Investigation into the Thermochromism of Vanadium Dioxide Thin Films

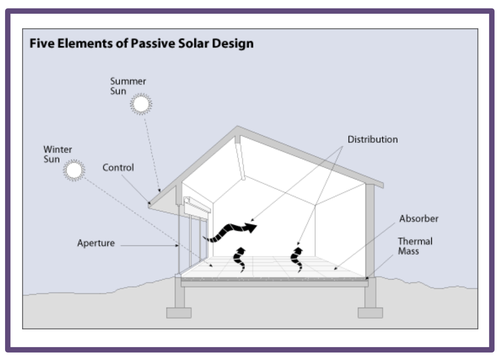
Ben Crozier, Premlal Balakrishnapillai, Merlyne De Souza
University of Sheffield, EEE department

In this work, VO_2 thin films were deposited using a modified precursor oxidation process[1], minimising the plasma power whilst still producing high purity VO_2. This is of paramount importance as the presence of vanadium pentoxide (V_2O_5) will increase the transition temperature.[2] The films are characterised using atomic force microscopy (AFM) and Raman spectroscopy, in conjunction with transmittance and reflectance measurements. Electrical measurements were taken at room temperature and above the transition temperature to observe the resistance change at the phase transition.

Introduction

The creation of a comfortable living environment requires between 30-40% of the annual energy consumed worldwide.[3] This must be reduced through alternative energy generation, or removed through novel heat management techniques.

A proven method for temperature regulation is solar passive heating, especially when combined with “smart windows”.

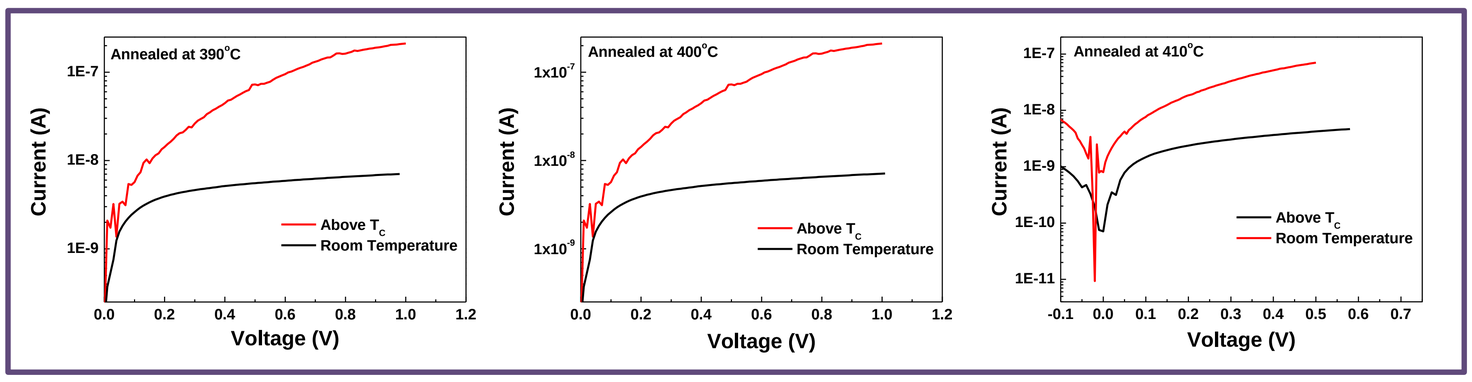


These are similar to conventional double glazed windows, but between the two panes of glass is a chromogenic film.[4]

Also possible are thermochromic films, those which change colour due to a shift in temperature. Due to its relatively low critical temperature (T_C) of approximately 68^0C,[5] vanadium dioxide has seen considerable research.

Resistance Measurements

It is well known that when VO_2 thin films are heated above the transition temperature (T_C) their resistance drops sharply.[1] Resistance values are calculated from I-V data



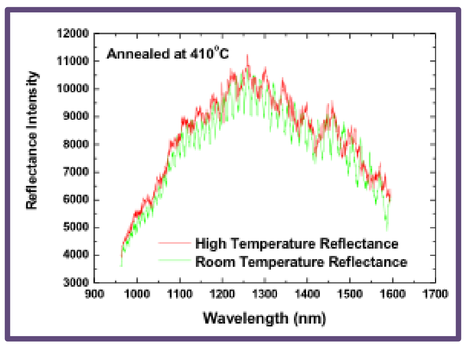
Above T_C, films exhibited a reduced resistance, with the maximum reduction 14 times lower than their room temperature resistance.

Annealing Temperature/ °C	390	400	410
Room Temperature Resistance/ Ω	17.3×10^b	127×10^b	159×10^b
High Temperature Resistance/ Ω	1.69×10^b	9.04×10^b	21.0×10^b

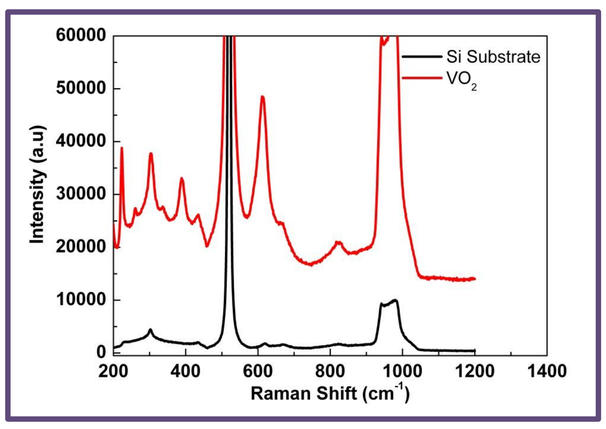
Reflectance Study

An enhancement in reflectance intensity is generally expected above the transition temperature (approximately 68^oC).[8] In our study, only a marginal enhancement was recorded which is under further investigation.

The spectra reveals periodic oscillations in the whole wavelength range whose origin is yet to be understood.

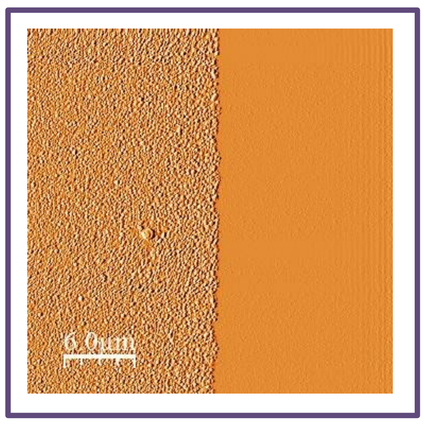


Deposition of VO_2 Thin Films



Raman spectroscopy was utilised to evaluate the presence of the pentoxide phase. Characteristic peaks at 250, 390 and 615 cm^{-1} were found to be unique to VO_2 when compared to the literature. No pentoxide was present due to the absence of a significant peak at 700 cm^{-1}.[7]

Production of VO_2 thin films often results in the unwanted formation of vanadium pentoxide, V_2O_5. The precursor oxidation process proposed by Gurvitch has been successful in restricting the formation of V_2O_5[1], by sputtering a vanadium metal precursor film, which once deposited is oxidised *in situ* to VO_2.



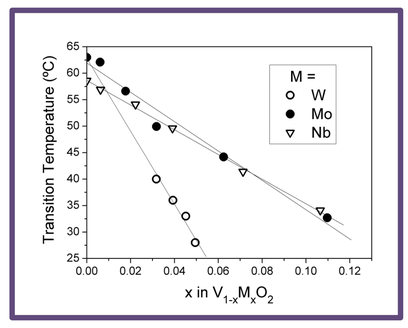
AFM of VO_2 film annealed at 400^oC

Conclusions

- Temperature dependency in I-V characteristics and Raman signatures prove VO_2 as the dominant phase
- Reflectance measurements suggest that much improvement is needed and the oscillations observed in the spectra should be further investigated
- Using in-house growth facility at Sheffield, a precursor oxidation process for the production of VO_2 thin films has been demonstrated.

Future Work

- Obtain accurate values for the transition temperature.
- Deposit doped films in an attempt to reduce the transition temperature.
- Revise reflectance techniques to correct the obvious flaws.



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Acknowledgements

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