CWM PROGRESS REPORT

VO_2 THIN FILM OPTICAL STUDIES

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Semiconductor Research Corporation

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Strongly correlated oxides

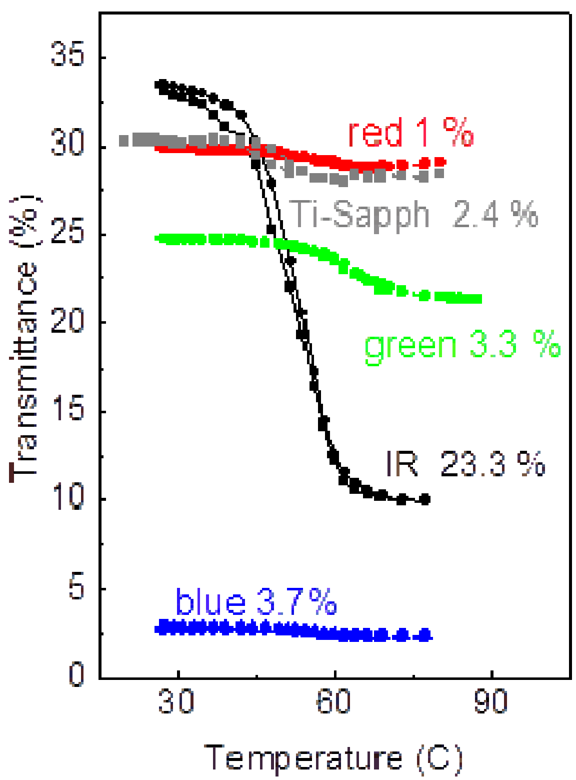
- Vanadium dioxide is a paradigm of strongly correlated oxides and shows many intriguing properties that are still not understood and remain great intellectual challenges.
- VO_2 has a metal–semiconductor transition at ~340 K, just above ambient temperature. The low-temperature semiconducting phase has a monoclinic crystal structure, while the metallic phase has a rutile structure above the transition temperature.
- Across the metal-insulator transition (MIT), the resistivity changes by more than four orders of magnitude and the optical properties are completely modified over a very broad frequency range. The MIT in VO_2 combines the properties of a pure Mott Hubbard electronic transition with those of a Peierls structural transition.
- The electronic character of the Mott transition is responsible for the extreme speed of the optical switching that has been observed.
- Understanding this transition and how to control it is a current challenge for both theory and experimental condensed matter physics.

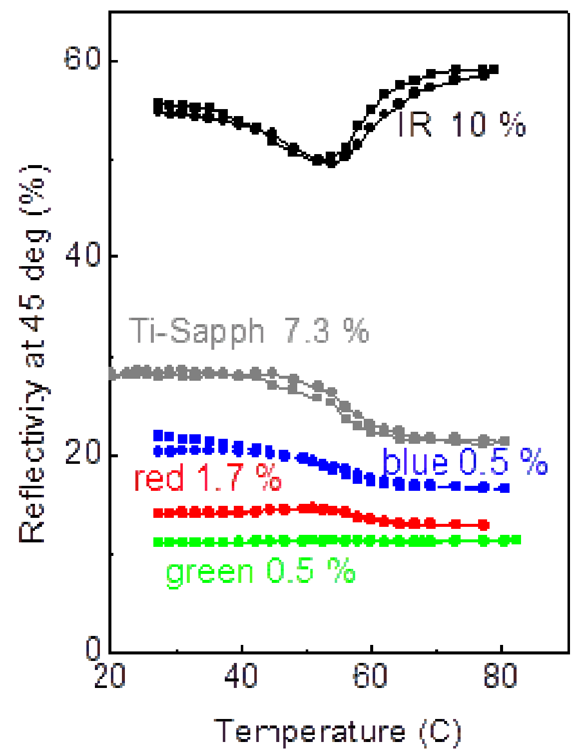
Experimental results

- We have investigated VO_2 films grown on sapphire.
- The optical measurements were carried out on 85 nm thick VO_2 films grown on c-plane sapphire. The films studied were strongly textured with (020) // (0001) sapphire.
- The measurements were performed using different laser wavelengths.

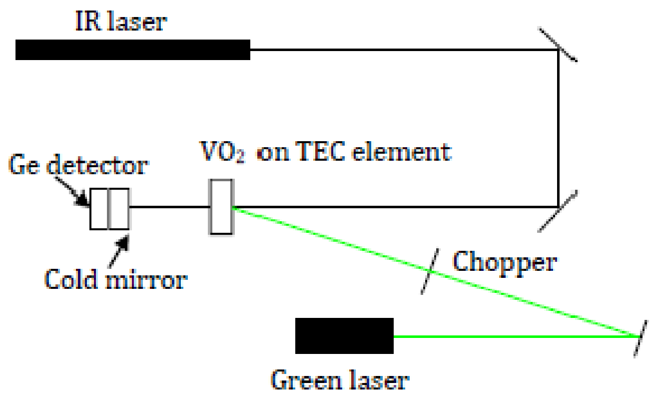
REFLECTIVITY AND TRANSMITTANCE MEASUREMENTS ON VO_2

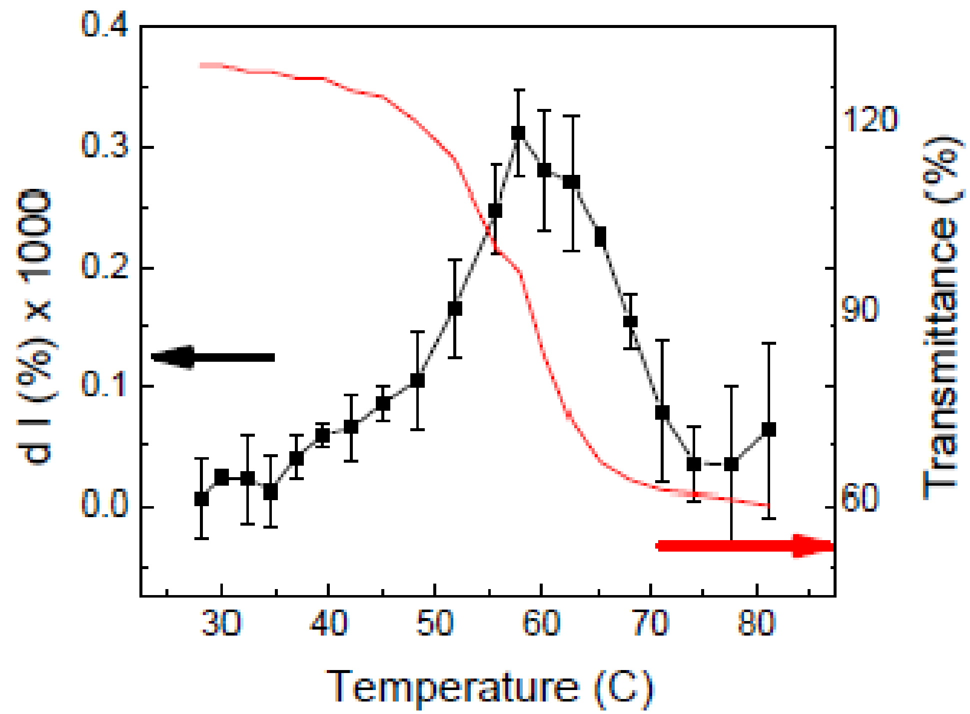
Lasers used: IR laser: 1520 nm; Ti-Sapphire: 800 nm; Red laser: 632.7 nm; Green laser: 500 nm; Blue laser: 405 nm





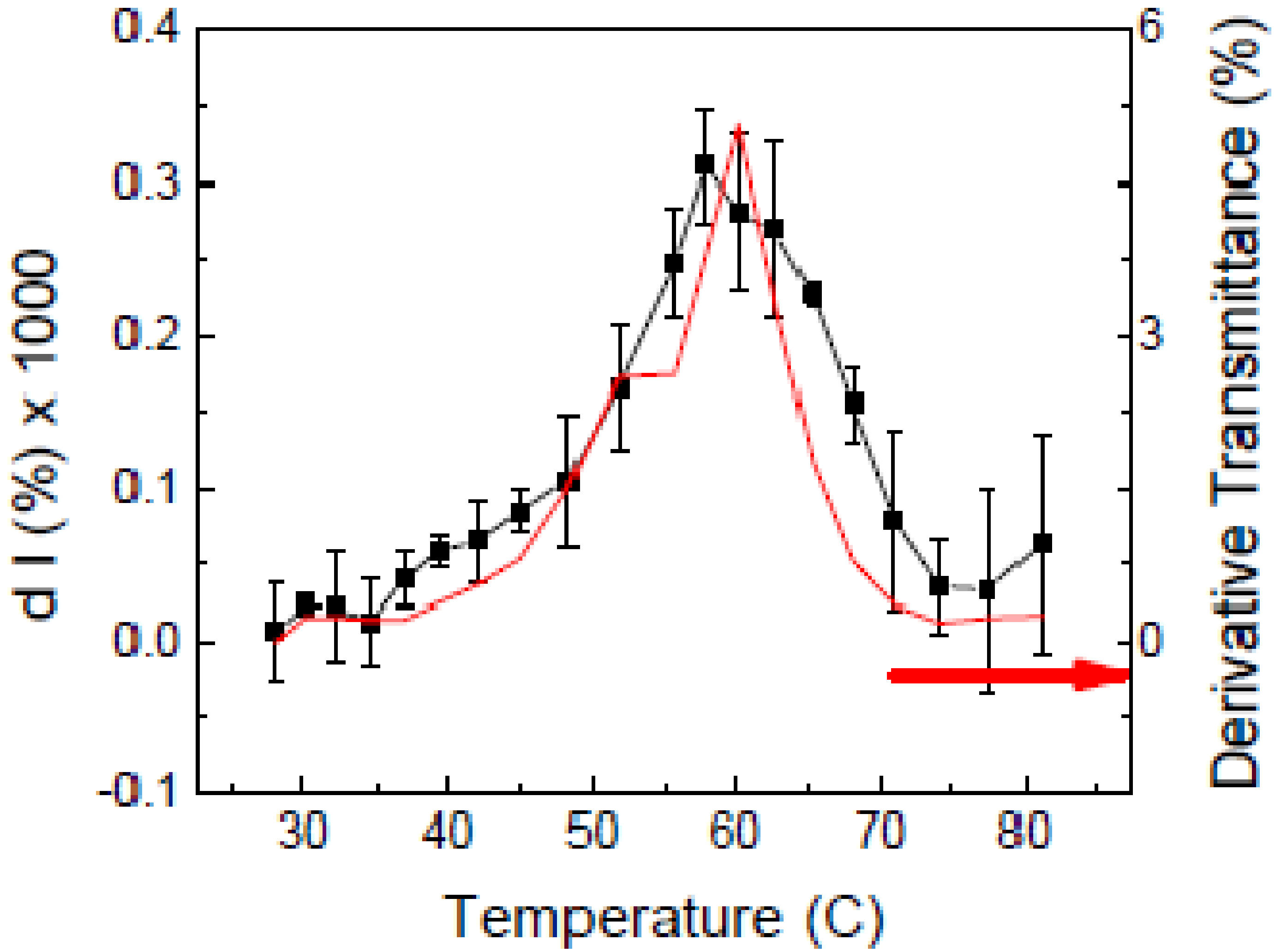
Preliminary pump-probe experiments



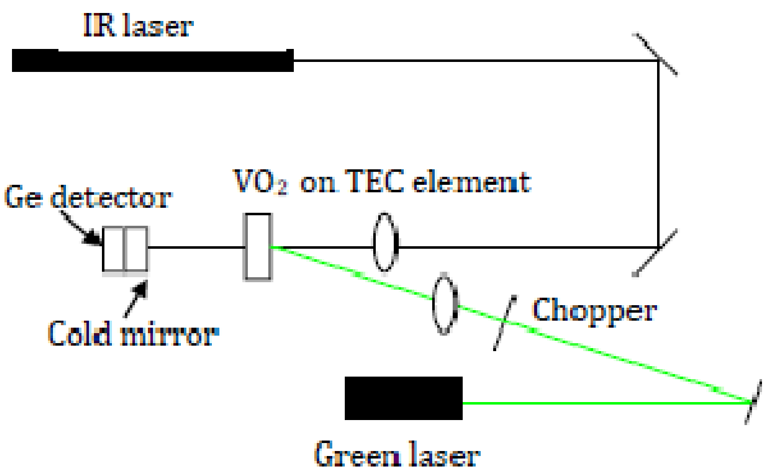


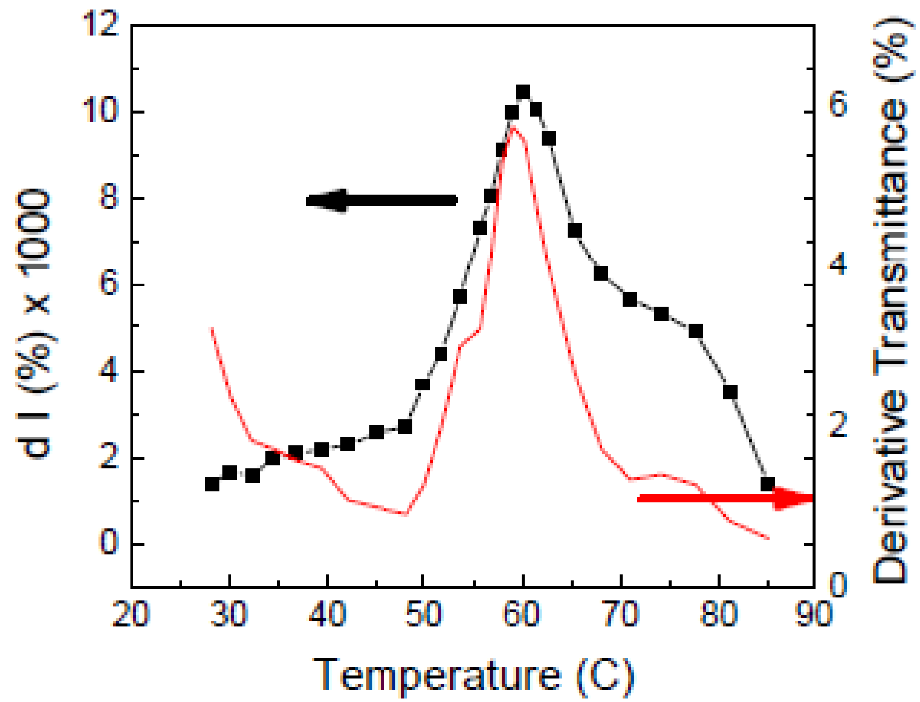
We measured the amplitude of the VO2 transmittance modulation when pumping with green laser modulated at 44 Hz vs. temperature.

We note that the maximum signal is found when the slope of the transmittance is maximum:

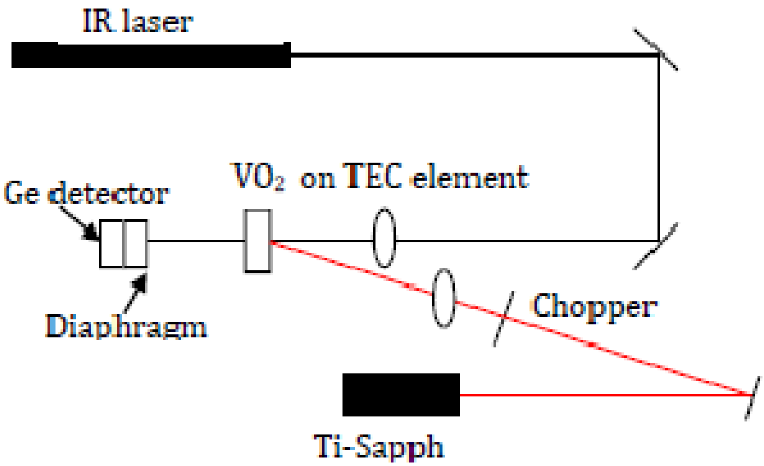


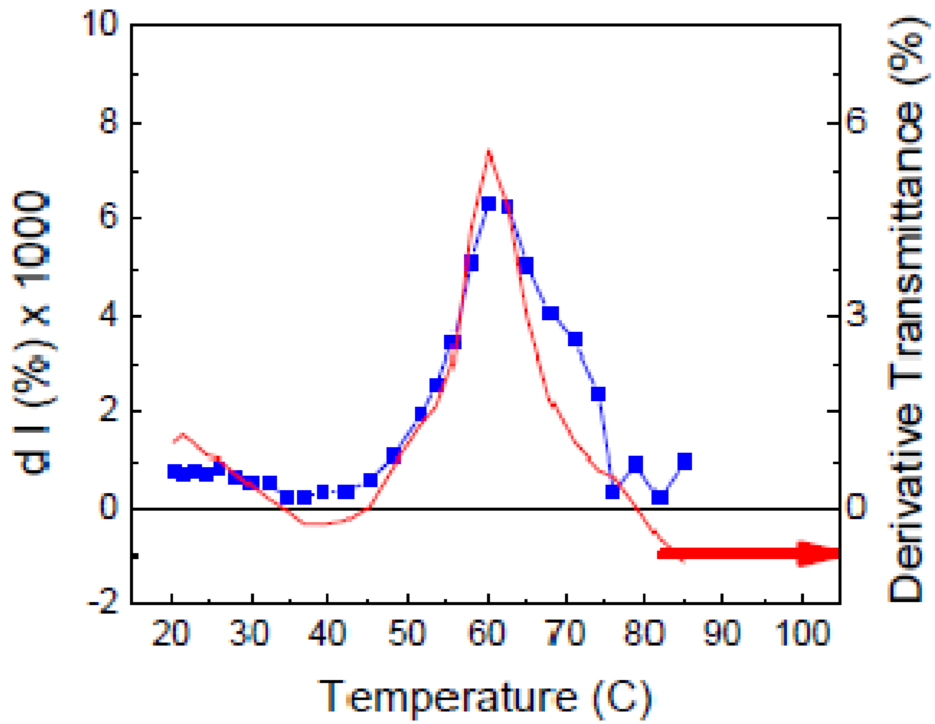
IMPROVING THE ALIGNMENT AND OVERLAP OF BOTH LASERS IMPROVED DRASTICALLY THE SIGNAL





Ti-SAPPHIRE LASER WAS USED AS PUMP LASER

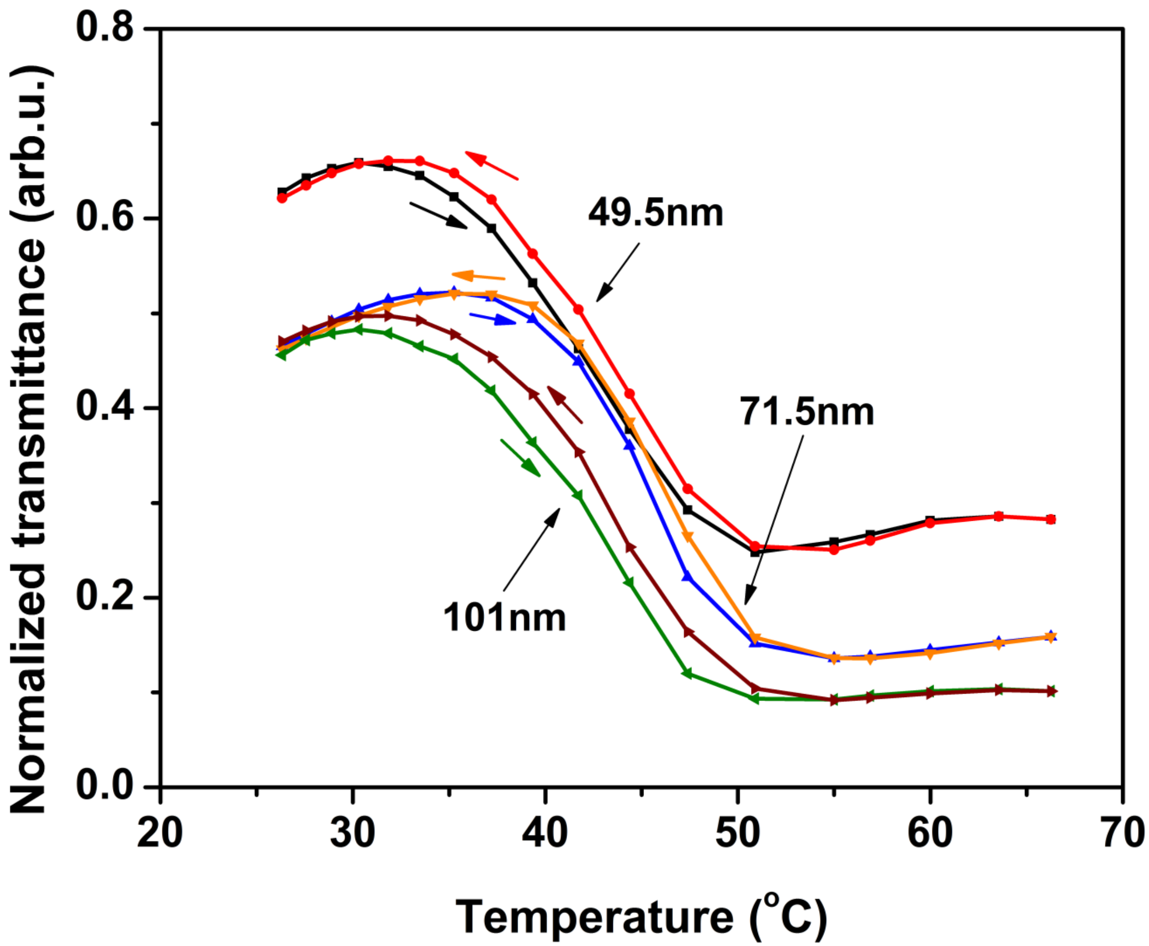




Again the signal follows the derivative of the transmittance curve.

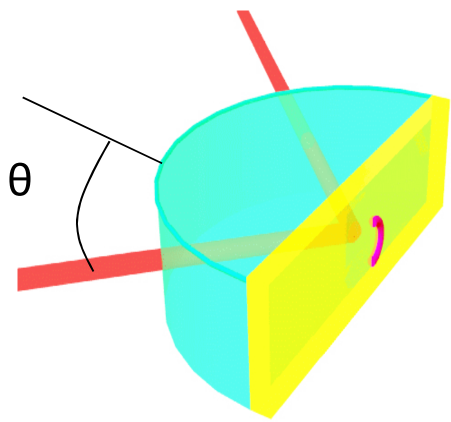
VO2 thin films thicknesses studies

49.5nm, 71.5nm and 101nm.



IR (λ=1520nm) transmission:
it clearly shows an optical transmittance change up to 40% during the MIT for all the three VO_2 thin film samples

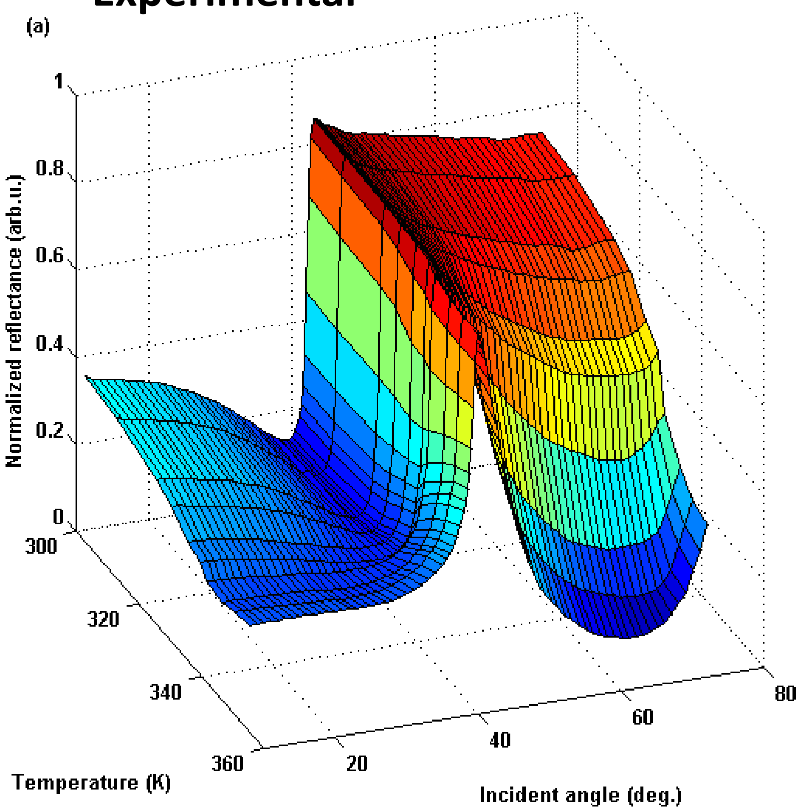
Surface plasmon polaritons



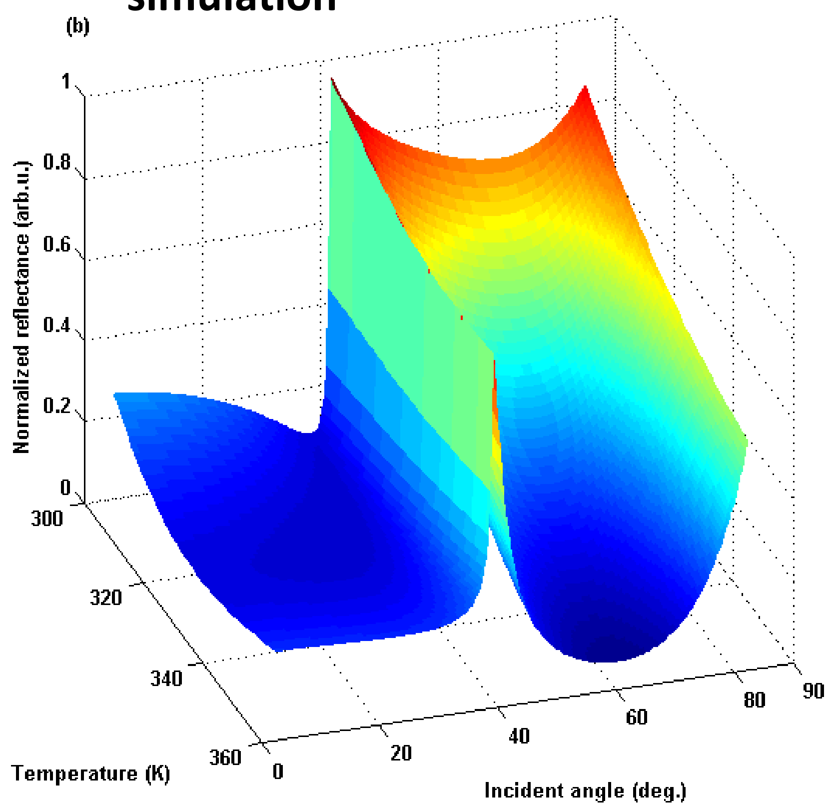
- SPR Investigated in Kretschmann configuration while heating the sample above its MIT so that it is in its conducting phase.

Temperature-dependence of SPR in 49.5nm VO_2 thin film in the IR region

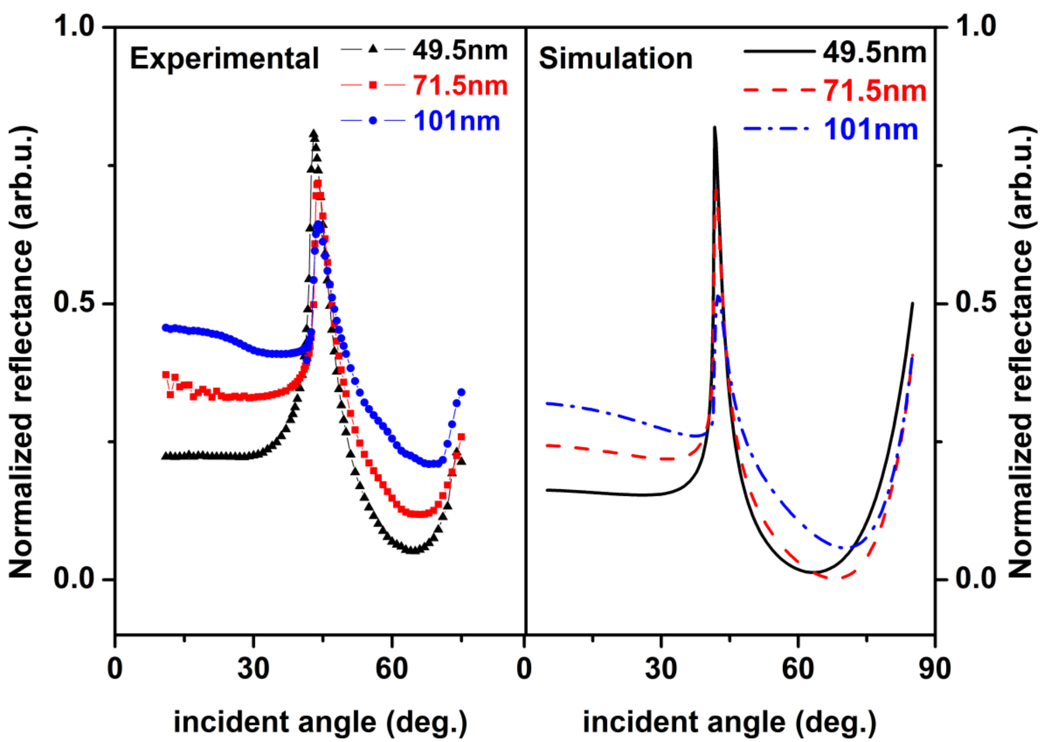
Experimental



simulation



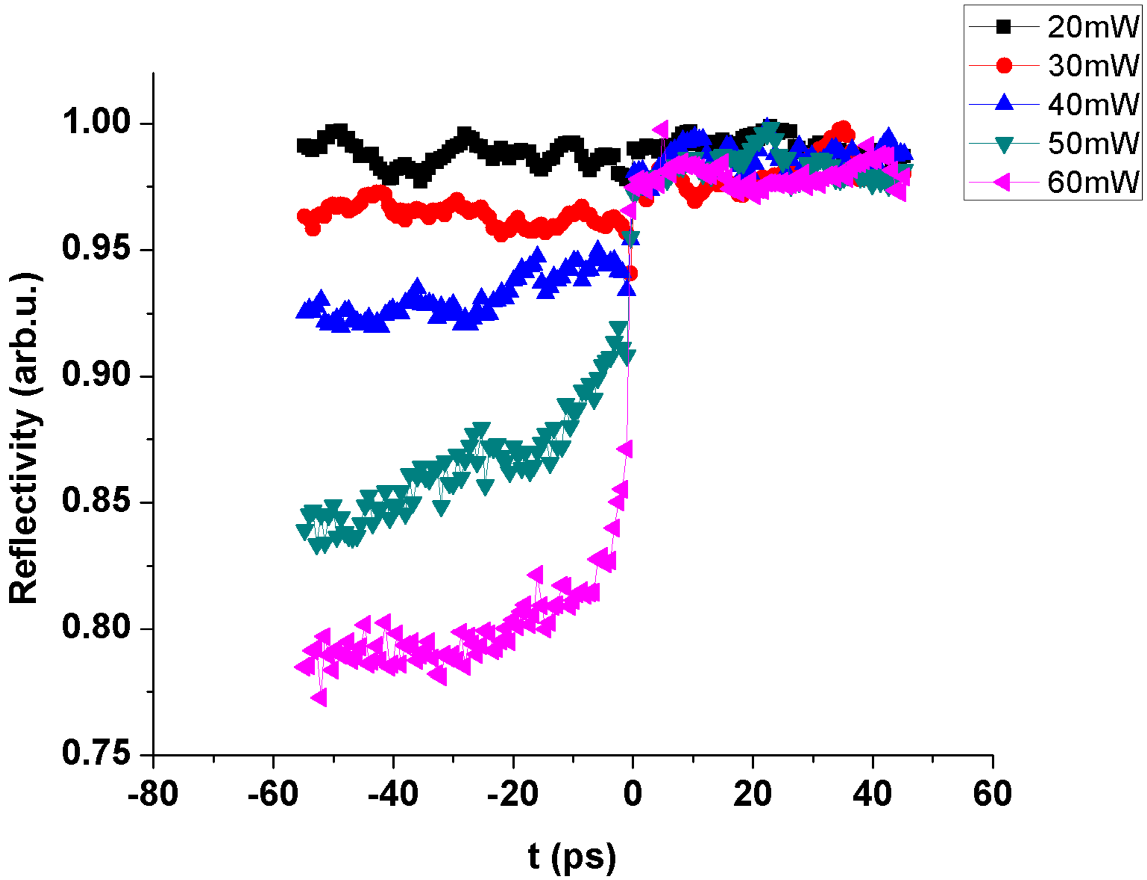
SPR in VO_2 thin films with different film thicknesses

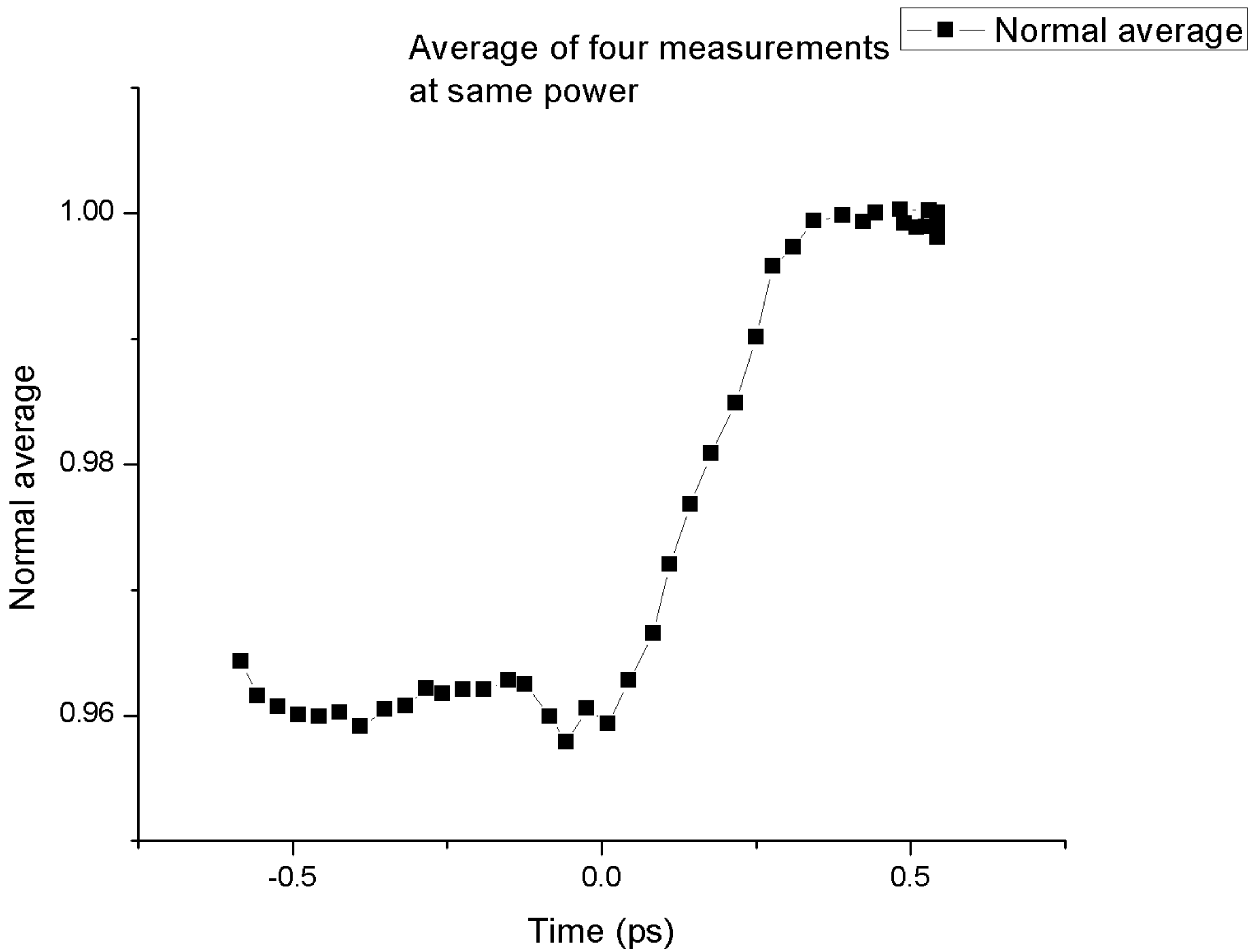


Experimental results (a) agree very well with the simulations (b).

The SPR excitation strongly depends on film thickness. The thinner films (49.5 and 71.5 nm) show higher absorption due to stronger SPR excitation; for the thicker film (101 nm), SPR signal decreases since most of the light is absorbed by the film and cannot reach the VO_2/air interface.

Time resolved MIT studies




Normal average
Average of four measurements
at same power
1.00
0.98
0.96
-0.5
0.0
0.5
Normal average
Time (ps)

THz vs IR studies of MIT