The Effect of Annealing on the Insulator to Metal Transition in VO_2 Nanowires

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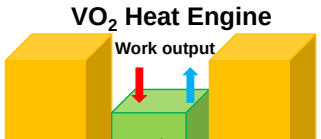
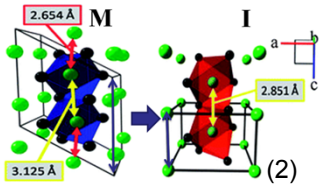
Abstract

Vanadium dioxide (VO_2) is a unique semiconductor with an insulator-to-metal transition (IMT) that makes it useful for scientific applications, such as micro-actuator and infrared sensors. The transition temperature (T_{IM}) can be modified by straining the nanowire, or by doping it. The key goal of this research is to study the effects of annealing cyclically across the IMT on W doped VO_2 nanowires. Our experiments show a cycle-based anneal does not produce any enhancement in W diffusion compared to single step anneals.

Background

- Optically, insulator phase is yellow, and metal phase is dark green.
- VO_2 nanowires shrink when heated above T_{IM}.
- Straining a VO_2 nanowire will cause metal domains to form.
- Possible applications in biology & micromechanical systems.





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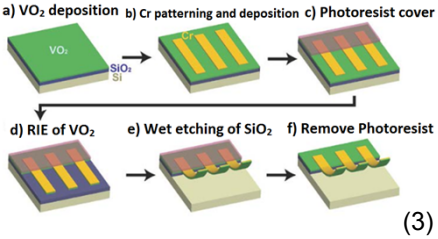

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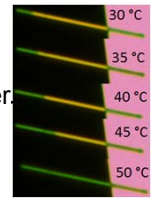
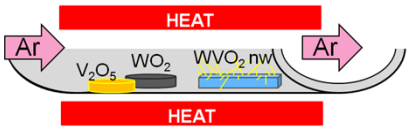
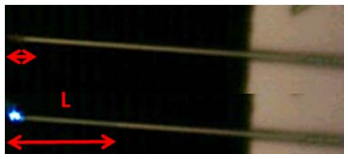
Methods

- VO_2 profiling with custom ramping heater and optical microscope.
- Laser annealing was performed with a 488nm Ar laser.
- VO_2 nanowires were grown in vacuum tube furnaces.
  - T = 950℃, K_{flow} = 2 - 6 sccm, t = 10 min - 3 hr, P = 10 torr

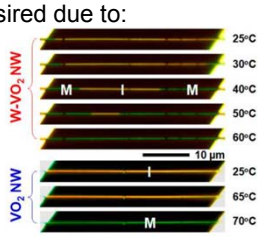






WVO_2 & VO_2 nanowires

- Graded W doped nanowires transition gradually.
- W doped nanowires have low T_{IM}.
- Pure nanowires have high T_{IM}.
- Cantilevers were desired due to:
  - No external strain
  - Even heating



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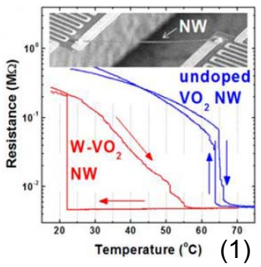

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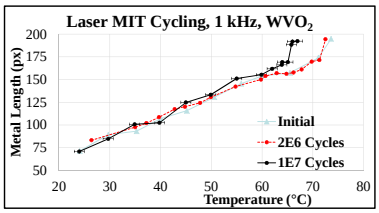
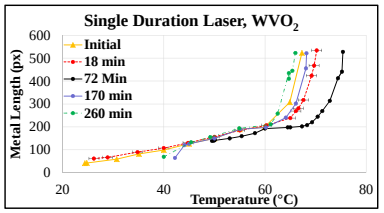
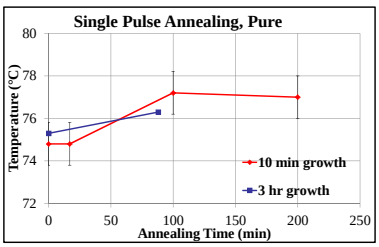
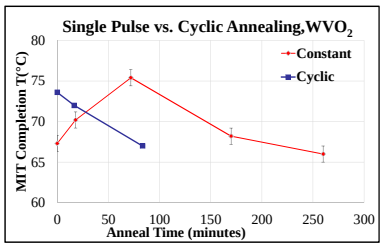
Results









- Grew nanowires under short and long growth conditions.
- Compared their T_{IM} against their time annealed.
- Converted cycles to single pulse time.
  - 2E6 cycles = 36 min cycled = 18 min single pulse

Conclusion & Discussion

Trends observed from the graphs and data collected:

- Single pulse annealing on pure nanowires has little to no effect on the T_{IM}.
- Annealing time reaches a saturation point for T_{IM} change for both cyclic and single pulse annealing.

Future testing:

- Doping VO_2 nanowires with other chemicals, such as hydrogen.

References

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