

Investigating Vanadium Dioxide Insulator–Metal Transition with Raman and Ultrafast Pulses

E. Radue¹, L. Wang¹, Evan Crisman¹, Russell Wincheski², S. Kittiwatanakul³, J. Lu³,
S.A. Wolf³, R. A. Lukaszew¹, Irina Novikova¹

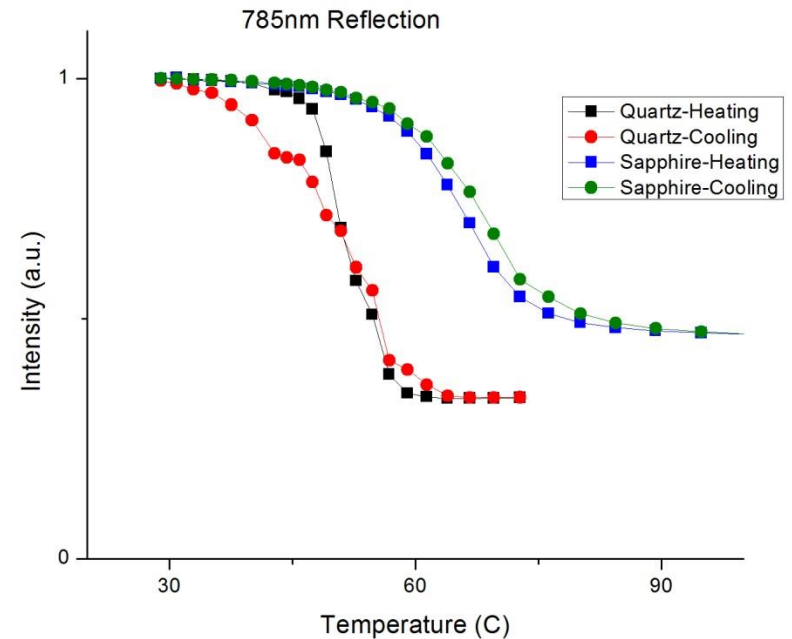
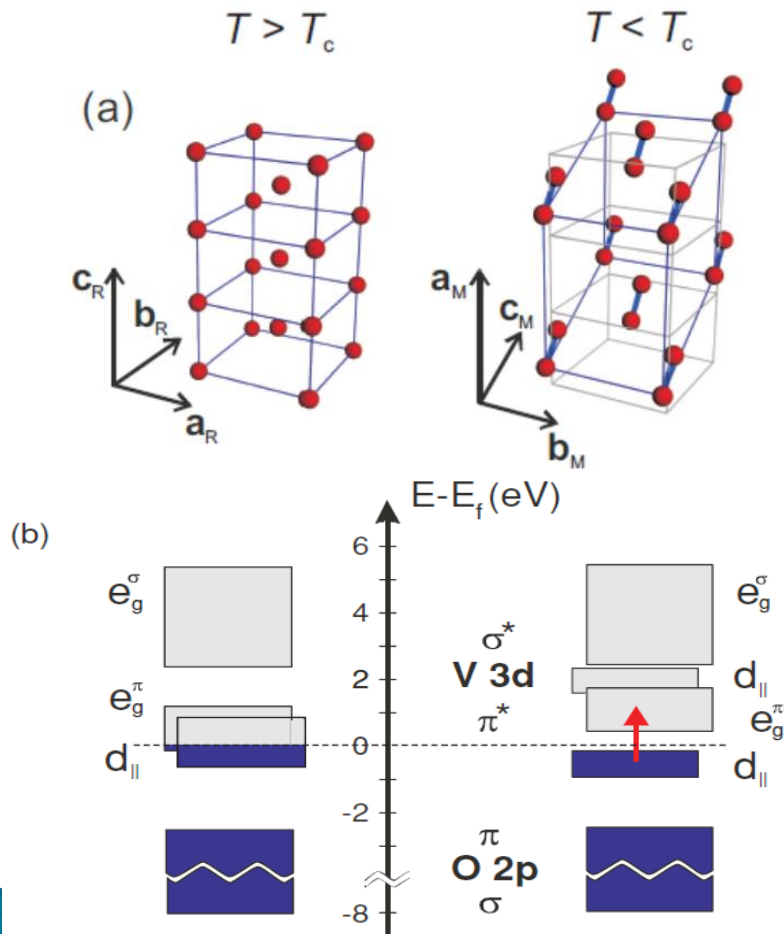
¹Department of Physics, College of William and Mary

²NASA Langley Research Center

³Department of Physics, University of Virginia

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VO₂ Metal-Insulator Transition



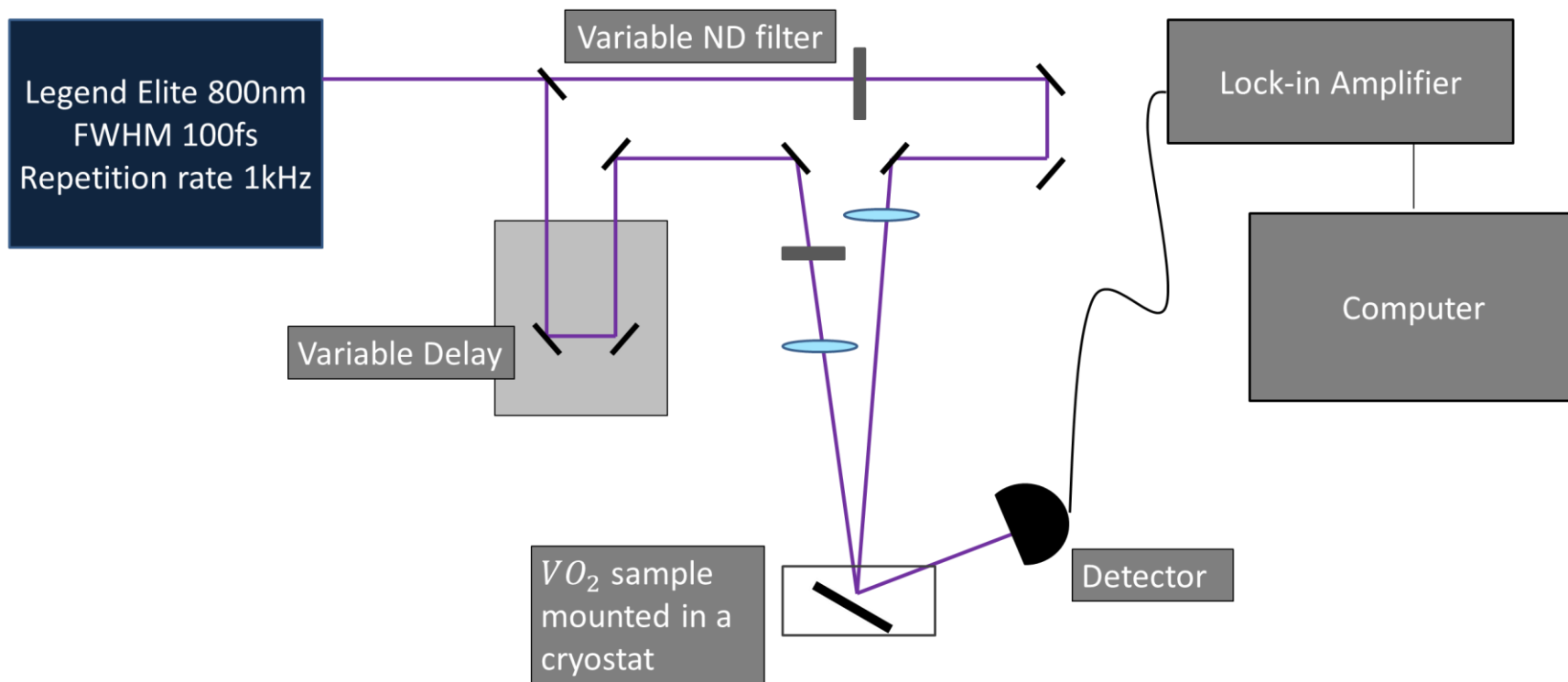
Change in optical properties

Pashkin, C. Kübler, H. Ehrke, R. Lopez, a. Halabica, R.F. Haglund, R. Huber, and a. Leitenstorfer, Physical Review B **83**, 195120 (2011).

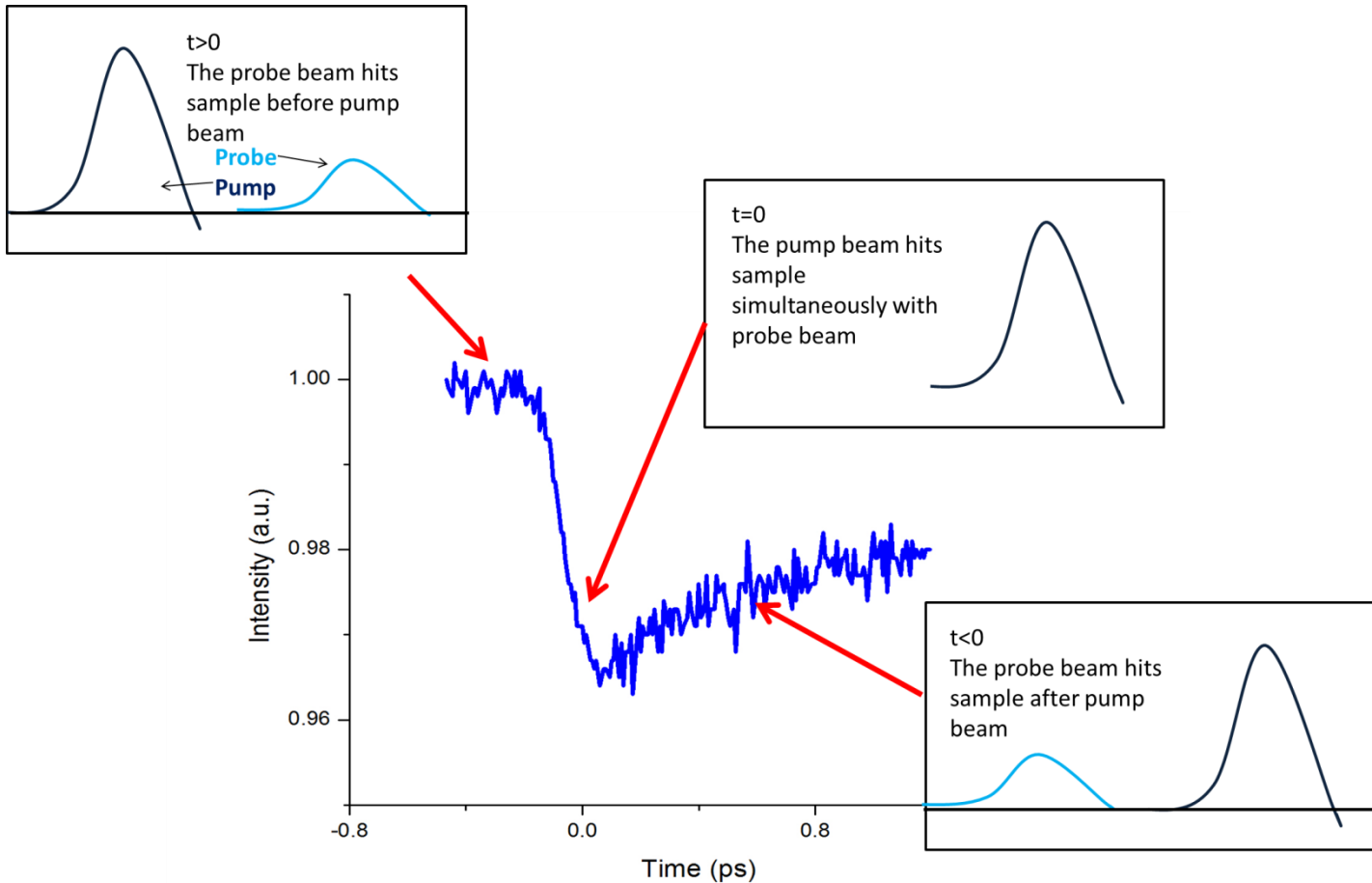
Our Work

- ▶ Studying optically induced phase transition with pump–probe configuration
 - Varying fluence
 - Varying film temperature
- ▶ Raman Spectroscopy of films grown on different films

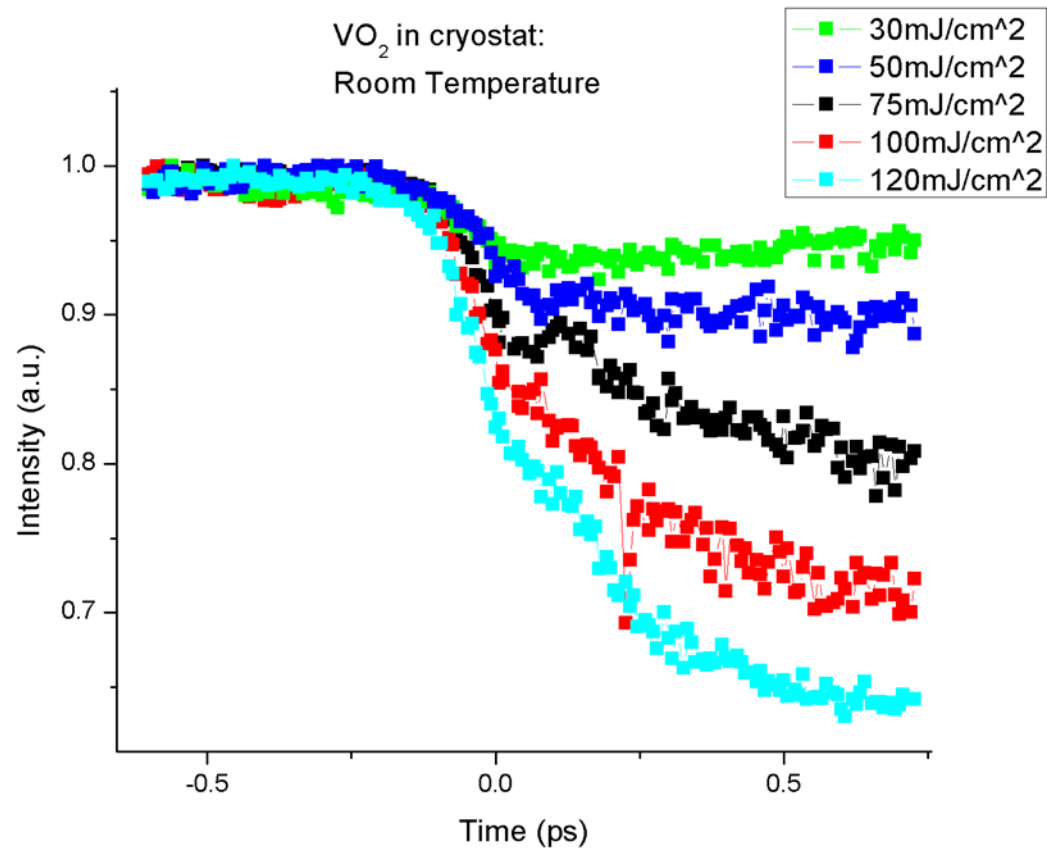
Pump-probe set up



Measure Drop in reflectivity



Varying Power of Pump Beam



Why mount sample in cryostat?

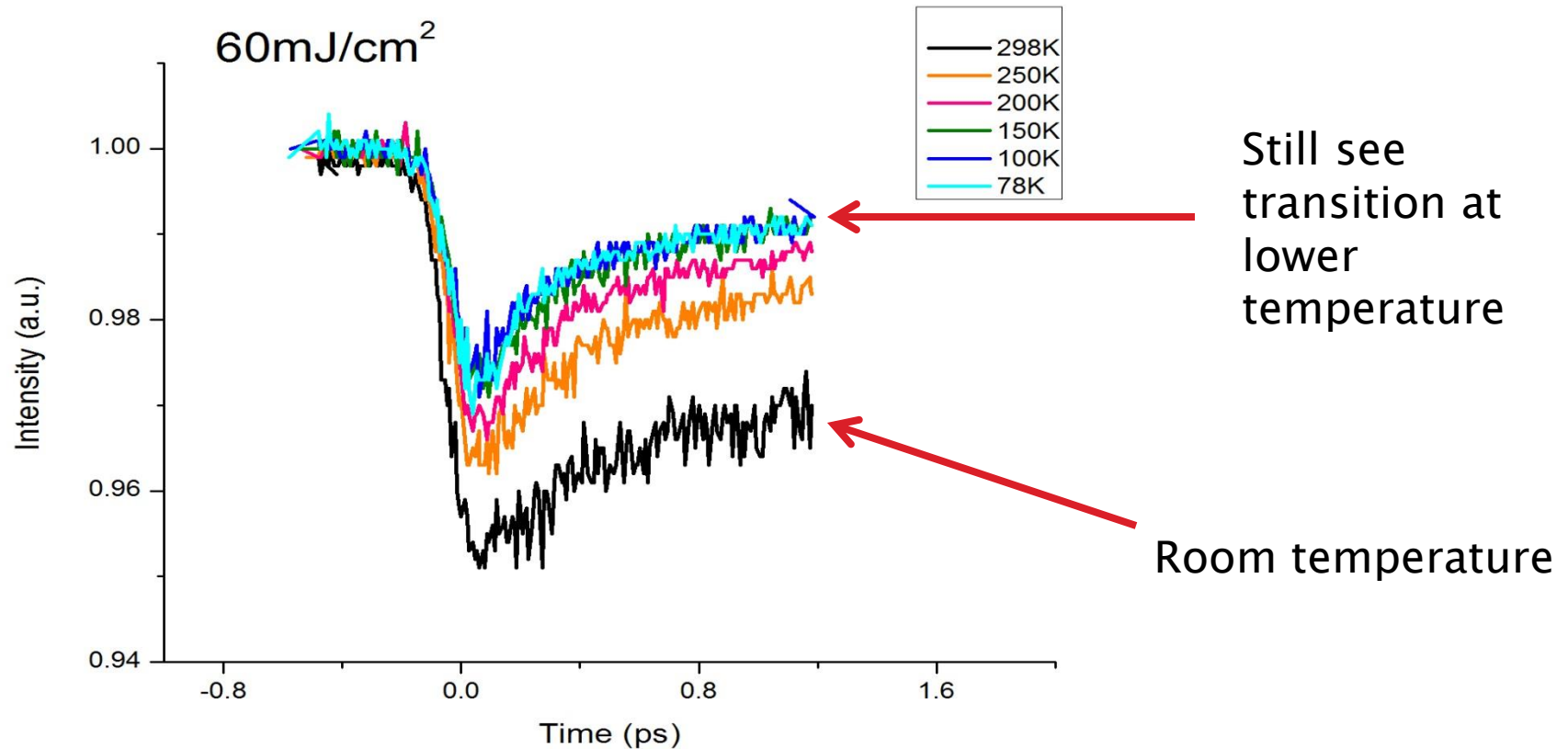
Effects of Temperature vs. Strong electric fields freeing electrons

→ Some controversy as to the main cause: fast response suggests electronic response vs. change in crystal lattice

T. Cocker, L. Titova, S. Fourmaux, G. Holloway, H.-C. Bandulet, D. Brassard, J.-C. Kieffer, M. El Khakani, and F. Hegmann, *Physical Review B* **85**, 155120 (2012).

D. Hilton, R. Prasankumar, S. Fourmaux, a. Cavalleri, D. Brassard, M. El Khakani, J. Kieffer, a. Taylor, and R. Averitt, *Physical Review Letters* **99**, 226401 (2007).

Cooling film in cryostat

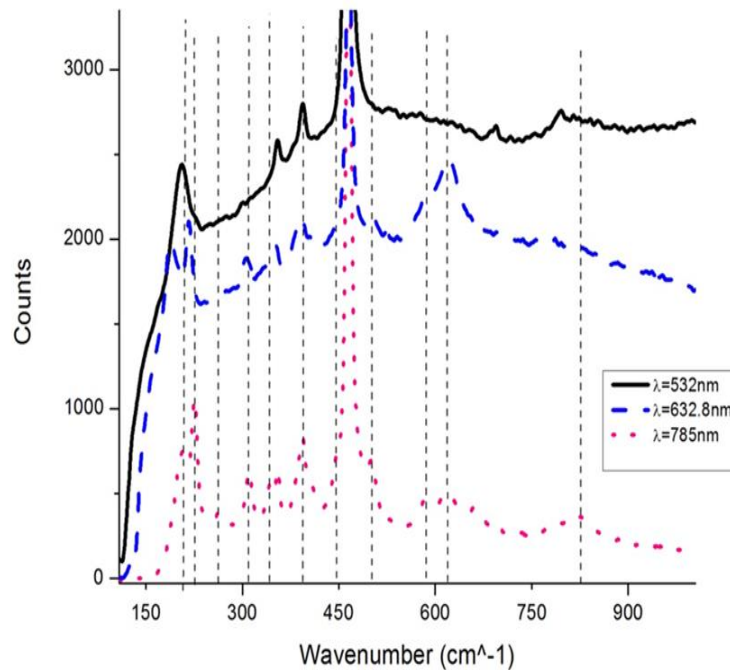


Threshold fluence same for all temperatures

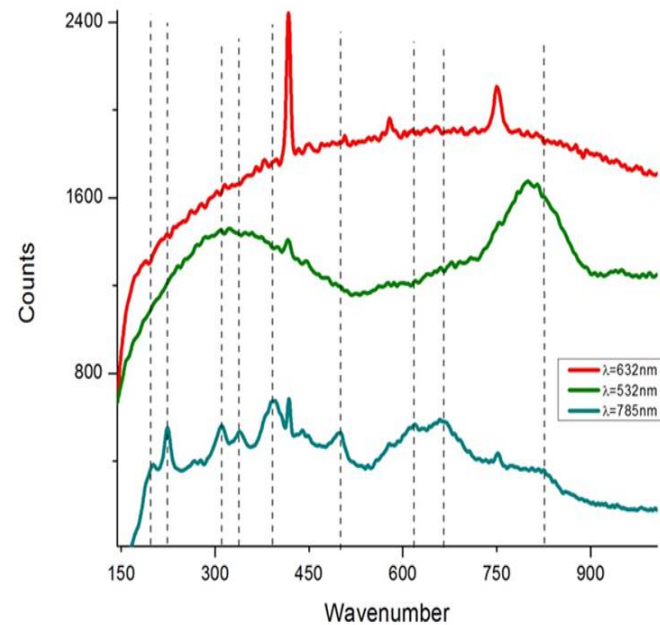
Raman Spectroscopy Studies

- ▶ Used Commercial Raman Spectrometer
 - Difficult to see peaks of VO₂ thin films: Maximizing our signal
- ▶ Differences between films due to differences in microstructure

Incident Beam Wavelength: minimizing effect from substrate

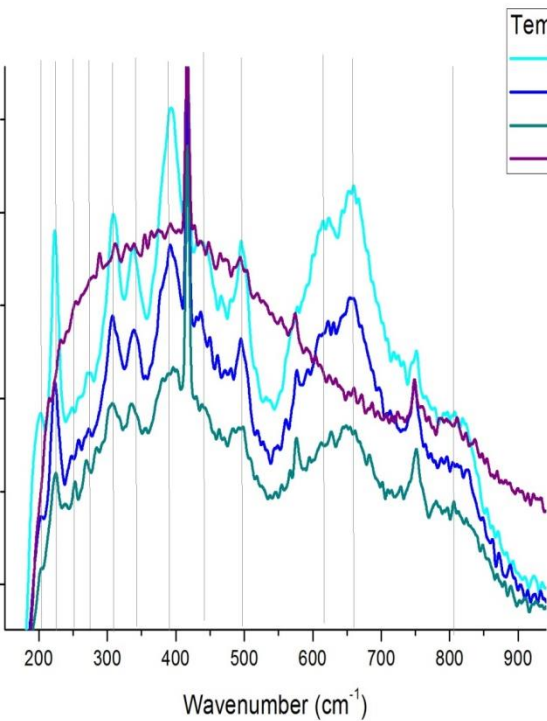


VO₂ film on Quartz

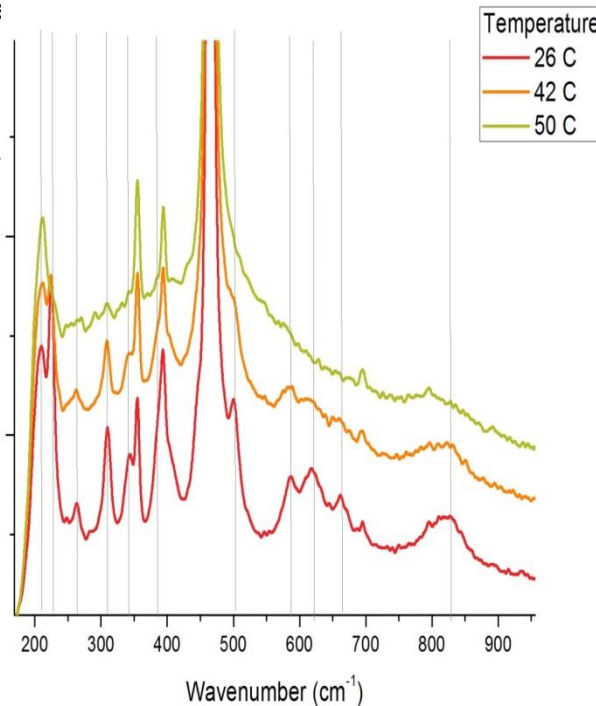


VO₂ film on Sapphire

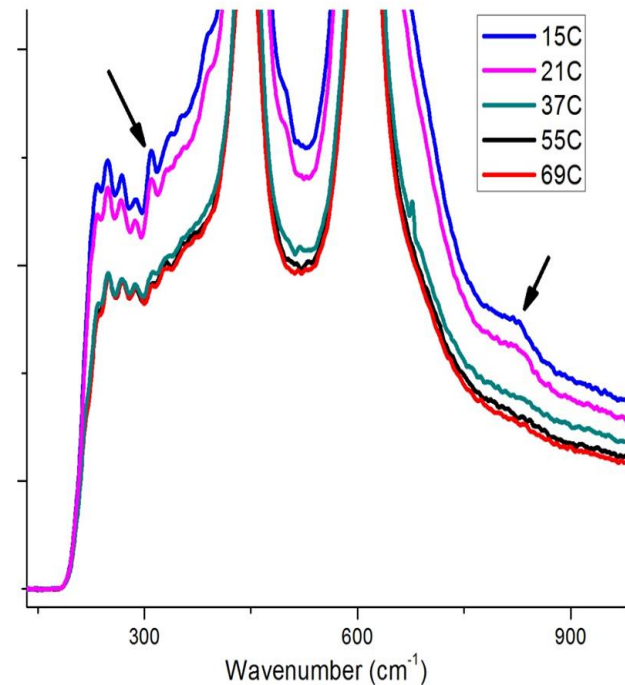
Raman Spectra through MIT



VO₂ film on sapphire



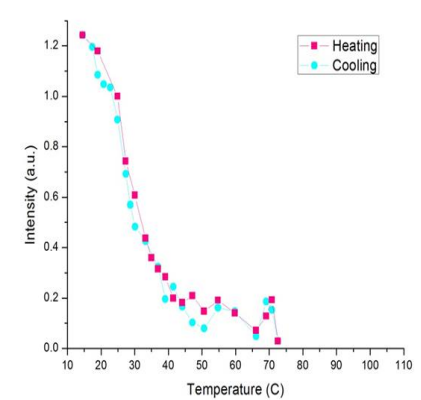
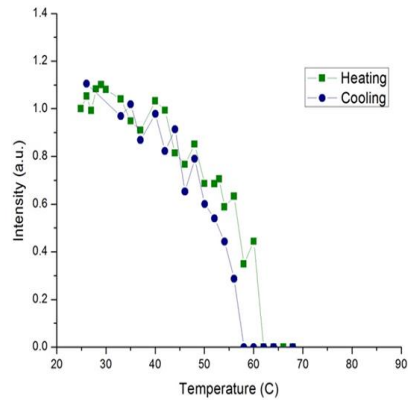
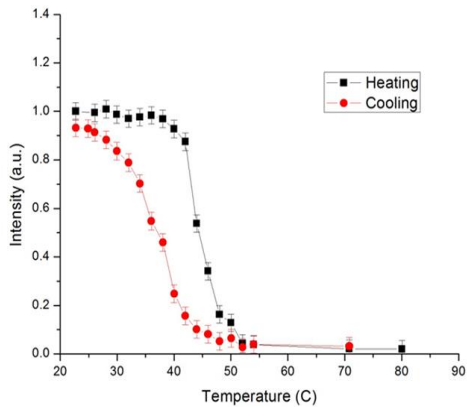
VO₂ film on quartz



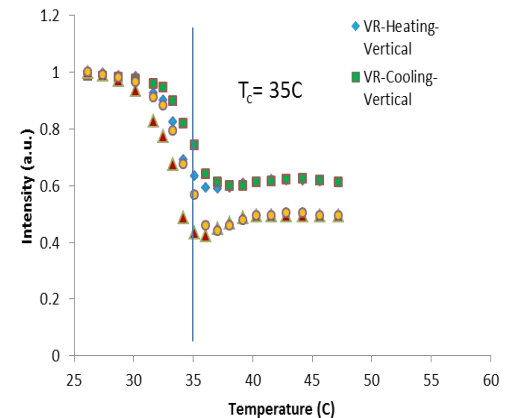
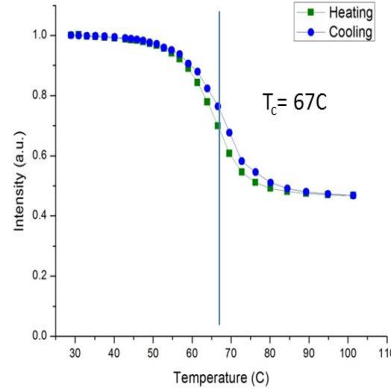
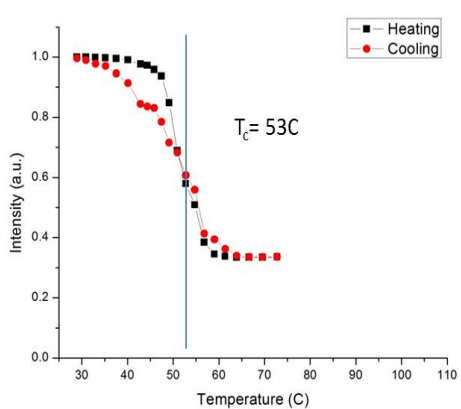
VO₂ film on rutile

Raman Peak amplitude and cw Optical Reflection Measurements

Raman Peaks vs. Temperature



CW Reflectivity vs. Temperature



VO₂ on Quartz

VO₂ on Sapphire

VO₂ on Rutile

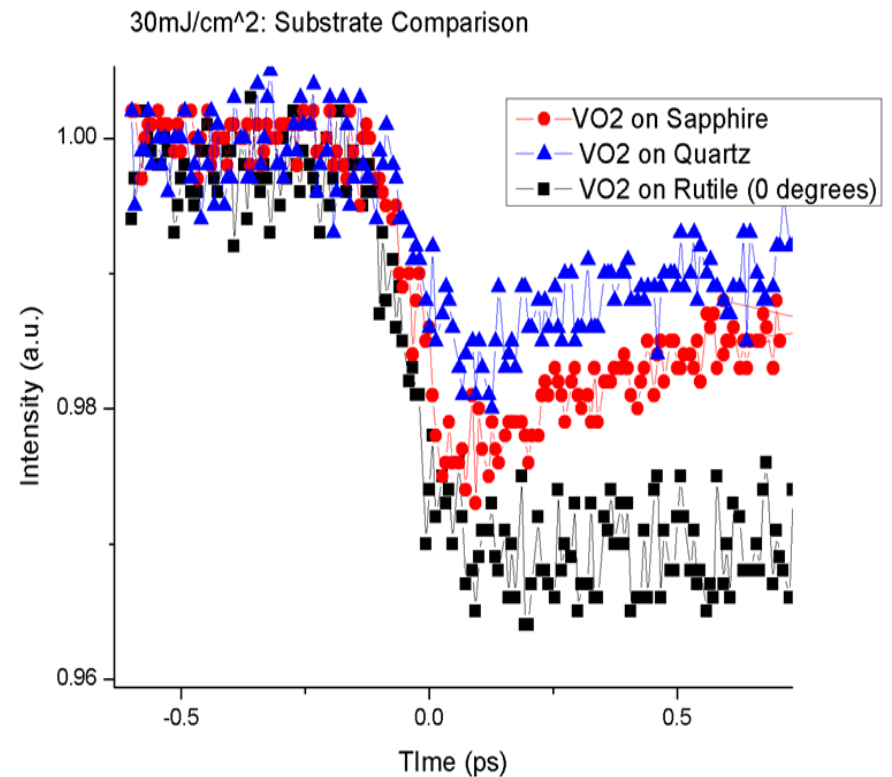
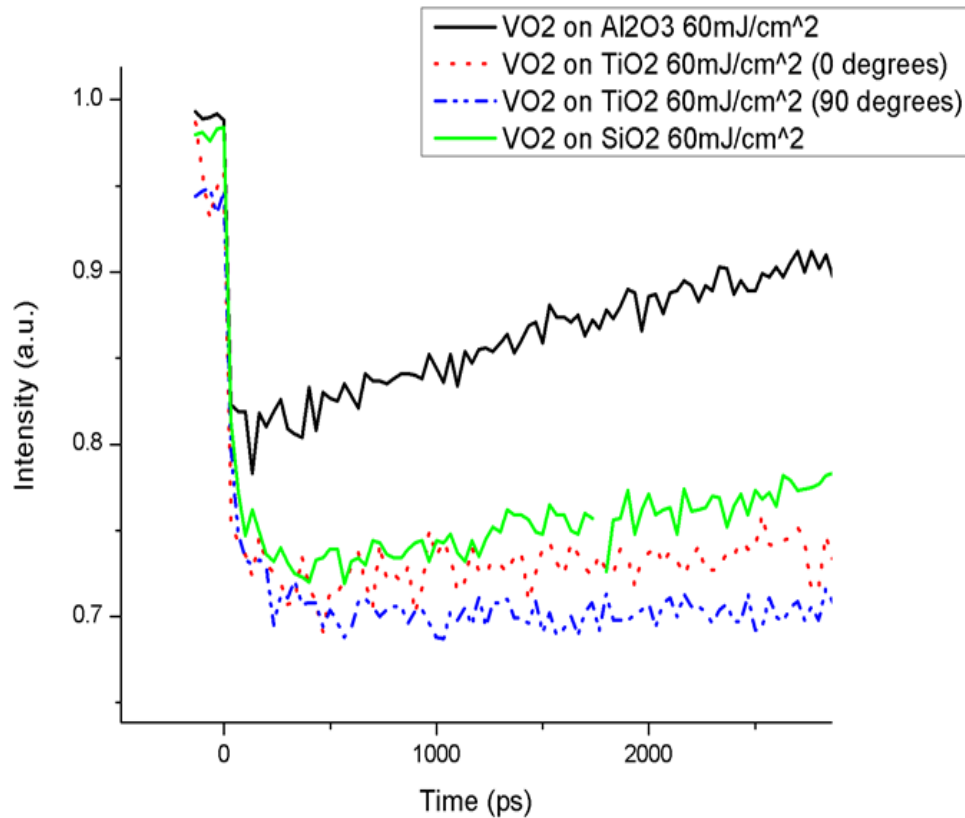
Summery

- ▶ See an ultrafast response in films, even at lower temperatures
- ▶ Able to identify VO_2 Raman peaks
 - Can see phase transition in spectra
 - Transition temperature effected by microstructure
- ▶ Future work: Further analysis on the relaxation of MIT

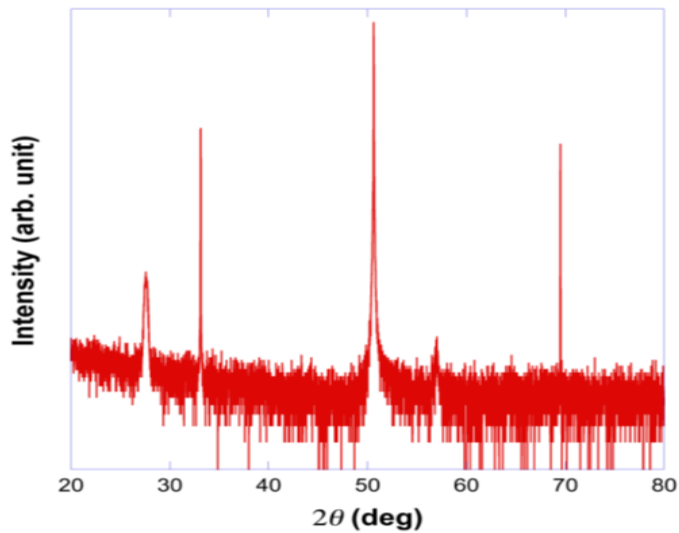
Acknowledgements

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- ▶ Thanks to Buzz Wincheski at NASA Langley Research Center for his time and equipment

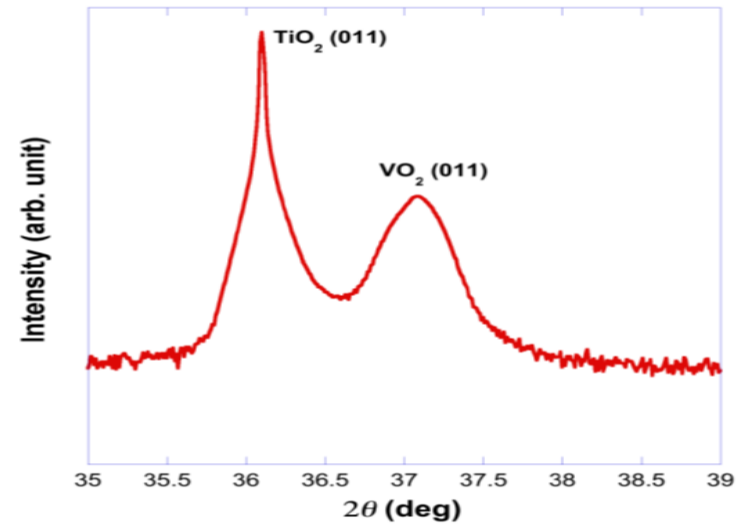
Comparison of Substrates In Ultrafast Transition



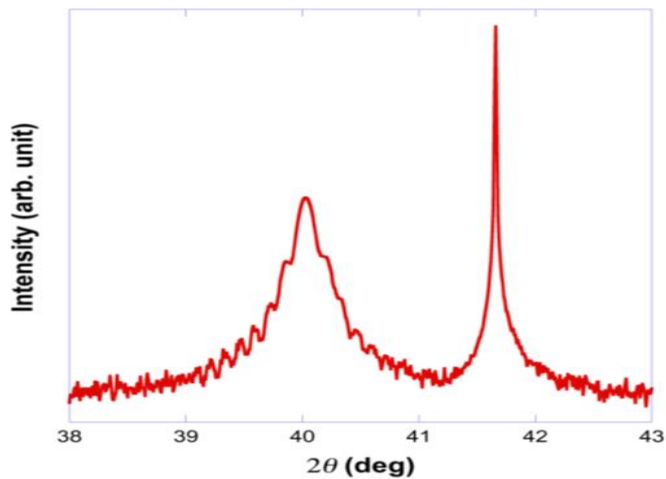
VO₂ on Quartz:
Grain Size ~70nm



VO₂ on Rutile
Grain size ~10nm

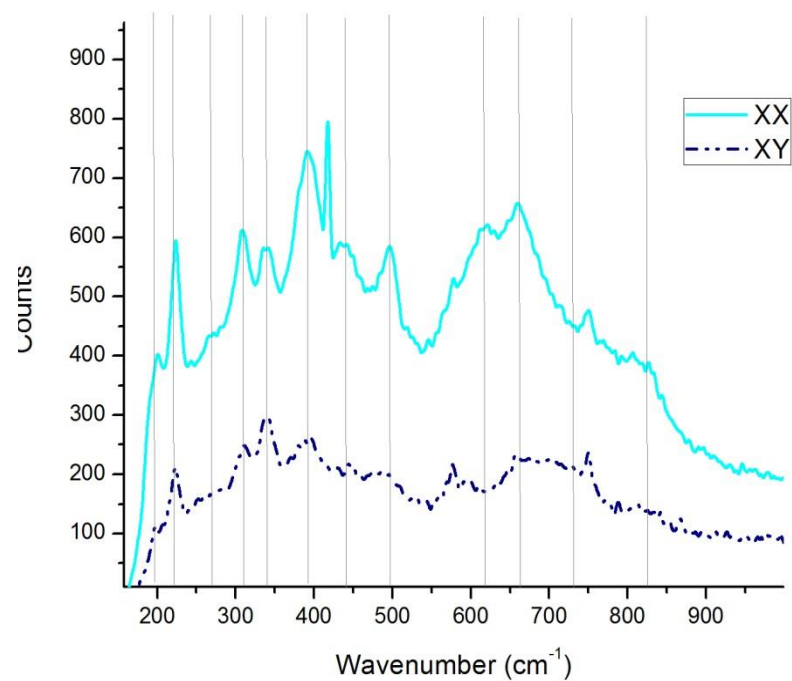
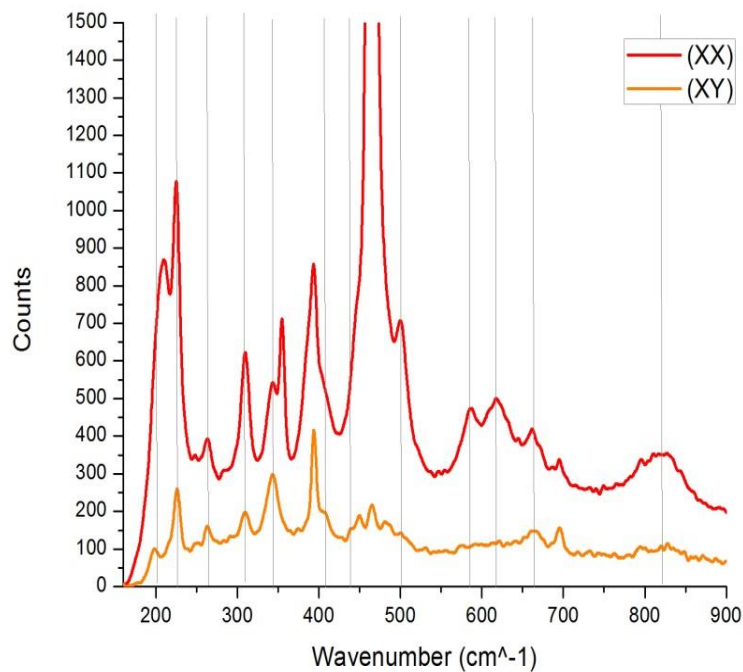


VO₂ on Sapphire
Grain Size ~20nm



XRD Characterization

Polarization of incident/reflected beam



Multiple peak fits: VO₂ on SiO₂

