Effects of High Temperature Annealing on Tungsten-doped VO_2 Phase Transition Temperature

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Research Question

This project seeks to address how annealing tungsten-doped vanadium dioxide at high temperatures affects the phase transition temperature and the change in transmittance between the metallic and insulating phases.

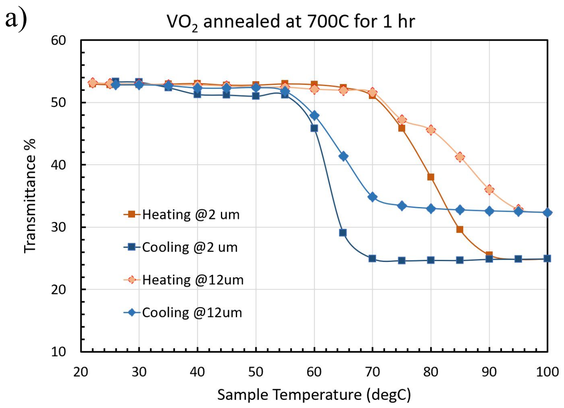
Motivation

The insulator to metal phase transition of undoped VO_2 happens around 68°C, and if the phase transition temperature could be lowered to ambient temperature, this material would be even more useful as a thermal control for spacecraft or smart window applications.

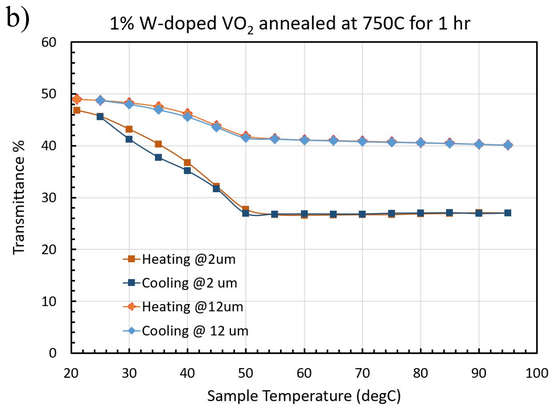
Results

The phase transition temperature for the VO_2 sample annealed at 700°C for 1 hour happens from 55-90°C, as seen in figure a. The hysteresis of this sample was larger than those annealed at lower temperatures, while it was expected that at higher annealing temperatures the hysteresis would be smaller.

a)

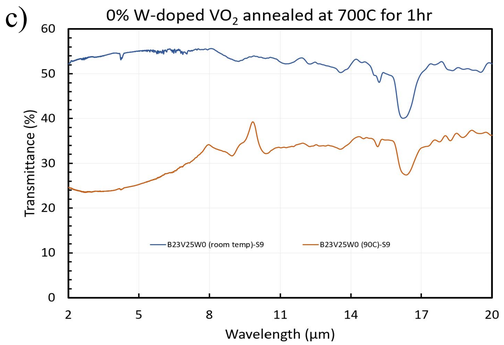


b)

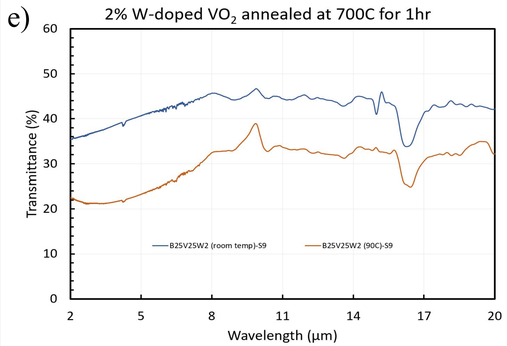


a) Heating cooling curve of VO_2 annealed at 700°C for 1 hr where the phase transition occurs around 75°C.
b) Heating cooling curve of 1% W-doped VO_2 annealed at 750°C for 1 hr where the phase transition occurs around 46°C.

c)

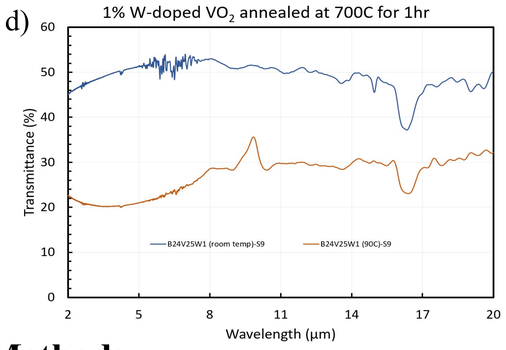


e)

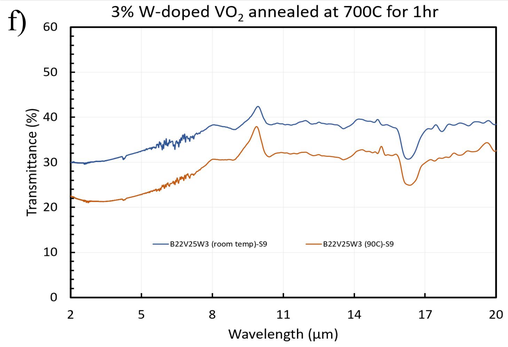


c-f) Transmittance of different levels of tungsten-doped VO_2 annealed at 700°C for 1 hr at room temperature and 90°C. As seen in the graphs, as the percent of tungsten increases the phase transition temperature is lowered.

d)



f)



Methods

Samples of 25 nm tungsten-doped vanadium on silicon substrates are annealed in a furnace and during this process the vanadium is oxidized and becomes VO_2. FTIR is used to measure the transmittance of the sample as it is being heated and cooled 5°C at a time. As seen in figures a and b, the change in transmittance measured reveals the phase transition temperature.

Future Work

By lowering the oxygen concentration in the furnace during the annealing process, the amount of V_2O_5 on the surface could be reduced and lead to more accurate measurements.

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