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Self-assembled spinodally decomposed VO_2-based nanostructured thin films for thermochromic applications

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Vanadium dioxide (VO_2) is a renowned oxide owing to its reversible first-order semiconductor-metal phase transition between low-temperature monoclinic (M) phase and high-temperature rutile (R) phase. For applications, the M phase is almost transparent to infrared light while the R phase is highly reflective, maintaining visible light transmittance. For this reason, VO_2-based thin films provide a promising application in energy-saving smart windows. One of the most efficient ways for fabricating high-performance films is to create multi-nanolayered structure. However, it is highly complex to make such layers in the VO_2-based films when using conventional techniques. Here, we report a facile two-step approach, i.e., the room temperature magnetron sputtering–annealing approach, to fabricate multilayered VO_2-TiO_2 thin films via spinodal decomposition mechanism. The layered structure and the resulting performances of the film can be optimized just by varying the degree of annealing. We use different types of sapphire substrates (A-plane (11-20) sapphire, R-plane (1-102) sapphire, C-plane (0001) sapphire, and M-plane (10-10) sapphire) to achieve different decomposition modes. We have clarified the well-ordered alternating arrangement of Ti- and V-rich epitaxial thin layers. By characterizing the phase structure, thermochromic performance, and durability of the decomposed films, we have found that the derived films exhibit superior optical modulation upon phase transition, significantly reduced transition temperature and hysteresis loop width, and high degradation resistance. Using the new approach, it has become possible to tailor the microstructure of the thin film, and thereby achieve excellent performances.

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