Effect of Al oxide top coatings on the durability of thermochromic VO_2 thin films

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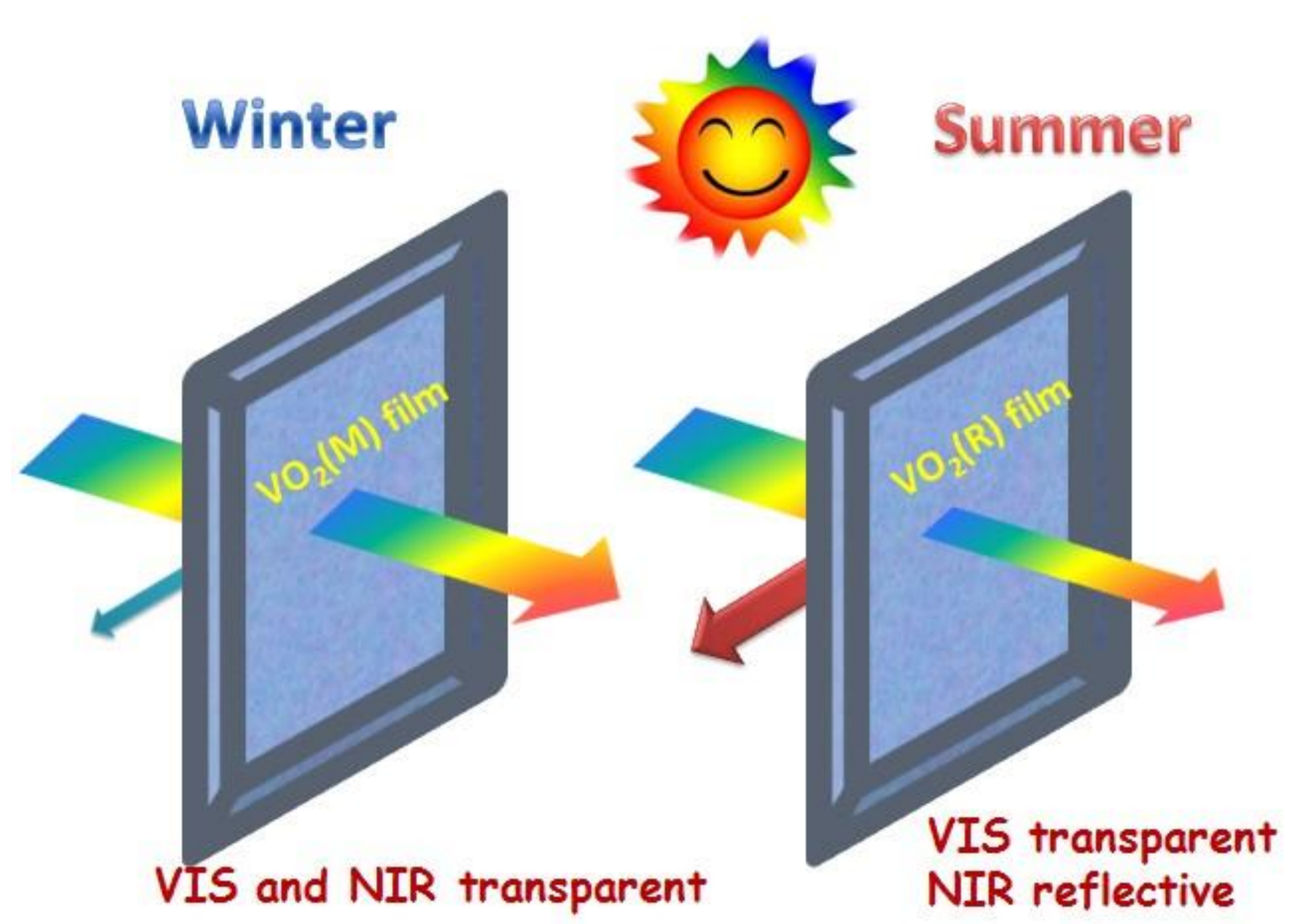
MOTIVATION

- VO_2 undergoes metal-to-insulator (rutile phase to monoclinic phase) transition at a critical temperature, τ_c, about 68 ℃
- It is a thermochromic (TC) material for energy-efficient window coating

(Modulation of the infrared transmittance of solar energy)

- Performance needs to be improved for practical use



OBJECTIVE

The VO_2-based films will lose their desirable properties during extended periods of time (Fig. 1) since VO_2 is not the thermodynamically stable oxide (V_2O_5).

The goal of this project is to preserve the thermochromism in VO_2-based materials by Al oxide top coating.

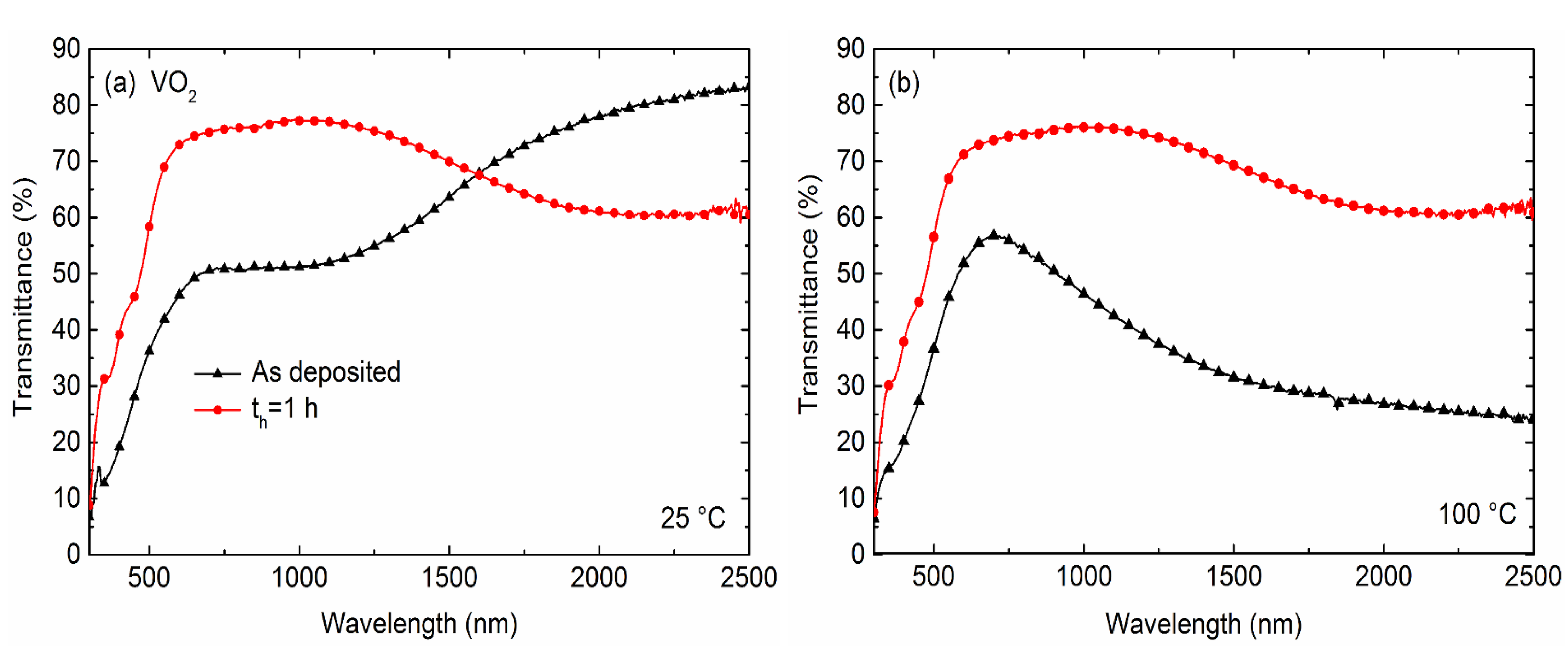
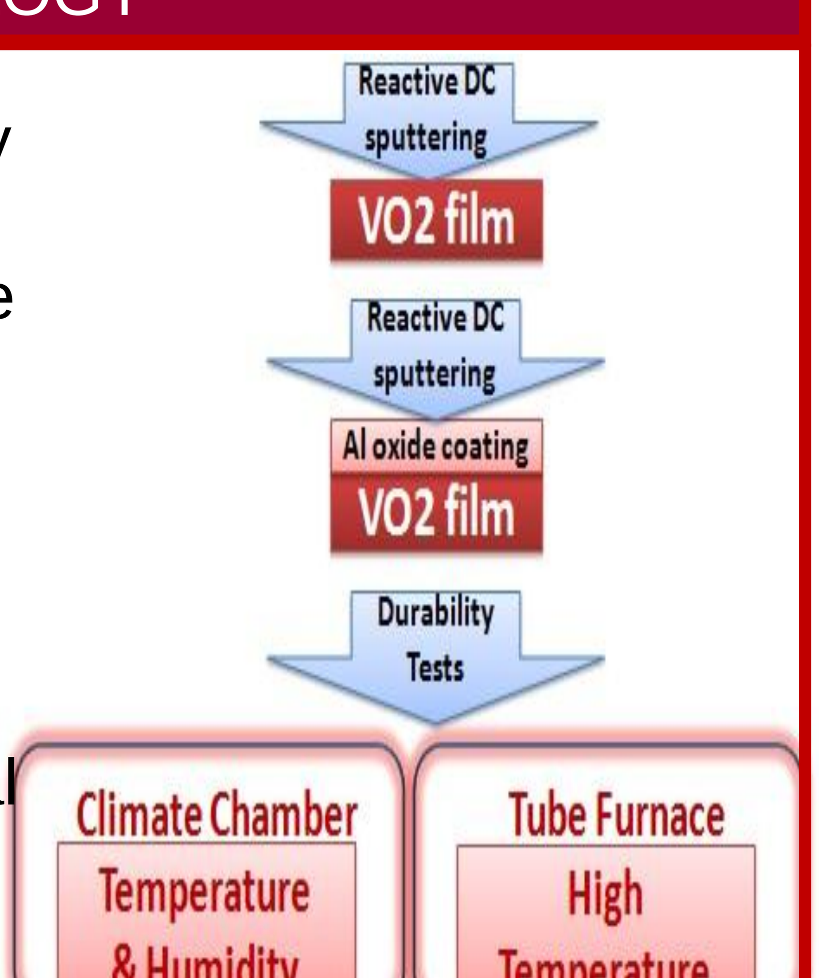


Fig. 1. Spectral transmittance for an 80-nm-thick VO_2 film in as-deposited state and after heating at 300 ℃ in dry air for one hour. Data were taken at $\tau < \tau_c$ (panel a) and $\tau > \tau_c$ (panel b).

METHODOLOGY

- Thin films of VO_2 were prepared by reactive DC magnetron sputtering on 1-mm-thick glass plates. Al oxide films with thickness in the 10 to 150 nm range were deposited onto VO_2 films.
- Films of VO_2 with and without Al oxide top layers, were subjected to two accelerated aging tests: thermal oxidative and humidity conditions.



RESULTS

The Al oxide prevents oxidation of the underlying VO_2 both in high temperature environment (300 ℃) (Fig. 2) and also in humidity condition (60 ℃, RH= 95 %) (Fig. 3) since the optical data are almost unchanged.

For the thinner Al oxide layer (10 nm), it gives good preservation of the TC properties up to t_h = 30 h in the hot air (Fig. 2 (a) and (b)) and up to t_h = 72 h in the humidity condition (Fig. 3 (a) and (b)). The thicker Al oxide coating (30 nm) gives better durability.

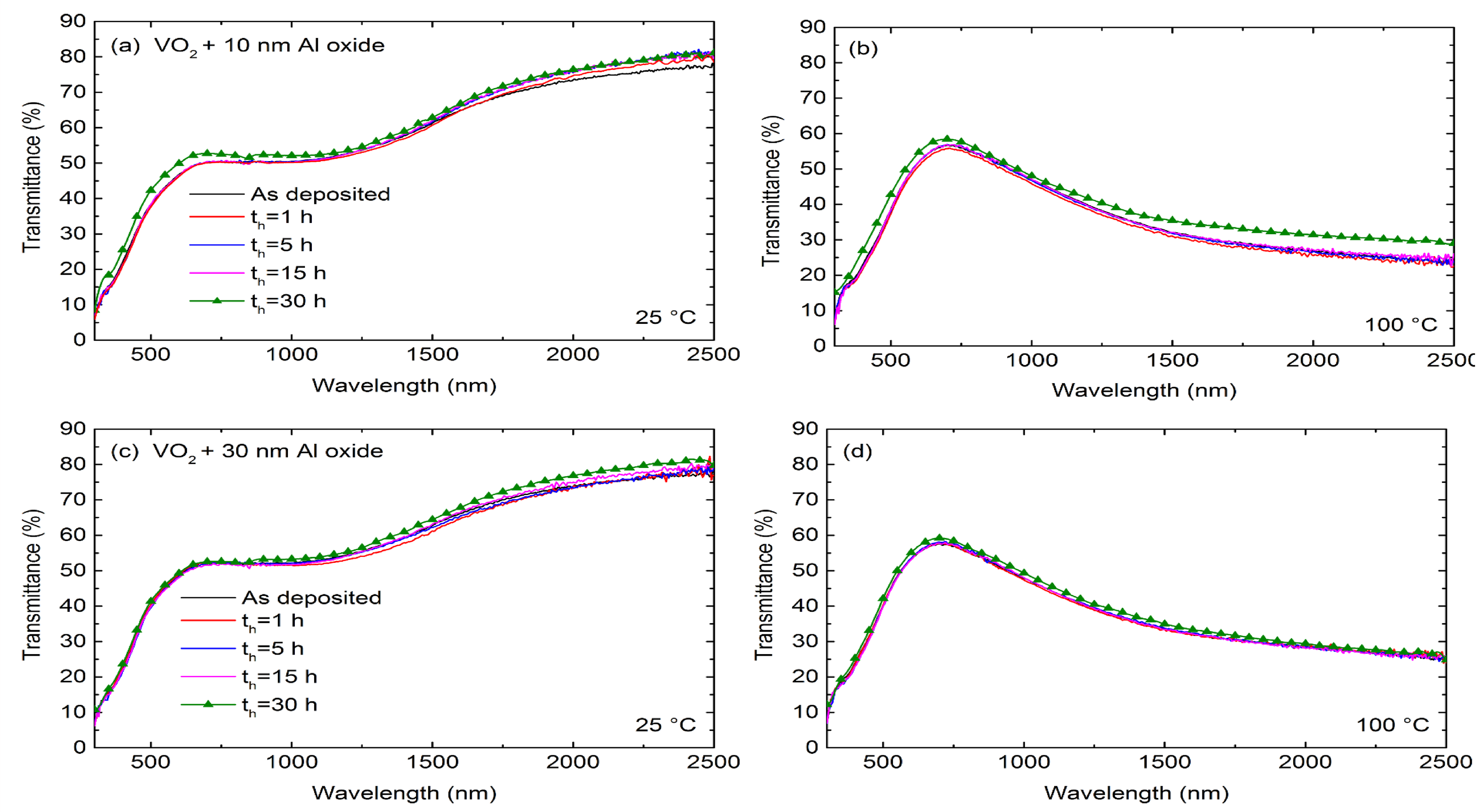


Fig. 2. Spectral transmittance for 80-nm-thick VO_2 films, coated with 10 nm (panels a and b) and 30 nm of Al oxide (panels c and d), in as-deposited state and after heating at 300 ℃ in dry air for the shown durations t_h. Data were taken at $\tau < \tau_c$ (panels a and c) and $\tau > \tau_c$ (panels b and d).

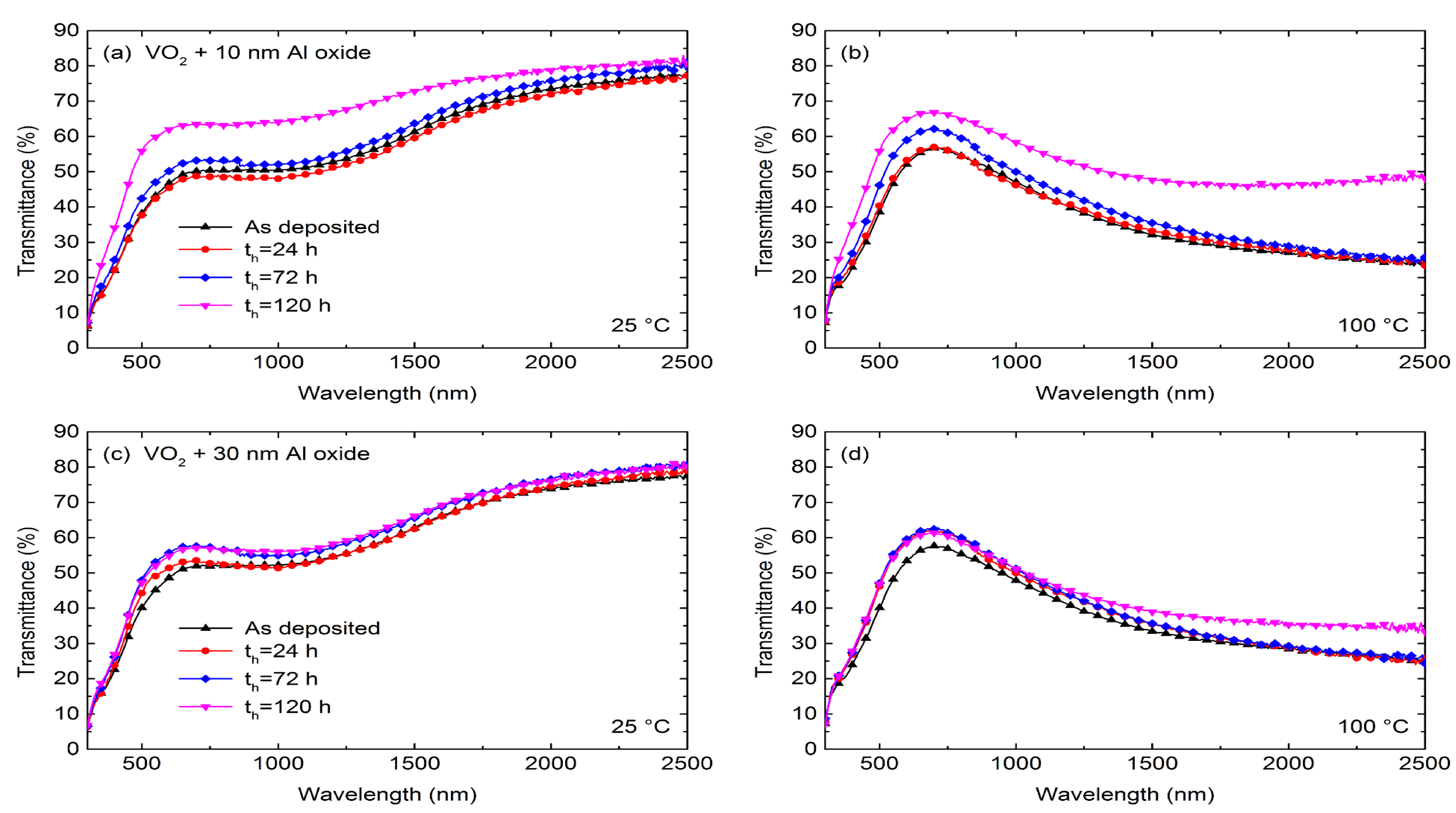


Fig. 3. Spectral transmittance for 80-nm-thick VO_2 films, coated with 10 nm (panels a and b) and 30 nm of Al oxide (panels c and d), in as-deposited state and after heating at 60 ℃ in air with a relative humidity of 95 % for the shown durations t_h. Data were taken at $\tau < \tau_c$ (panels a and c) and $\tau > \tau_c$ (panels b and d).

CONCLUSIONS

- 80-nm-thick VO_2 films rapidly converted to non-TC V_2O_5 under the chosen harsh conditions.
- A 30-nm-thick sputter-deposited Al oxide top coating provided good protection and delayed the oxidation for more than one day upon heating in dry air at 300 ℃ and that protection occurred for several days at 95 % relative humidity and 60 ℃.
- Increased thickness of the Al oxide yielded enhanced protection.

REFERENCES & ACKNOWLEDGEMENTS

Y-X Ji, S-Y Li, G. A. Niklasson, C. G. Granqvist, *Thin Solid Films*, in press, http://dx.doi.org/10.1016/j.tsf.2014.03.043

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