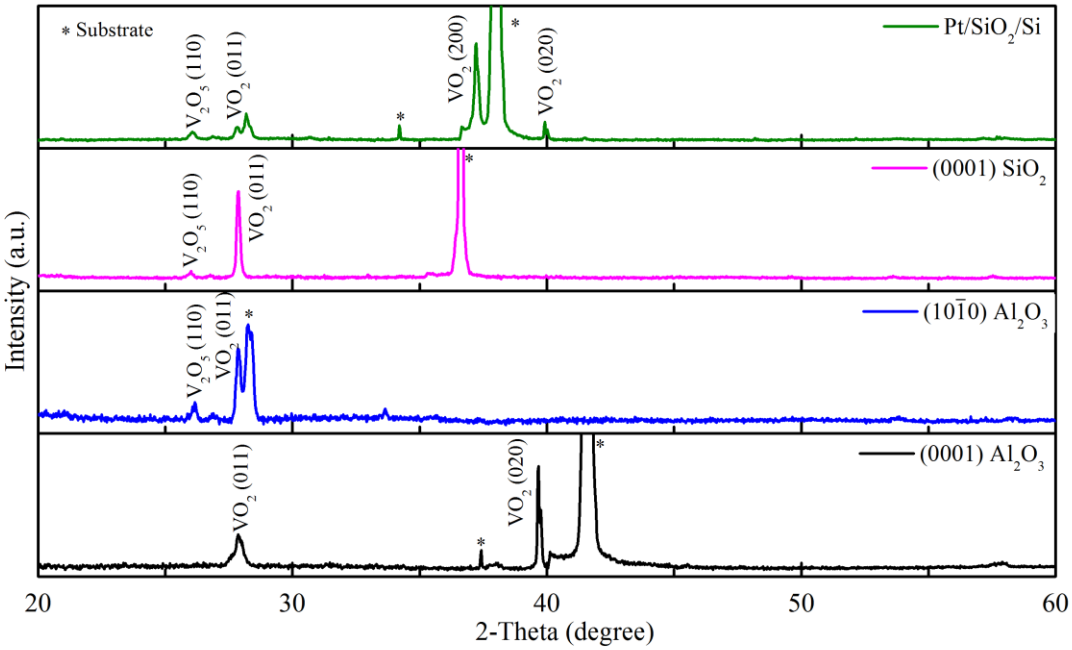

Fig. S3. XRD patterns of VO_2 low-dimensional structures (LDSs) deposited on different substrates under reference conditions (8 Pa of deposition oxygen pressure, 1073 K of deposition temperature with a thirty-minute annealing process at this temperature, 1 Hz of pulse frequency and 3000 counts of laser pulse).

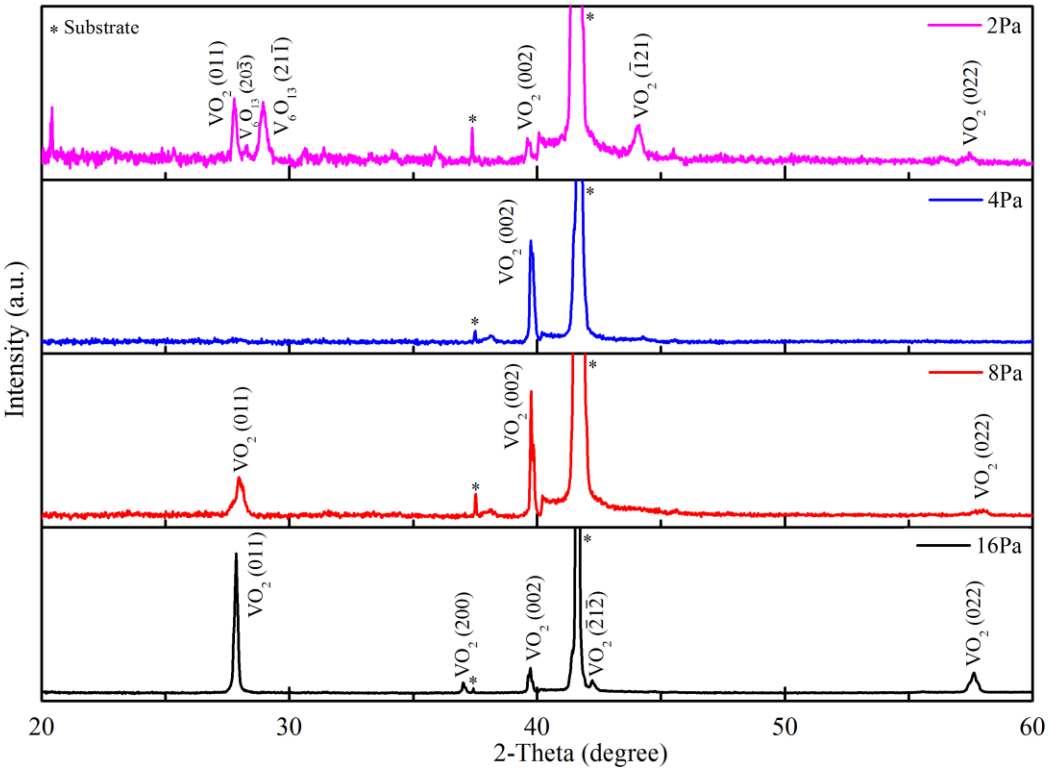

Fig. S4. XRD patterns of VO_2 LDSs deposited under different oxygen pressure conditions (1073 K of deposition temperature with a thirty-minute annealing process at this temperature, 1 Hz of pulse frequency and 3000 counts of laser pulse).

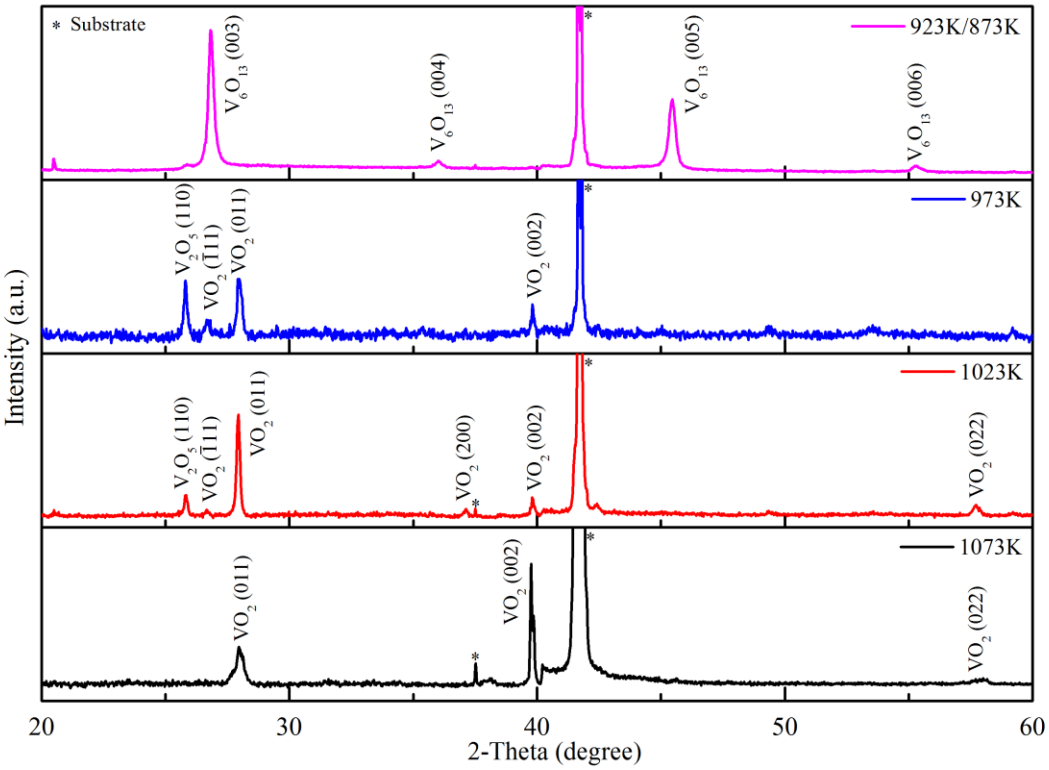

Fig. S5. XRD patterns of VO_2 LDSs deposited at different deposition temperatures (8 Pa of deposition oxygen pressure, 1 Hz of pulse frequency and 3000 counts of laser pulse).

From the Fig. S5, we find that the deposition temperature has great influence on the growth process. When deposition temperature is lower than 973 K, samples with pure and highly oriented V_6O_{13} phase are obtained. At 973 K, coexisting phase of V_2O_5 and VO_2 is distinguished from the XRD pattern. The intensity of peak related to V_2O_5 gradually decreases with the increase of deposition temperature, and disappears when deposition temperature reaches 1073 K. By systematically and carefully analyzing the XRD results and SEM images, we suppose that the growth process of VO_2 LDSs in this work could be as follows: a) V_2O_5 firstly forms under high oxygen pressure; b) V_2O_5 melts at high temperature; c) VO_2 separates out from V_2O_5 droplet.

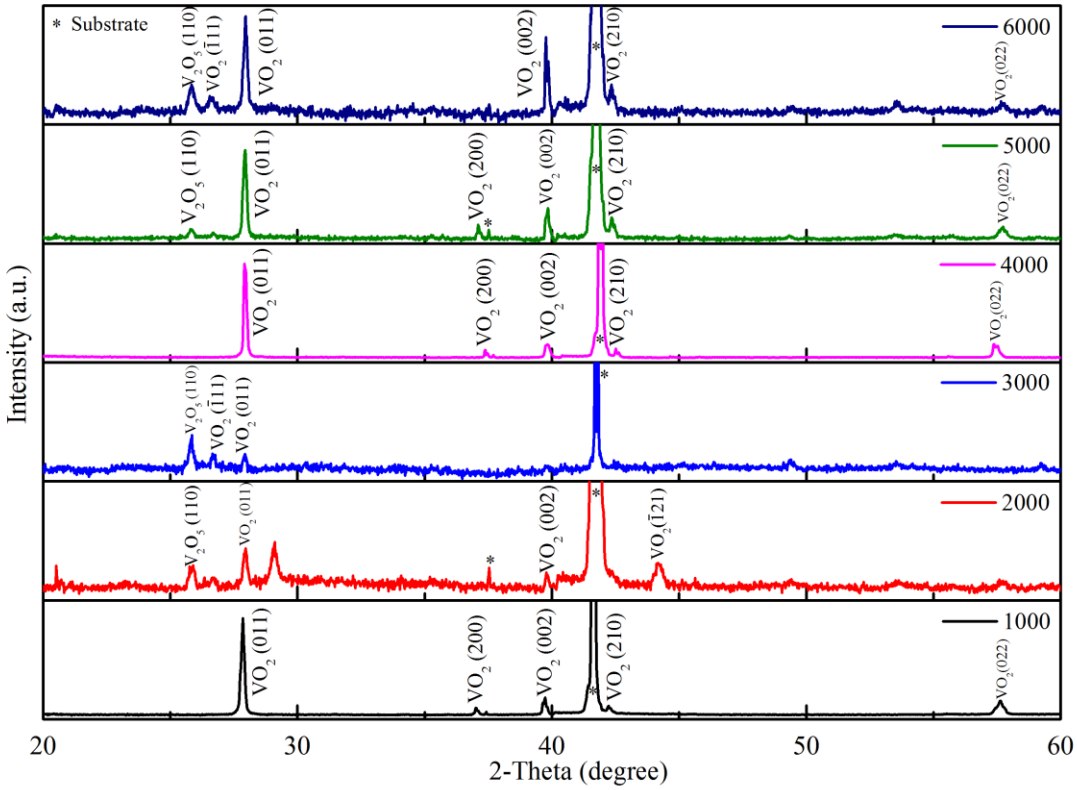

Fig. S6. XRD patterns of VO_2 LDSs deposited with different counts of pulsed laser (8 Pa of deposition oxygen pressure, 1073 K of deposition temperature with a thirty-minute annealing process at this temperature, 1 Hz of pulse frequency).

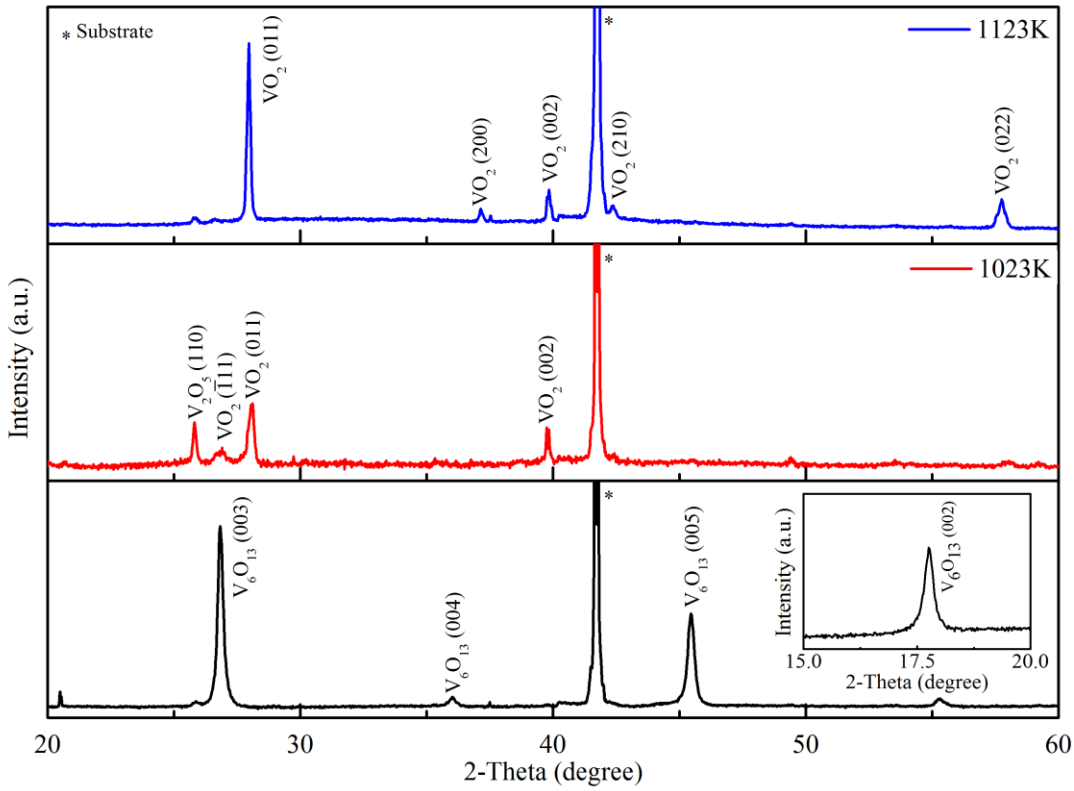

Fig. S7. XRD patterns of VO_2 LDSs deposited under different annealing temperatures (8 Pa of deposition oxygen pressure, 873 K of deposition temperature, 1 Hz of pulse frequency and 3000 counts of laser pulse).

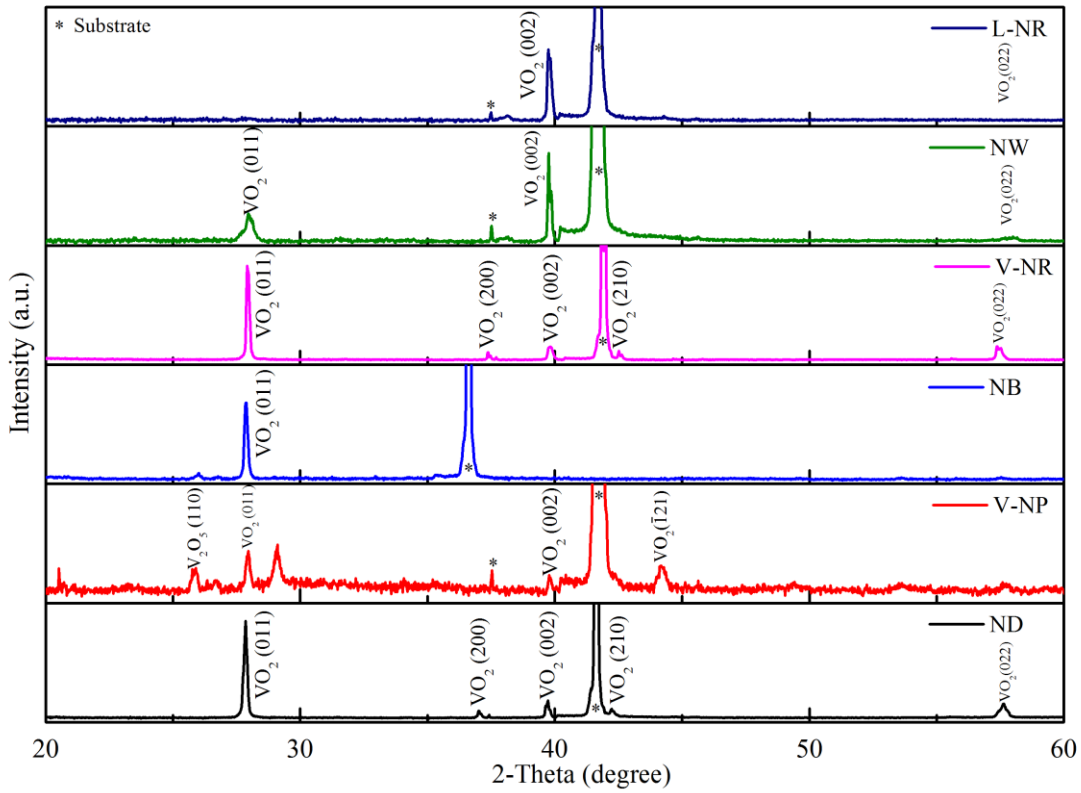

Fig. S8. XRD patterns of different LDSs

XRD patterns of all LDSs for TD-RS and TD-XRD investigations are shown in Fig. S8. From the XRD patterns, samples of L-NR, V-NR, NW, NB and ND exhibit pure phase of VO_2. For the V-NP, XRD pattern indicates that there are phases of V_2O_5 and other uncertain impurities. But the phase transition behavior of V-NP is characterized by TD-RS, which is performed by focusing a laser beam with a spot size of approximately 2 μm onto the VO_2 LDSs. The selected area of V-NP for TD-RS measurement is demonstrated as pure VO_2, according to the Raman spectrum at RT.

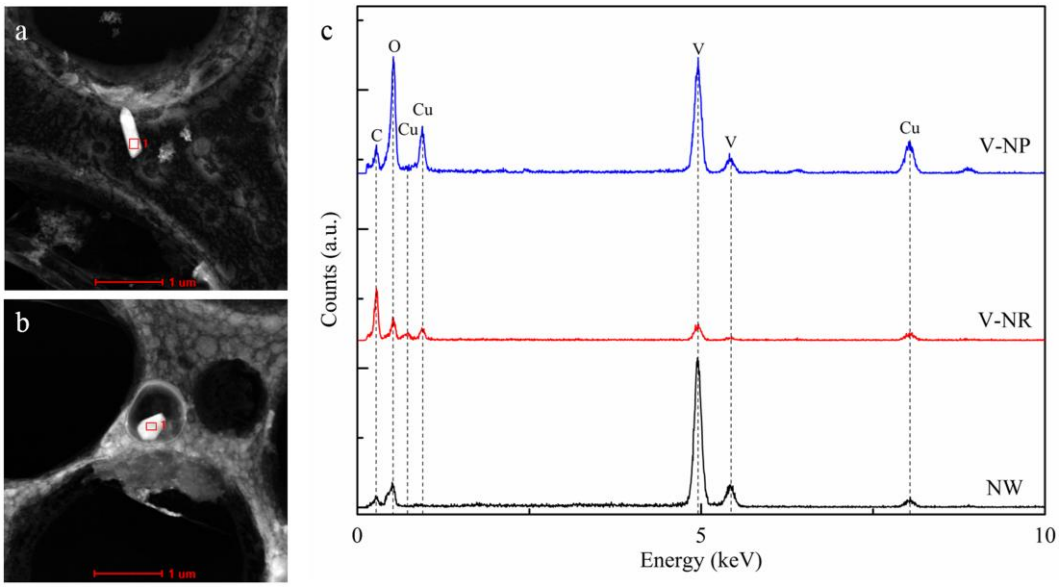

Fig. S9. Selected areas of (a) vertically-grown nanorod (V-NR) and (b) vertically-grown nanoplatelet (L-NP) for energy dispersive spectroscopy (EDS) measurement. (c) EDS patterns of nanowire (NW), V-NR and V-NP.

Table S1 Comparison of key PLD parameters in this work and in the literatures

Reference	Ref. S1	Ref. S2	Ref. S3	Ref. S4	This work
Target	V_2O_3	VO_2	V	V	VO_2
Pulse frequency	--	5 Hz	25 Hz	10 Hz	1-4 Hz
Substrate	(0001) Al_2O_3 (10-10) Al_2O_3	Glass	Glass (0001) Al_2O_3 (100) Si	Si/SiO_2	(0001) Al_2O_3 (10-10) Al_2O_3 (0001) SiO_2 $Si/SiO_2/Pt$
Oxygen pressure	2.6-3.9 Pa	1-5 Pa	1.47 Pa	0.1-6.7 Pa	2-16 Pa
Deposition temperature	903 K	773 K	--	773-973 K	873-1073 K
Annealing temperature	--	--	723 K	--	873-1123 K
Annealing condition	--	--	33 Pa O_2	--	High vacuum

Some key deposition parameters in the references[S1-S4] and in this work are listed and compared in Table S1. For the deposition parameters, we find that the main differences that may determine the growth of LDSs are the deposition temperature, the oxygen pressure and the annealing condition. In previous works, V, VO_2 and V_2O_3 targets were used. The films were deposited under the relative low oxygen pressure and deposition temperature. These parameters were chosen to avoid the oxygen rich phases, such as V_2O_5 or V_6O_{13}. In another aspect, in previous works post-annealing process was always absent or was performed at a low temperature. In our work, the annealing process is performed under a high temperature and high vacuum environment. But from previous works, one can notice that V_2O_5 or other impurities also appeared even under the low oxygen pressure and deposition temperature. In contrast, samples with pure VO_2 also can be fabricated under the high oxygen pressure and deposition temperature in this work. This is because that different growth mechanism is working in the fabrication processes. The fabrication in the references belongs to conventional physical deposition, while the growth processes in this work are much similar to the CVD method.

References

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