Thermochromic Radiator

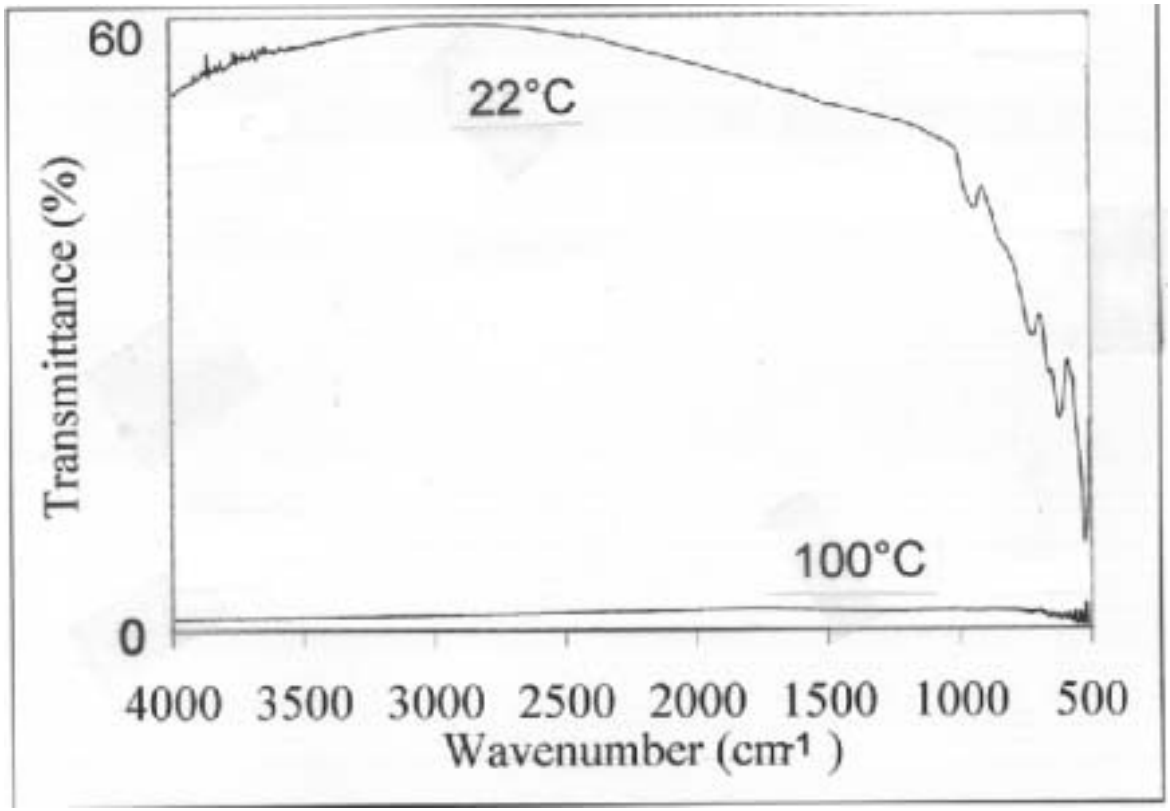
- Using a thermochromic material a variable emittance structure has been developed

Dr A. J. Topping

Department of Engineering Science

Oxford University

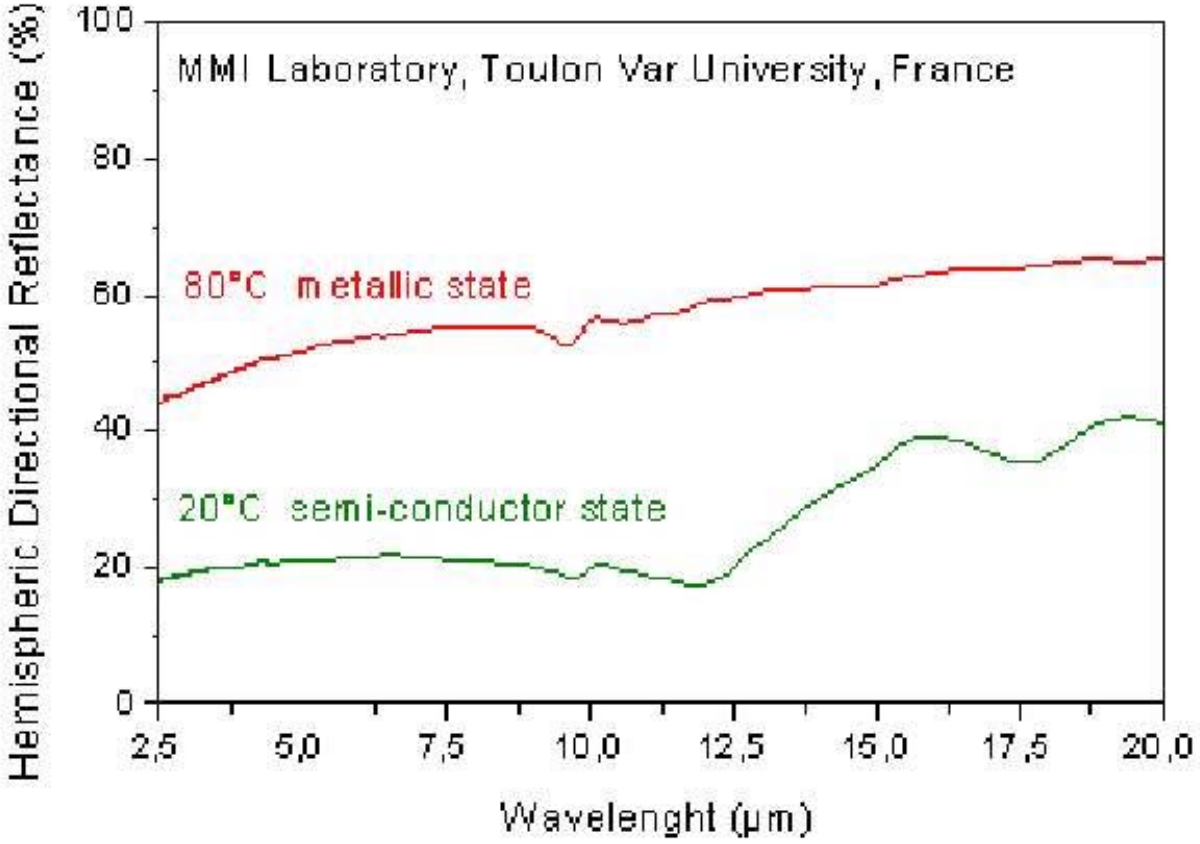
Transmission properties of VO_2



$$T = (1 - R)e^{(-\alpha d)}$$

- Transmission is very large
- Indicates a high absorption coefficient

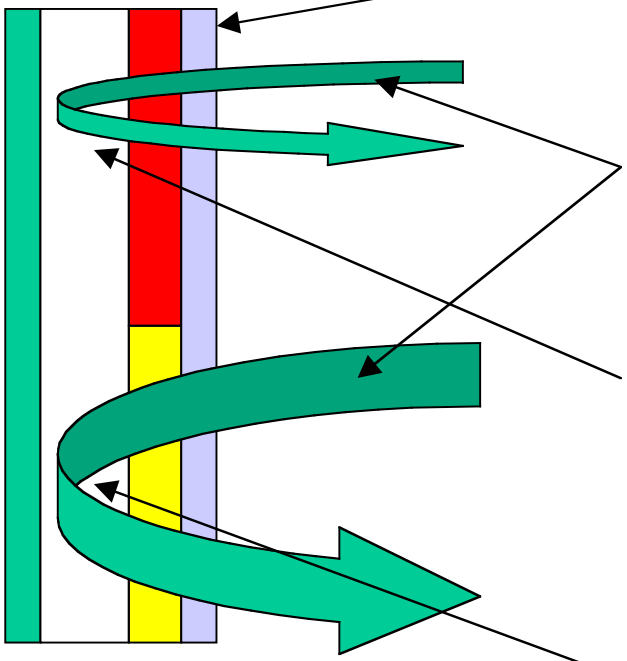
Reflection properties of VO_2



$$R = \frac{(n_1 - n_2)^2 + (k_1 - k_2)^2}{(n_1 + n_2)^2 + (k_1 + k_2)^2}$$

- After transition material becomes reflective
- Low emittance when hot-unsuitable for radiative cooling

Intelligent Radiator Structure



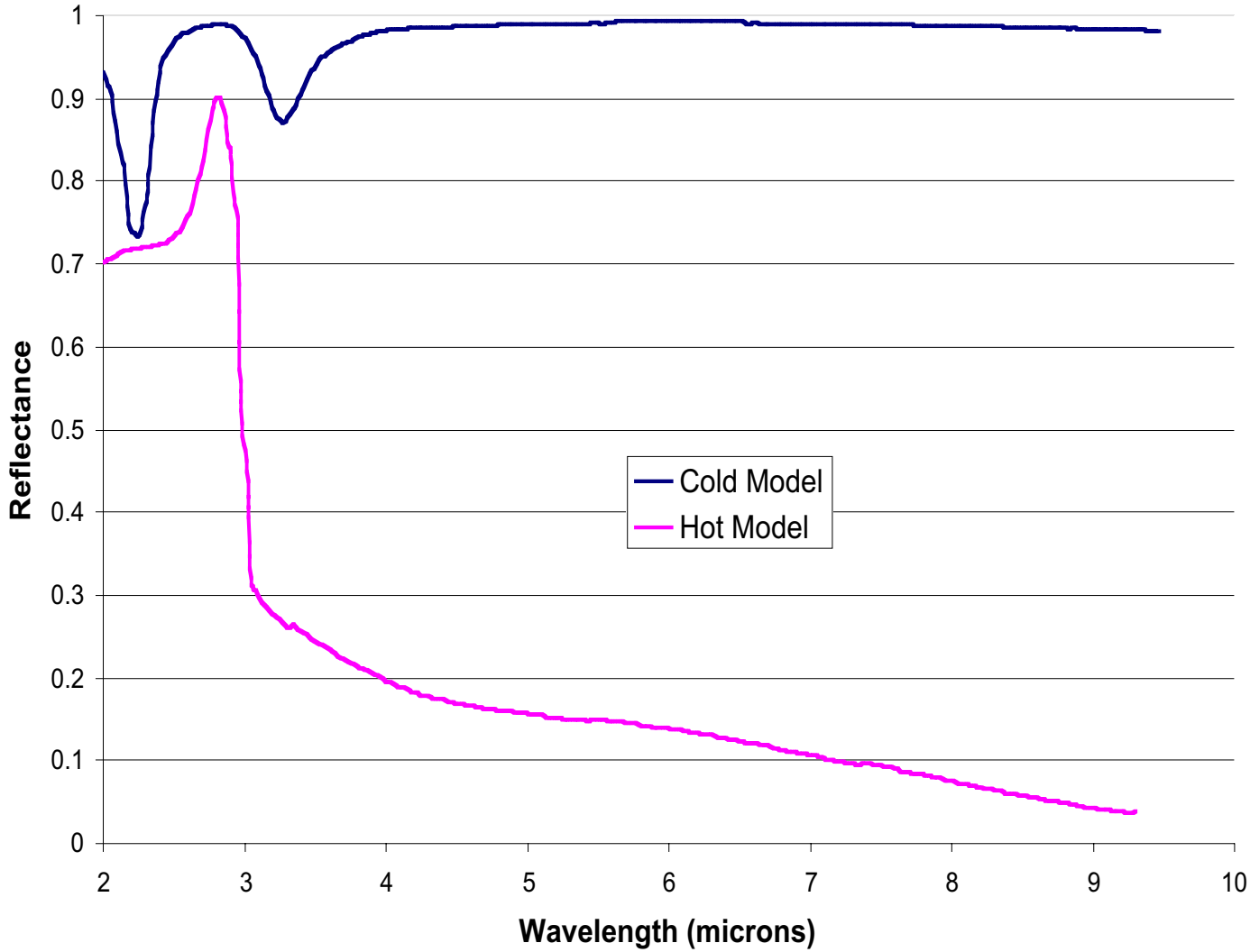
Using an index matched coating as the window to the structure (matching the metallic state)

This allows reflectance modulation by variable transmission through the structure

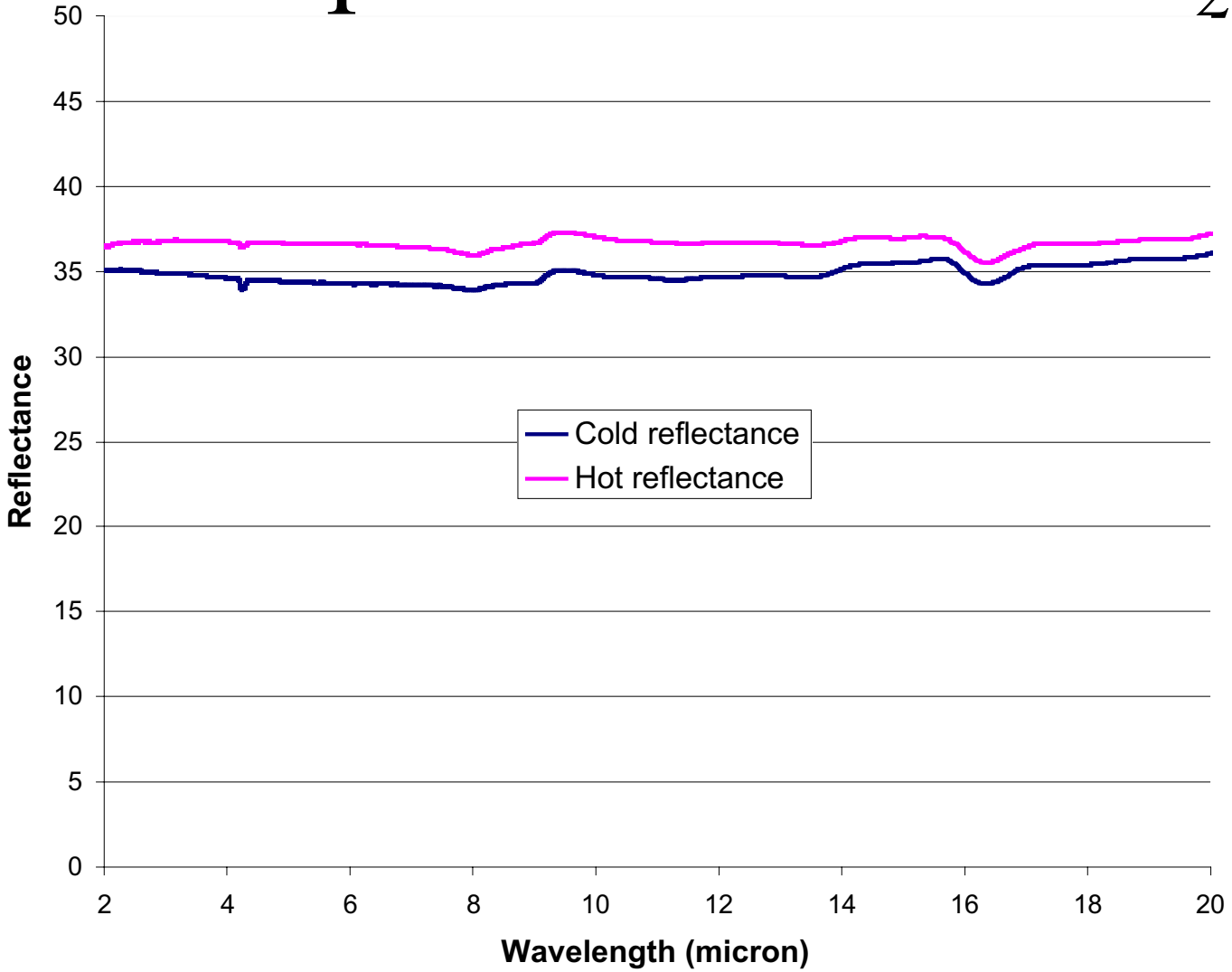
In the metallic state the VO2 interface reflection is reduced coupling more energy into the absorbing structure

In the semi conducting state all constituents are transparent except the rear reflecting layer

Intelligent Radiator Model

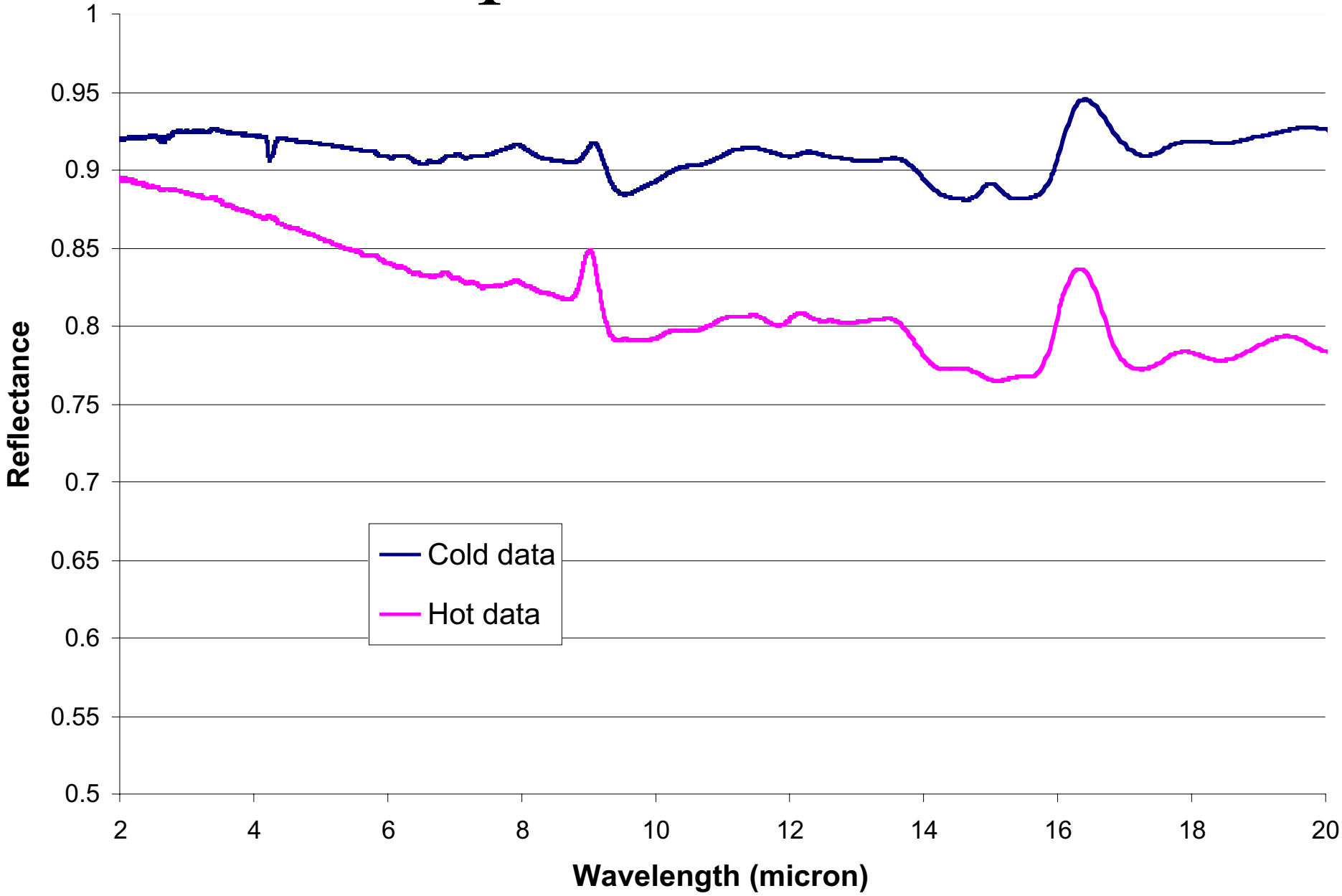


Properties of Test VO_2



- Initial VO_2 film show poor thermal reflectance modulation *(change in optical constants small)*

Initial Experimental Results



Transformation of Transition

- Transition temperature of VO_2 has been shown to be tunable, with doping of tungsten
- Transition temperatures have been reportedly reduced to 110K with 6% Tungsten doping

Type of Emittance Change

- Researchers have shown with control of constituents and crystallinity
  - Variation of the speed of transition
    - Both fast (step) and slow (linear) changes
  - Designs have been produced allowing for a mixture of transitions:of temperature or type

Other Vary-e Systems

- Electrochromic- Transition metal oxide
- Electrochromic- Conductive polymers
- Electrostatic
- MEMS
  - micro electro mechanical systems

Strengths of the intelligent radiator

- Extreme reduction in mass with no loss of performance
- No power requirements or moving parts
- Failure modes reduced due to durable nature of structure
- Applicable to any surface with no loss of performance
- Damage insensitive—ideal for hostile environments

Potential for intelligent Radiator

- Use as (or with) fully integrated autonomous thermal control system
- Specialised use where power supply and control is difficult
- Personal heat removal from environmental suits

References

Transmittance data
Dr. Guillaume Guzman's website
http://www.solgel.com/articles/August00/thermo/Guzman.htm

Reflectance data:
http://www.univ-tln.fr/Recherche/unites/l2mi/fred/vo2.htm

John Topping
johntopping@hotmail.com