Effect of strain on the dynamics of optically induced metal-insulator transitions of VO_2 thin films

Elizabeth Radue , Matt Simons , Lei Wang ,Evan Crisman, S. Kittiwatanakul , J. Lu , S.A. Wolf , R.A. Lukaszew , Irina Novikova

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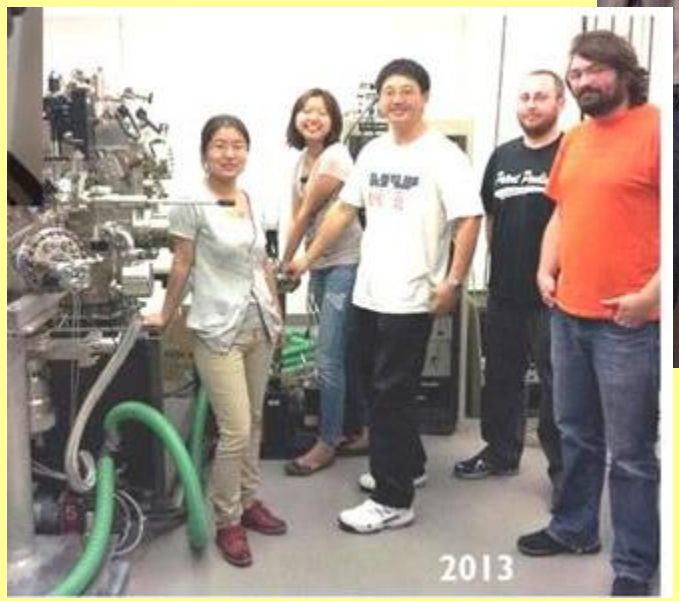

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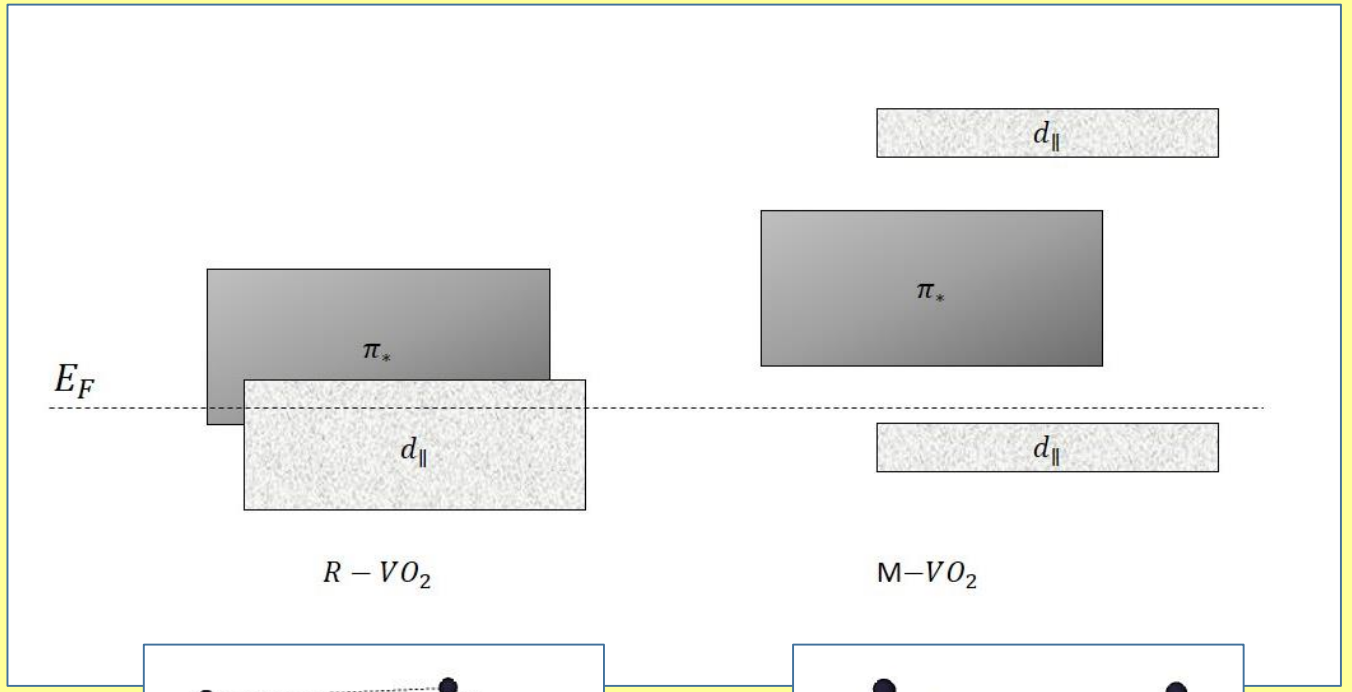
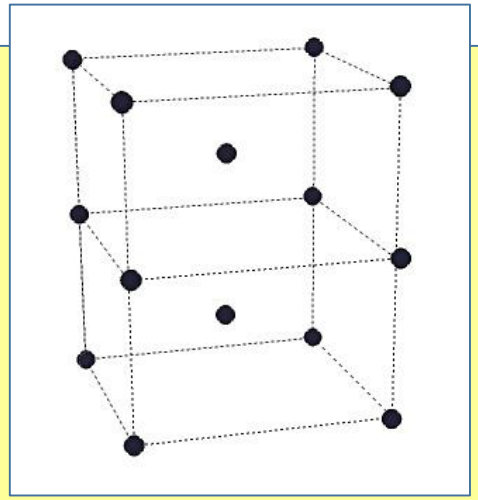
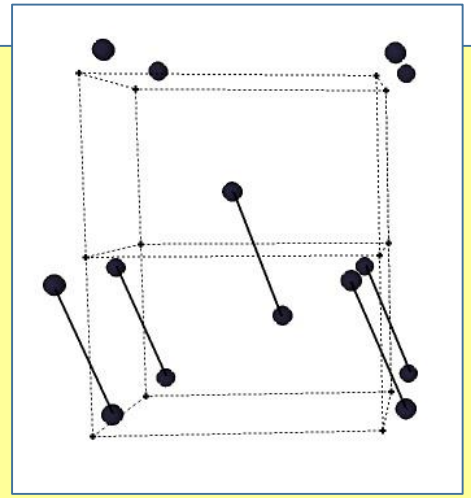
VO_2 Phase transition

- Highly correlated material
- Undergoes metal-insulator transition when heated (340K)
- Reversible in thin films

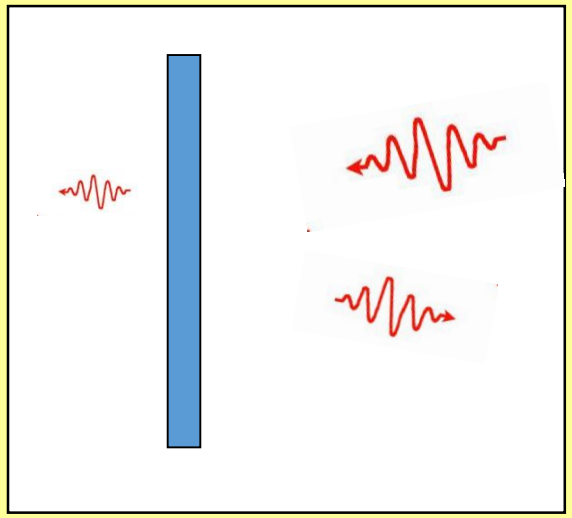


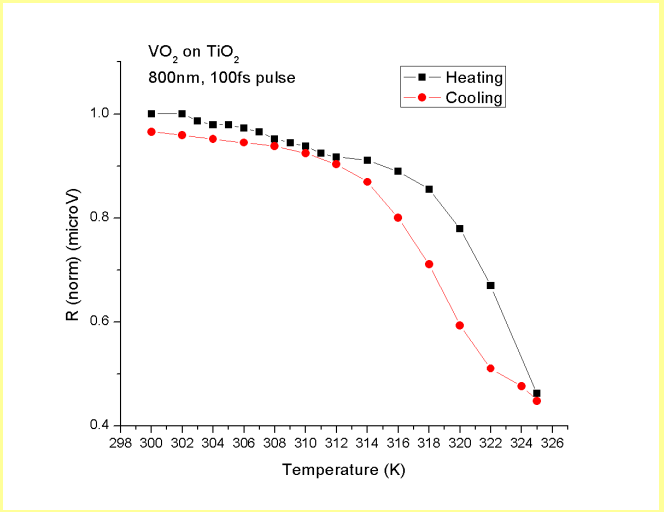


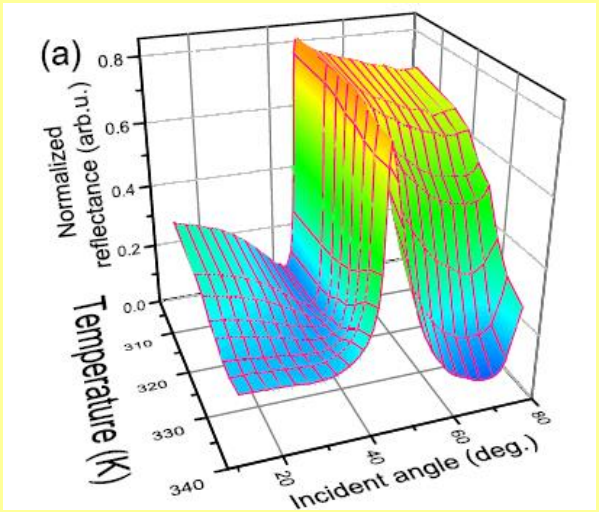


Exciting applications

- Many possible novel technologies with VO_2



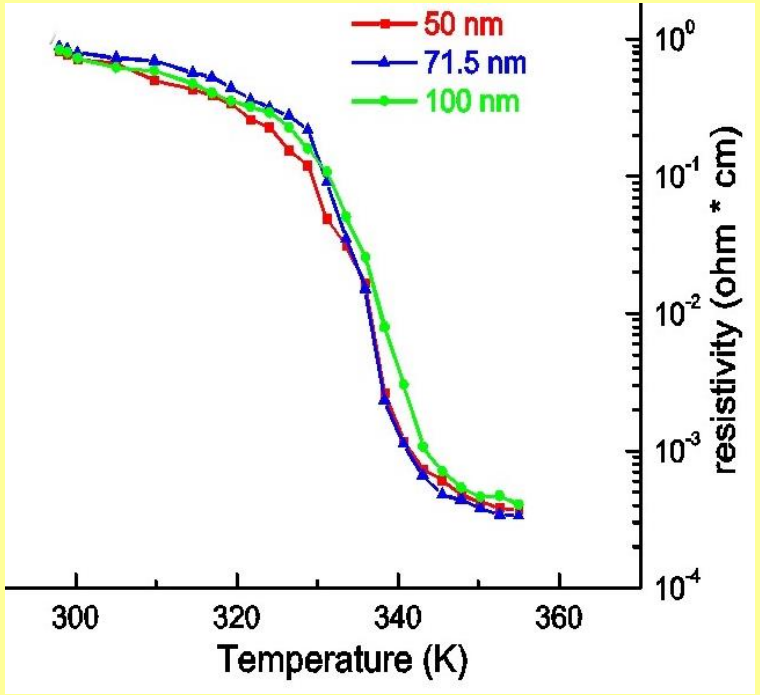


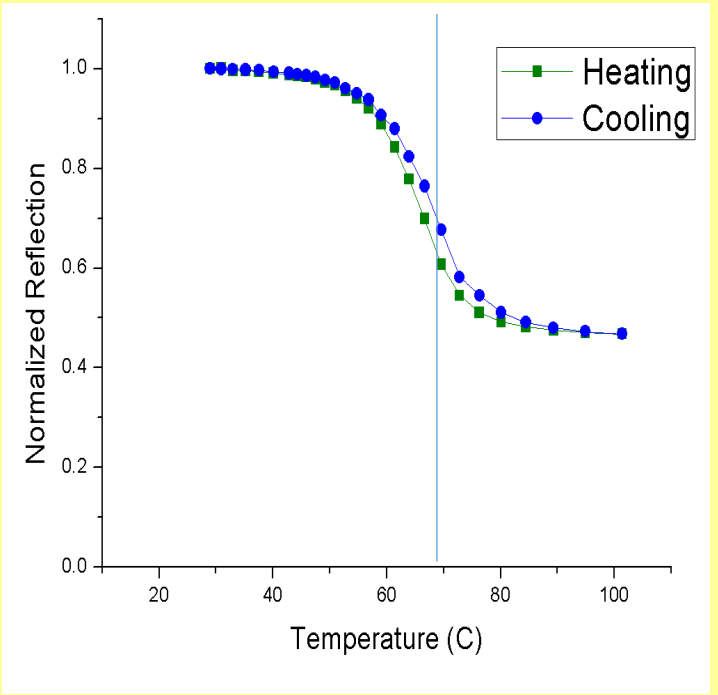


- The better we understand the mechanisms for the transition and how different substrates and microstructure affects them, the better we'll be able to tune the film for specific needs.

Probing the Metal-insulator transition (MIT)

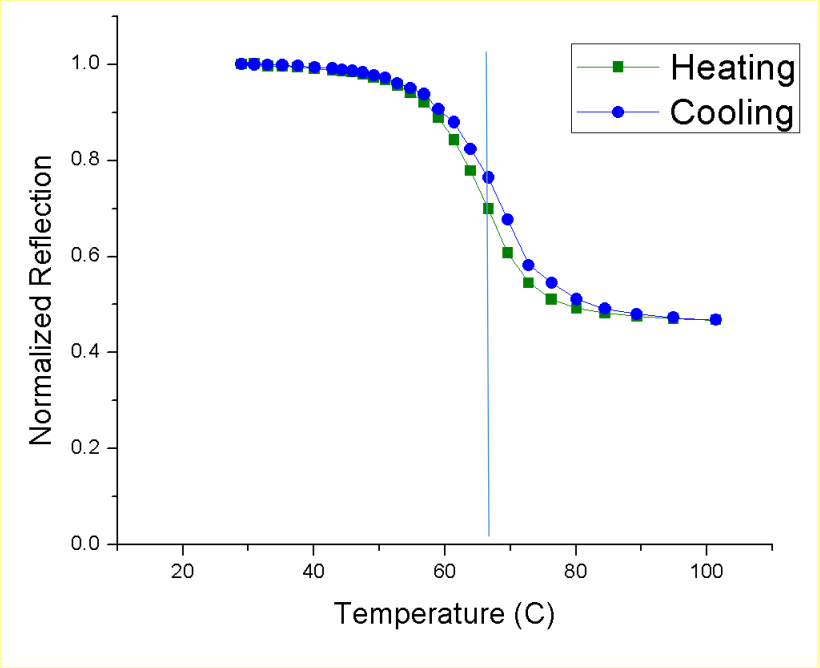
- Large change in conductivity/index of refraction



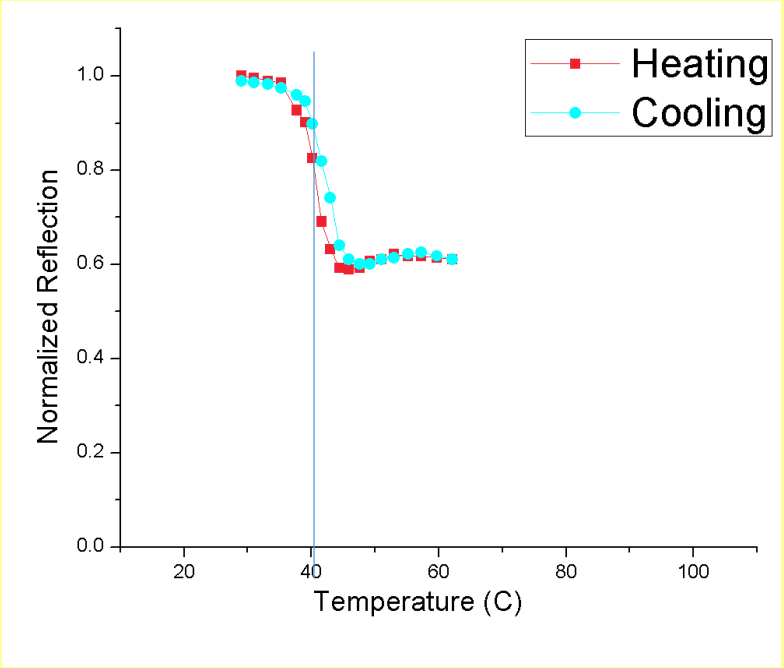


Effect on microstructure on Metal-Insulator Transition

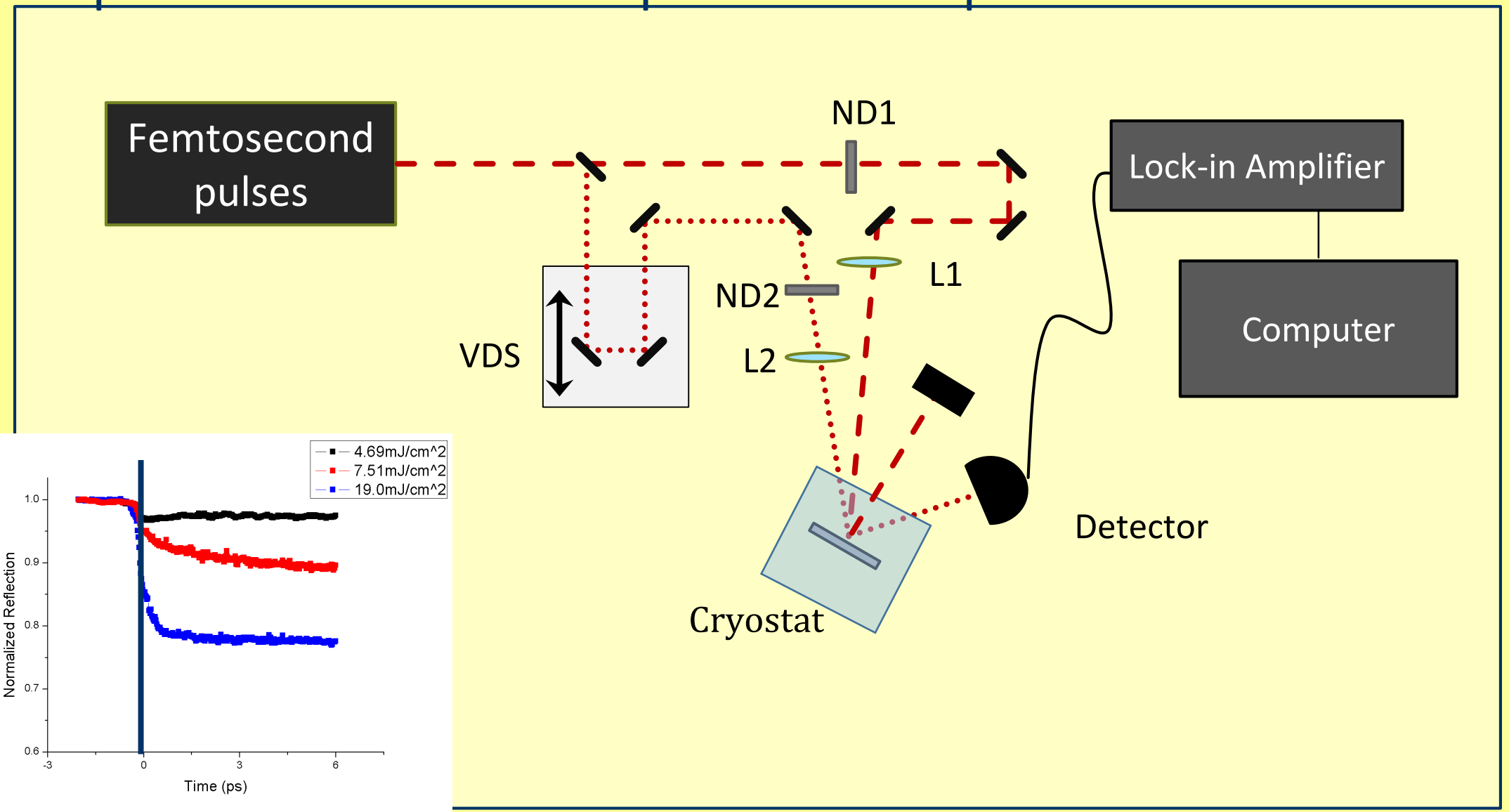
VO_2 on Al_2O_3
T_c=341K



VO_2 on TiO_2
T_c=306K



Experimental Set up for Pump Probe



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Phase diagram of the ultrafast photoinduced insulator-metal transition in vanadium dioxide

T. L. Cocker,[1,*] L. V. Titova,[1] S. Fourmaux,[2] G. Holloway,[1] H.-C. Bandulet,[2] D. Brassard,[2] J.-C. Kieffer,[2]
M. A. El Khakani,[2] and F. A. Hegmann[1,†]
[1]*Department of Physics, University of Alberta, Edmonton, Alberta T6G 2E1, Canada*
[2]*INRS-EMT, Université du Québec, Varennes, Québec J3X 1S2, Canada*
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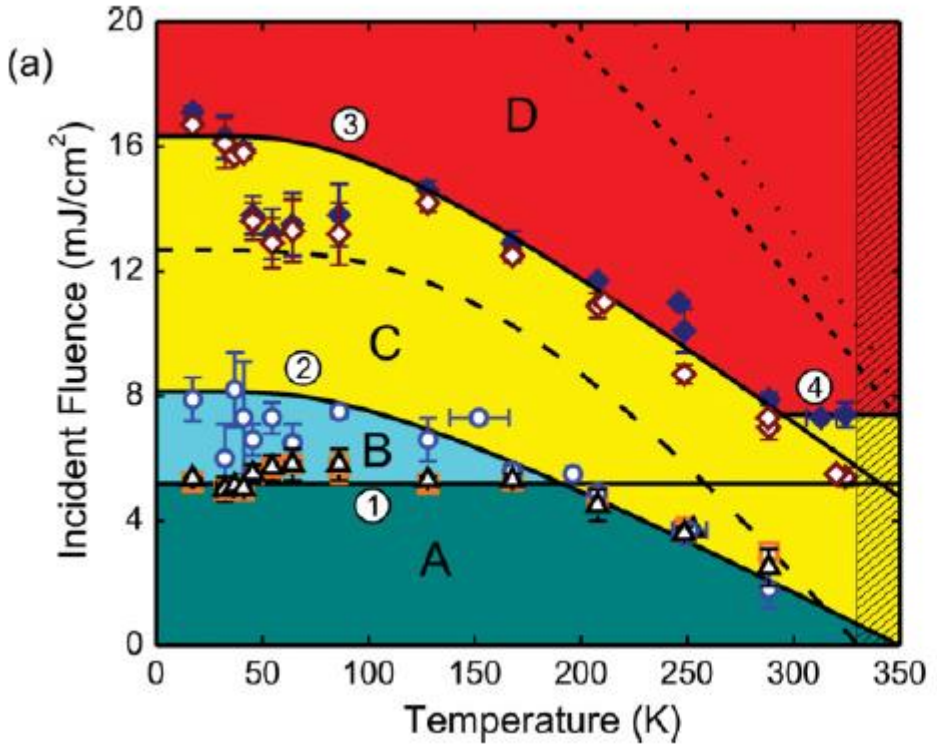
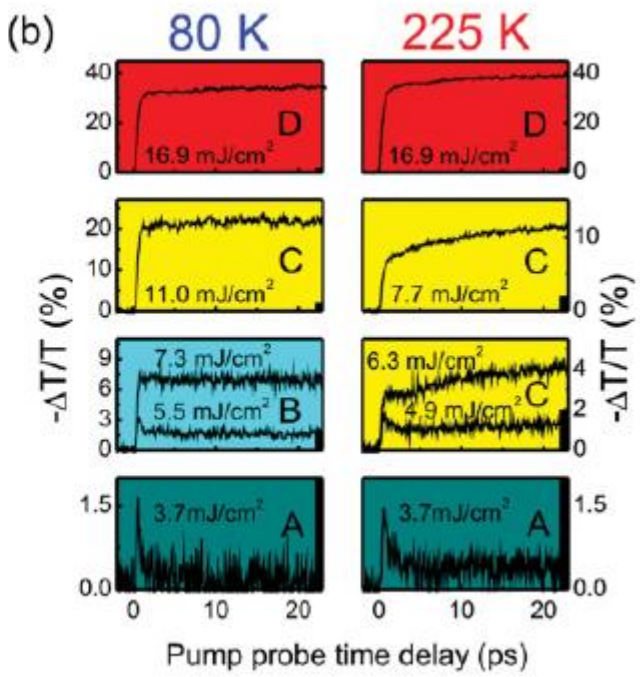




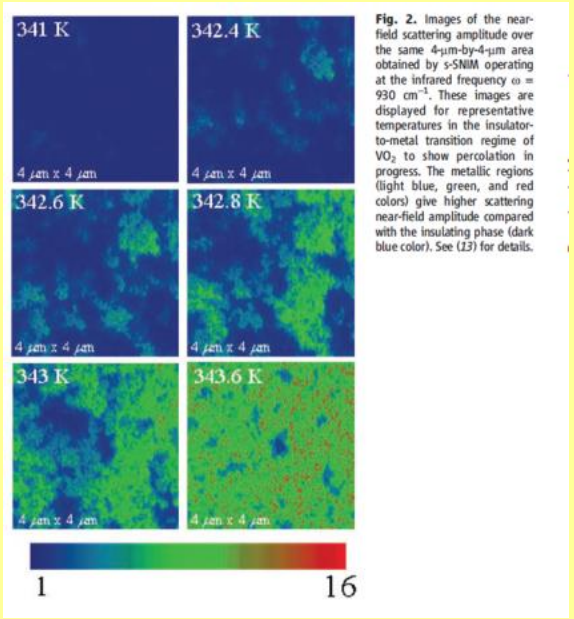
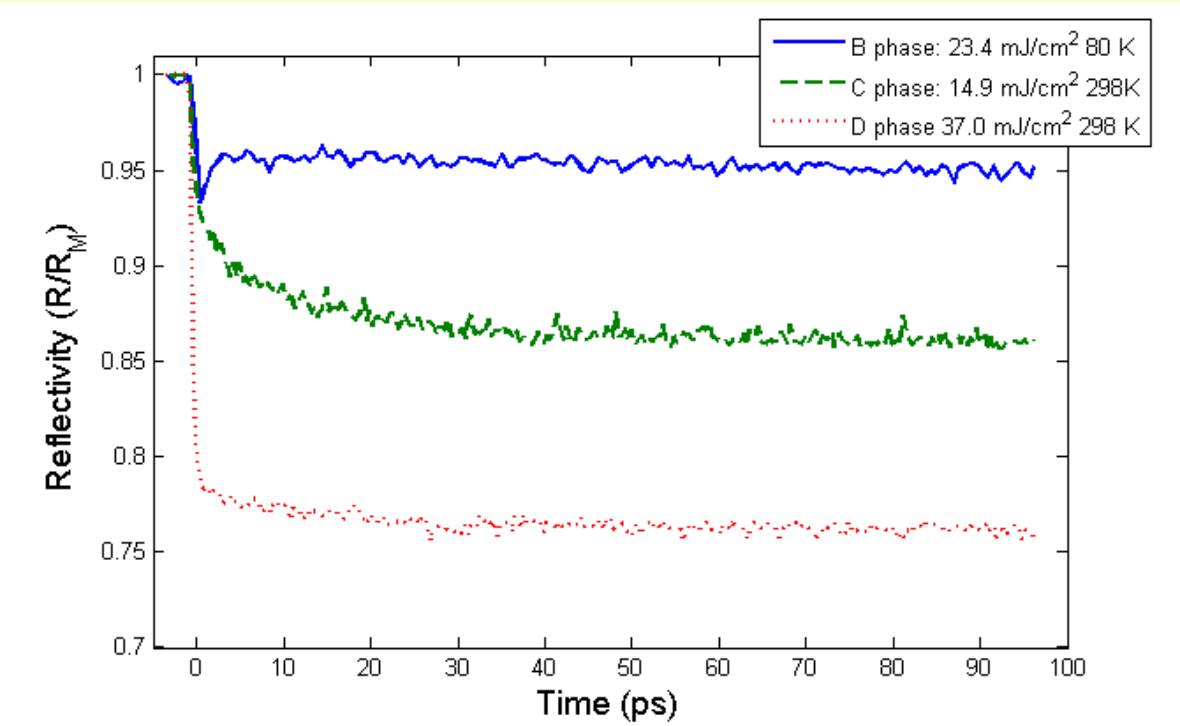


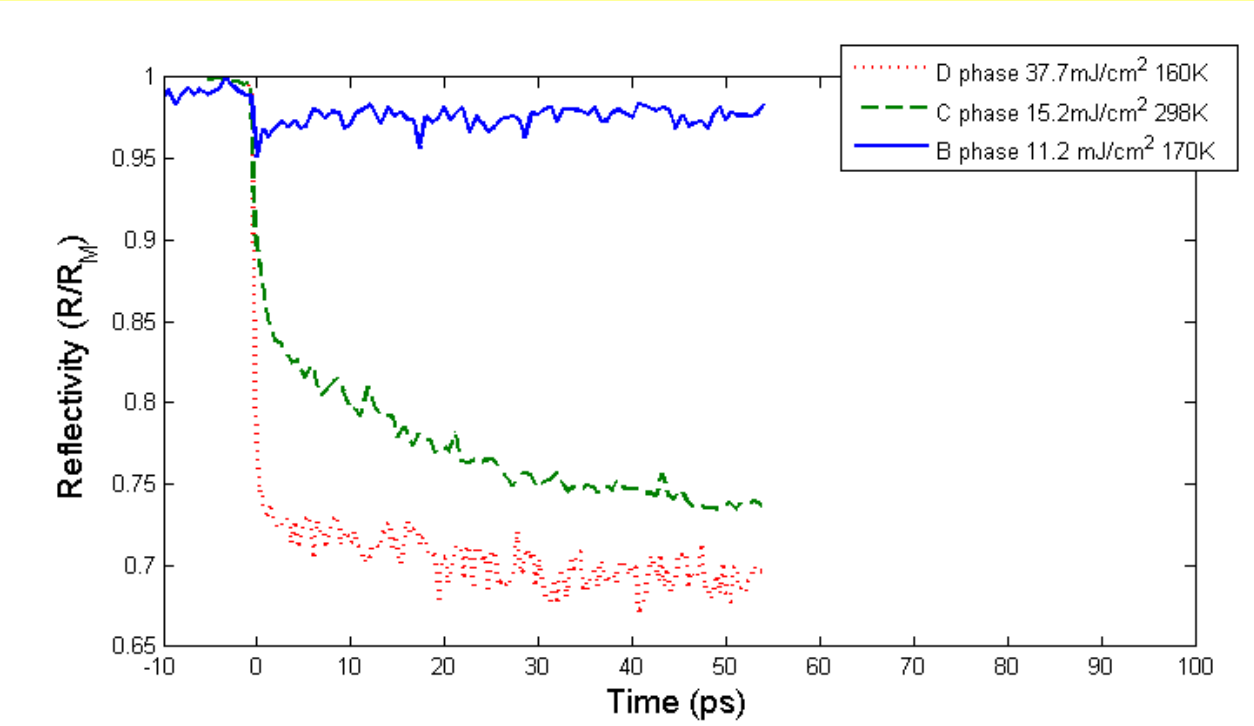
Fig. 2. Images of the near-field scattering amplitude over the same 4-μm-by-4-μm area obtained by s-SNIM operating at the infrared frequency ω = 930 cm⁻¹. These images are displayed for representative temperatures in the insulator-to-metal transition regime of VO_2 to show percolation in progress. The metallic regions (light blue, green, and red colors) give higher scattering near-field amplitude compared with the insulating phase (dark blue color). See (*13*) for details.

M.M. Qazilbash, M. Brehm, B.-G. Chae, P.-C. Ho, G.O. Andreev, B.-J. Kim, S.J. Yun, a V Balatsky, M.B. Maple, F. Keilmann, H.-T. Kim, and D.N. Basov, Science (New York, N.Y.) 318, 1750 (2007).

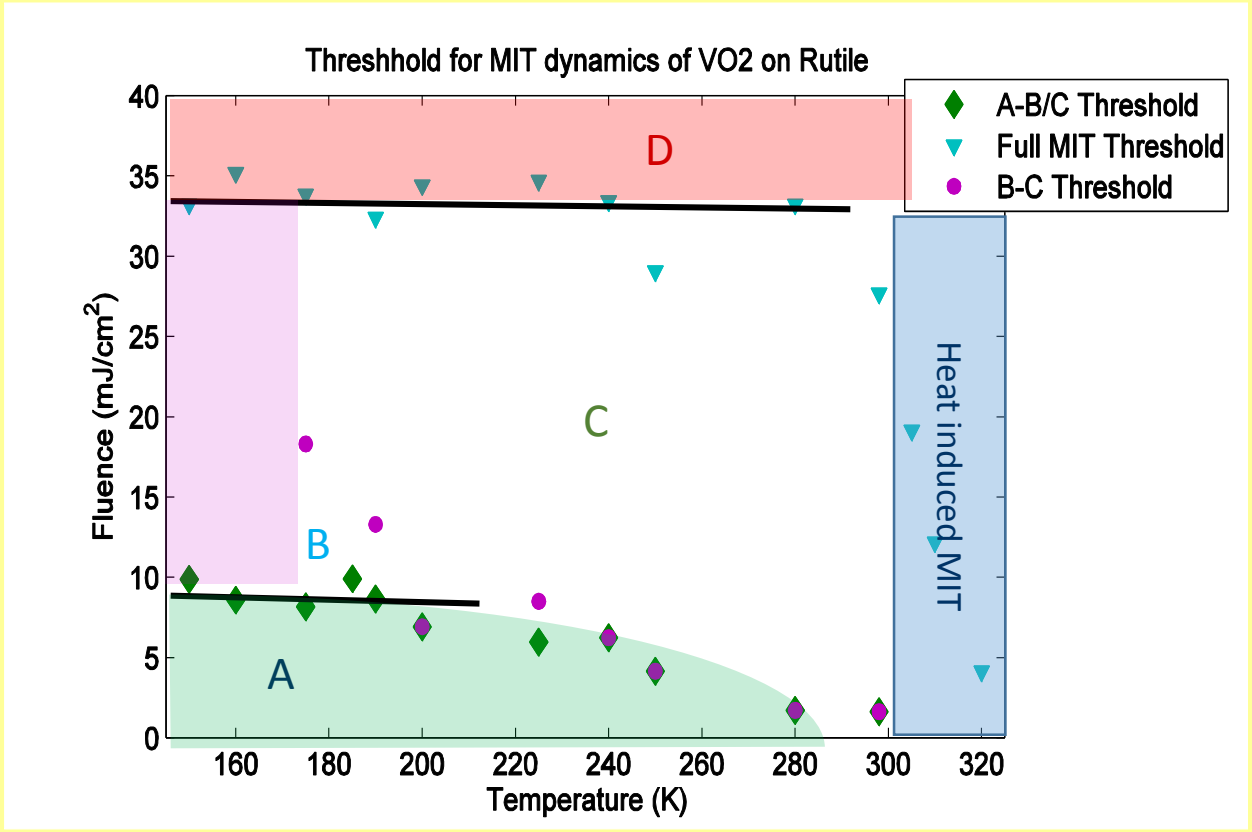
Comparing dynamics of MIT

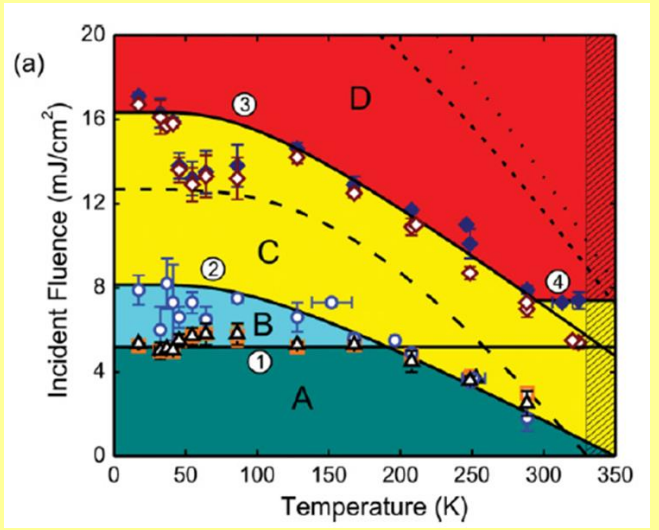
- Pump probe measurements at 800nm

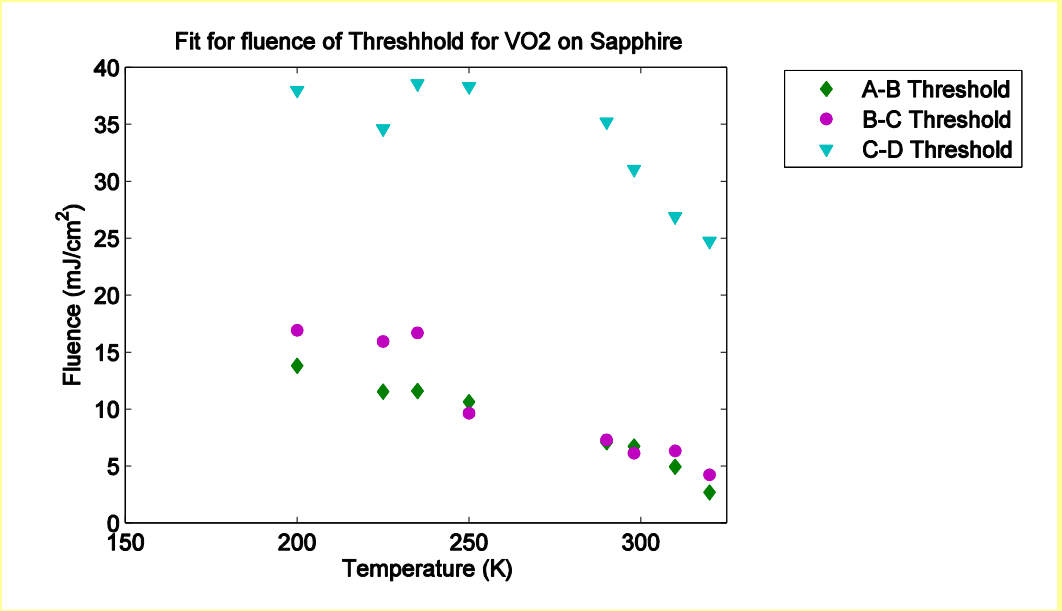




Phase Diagram for VO_2 Dynamics







Conclusion & Future Work

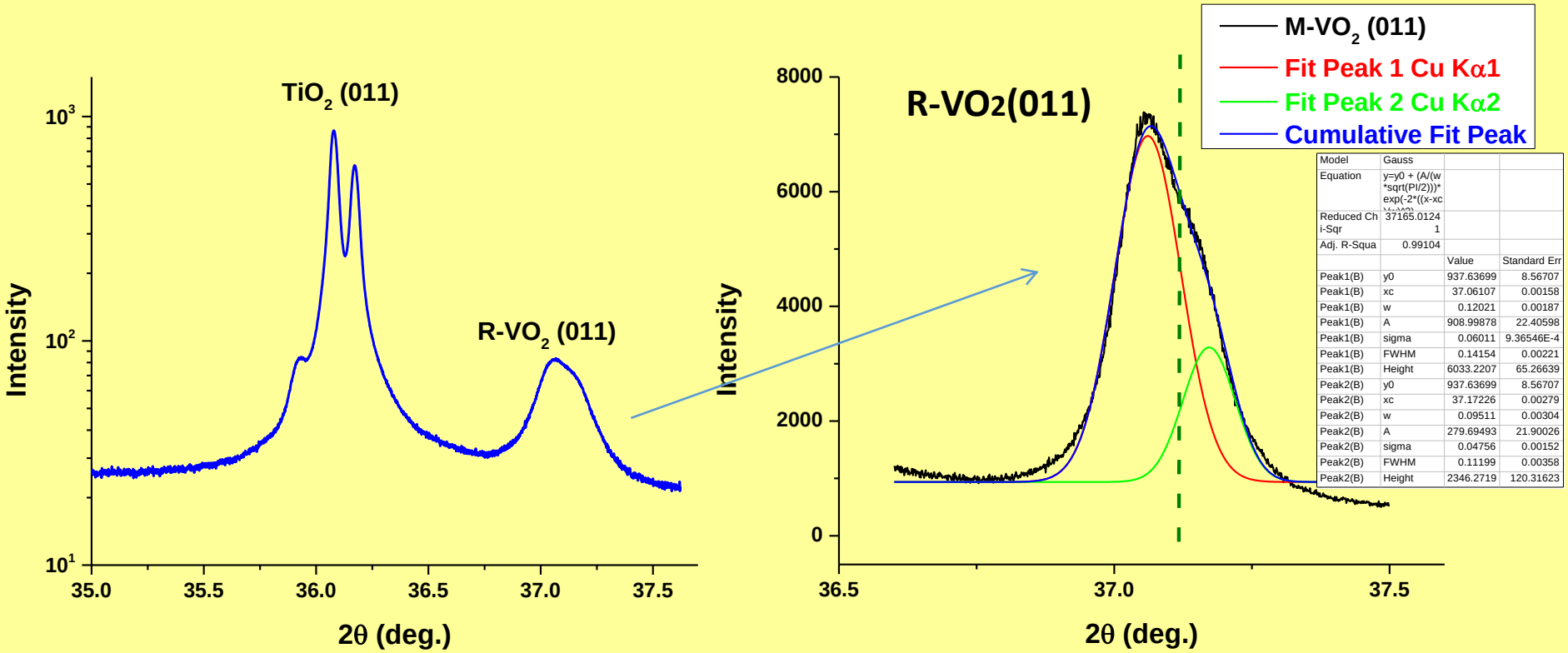
- We have explored how films on Al_2O_3 and TiO_2 have different MIT dynamics at various temperatures
- Future work: to explain the differences in MIT dynamic thresholds between different films.

Properties of Our Thin Films

VO_2 on Al_2O_3	VO_2 on SiO_2	VO_2 on TiO_2
Crystalline M-VO_2 (020) with in plane 6-fold symmetry	Out of plane M-VO_2 (011), in plane polycrystalline	R-VO_2 (011) monocrystalline
Average Grain size out of plane=447 Å In plane=93Å	Average Grain size=367Å	Average Grain size out of plane=593Å In plane=179Å
T_c= 341K	T_c=324K	T_c=306K
Strain In plane: -0.53% Out of plane: -2.81%	Strain Out of plane: 0.92%	Strain In plane: 0.14% Out of plane: 0.54%

L121611B1 VO_2_TiO_2 (011)

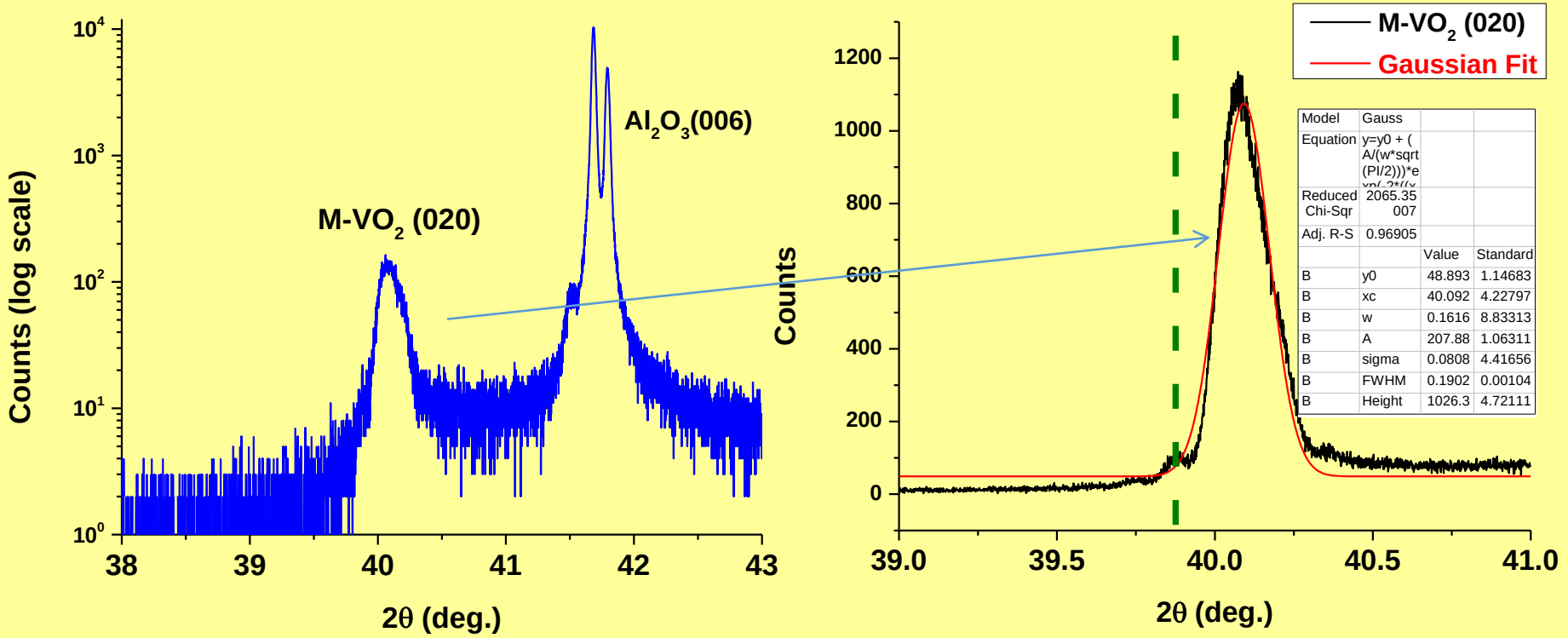
Symmetric scan



Model	Gauss		
Equation	y=y0 + (A/(w *sqrt(PI/2)))* exp(-2*((x-xc		
Reduced Chi-Sqr	37165.01241		
Adj. R-Squa	0.99104		
		Value	Standard Err
Peak1(B)	y0	937.63699	8.56707
Peak1(B)	xc	37.06107	0.00158
Peak1(B)	w	0.12021	0.00187
Peak1(B)	A	908.99878	22.40598
Peak1(B)	sigma	0.06011	9.36546E-4
Peak1(B)	FWHM	0.14154	0.00221
Peak1(B)	Height	6033.2207	65.26639
Peak2(B)	y0	937.63699	8.56707
Peak2(B)	xc	37.17226	0.00279
Peak2(B)	w	0.09511	0.00304
Peak2(B)	A	279.69493	21.90026
Peak2(B)	sigma	0.04756	0.00152
Peak2(B)	FWHM	0.11199	0.00358
Peak2(B)	Height	2346.2719	120.31623

L080611A1 VO_2_*c*-Al_2O_3

Symmetric scan



Model	Gauss		
Equation	y=y0 + (A/(w*sqrt (PI/2)))*e xp(-2*((x		
Reduced Chi-Sqr	2065.35 007		
Adj. R-S	0.96905		
		Value	Standard
B	y0	48.893	1.14683
B	xc	40.092	4.22797
B	w	0.1616	8.83313
B	A	207.88	1.06311
B	sigma	0.0808	4.41656
B	FWHM	0.1902	0.00104
B	Height	1026.3	4.72111

We can probe this phase transition by looking at the reflected and transmitted light.