Variable Reflectivity Coatings for Optical Propulsion Applications

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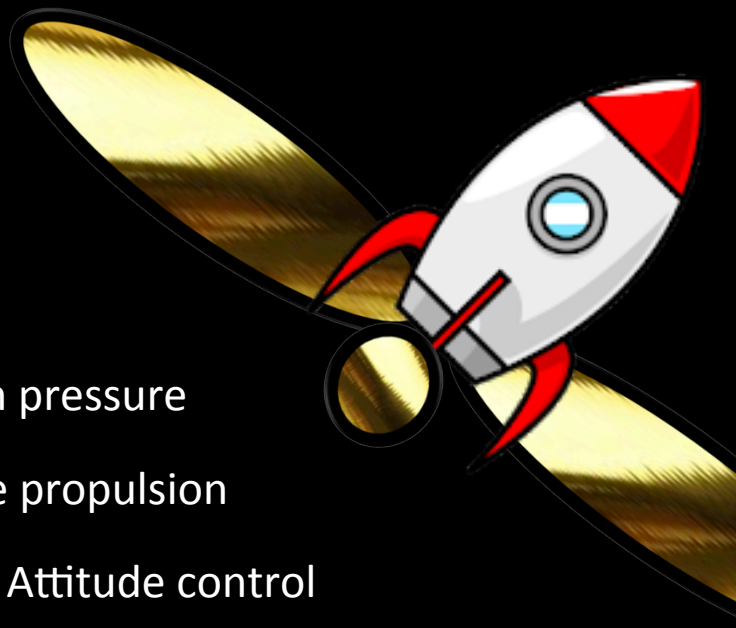
Solar Sailing



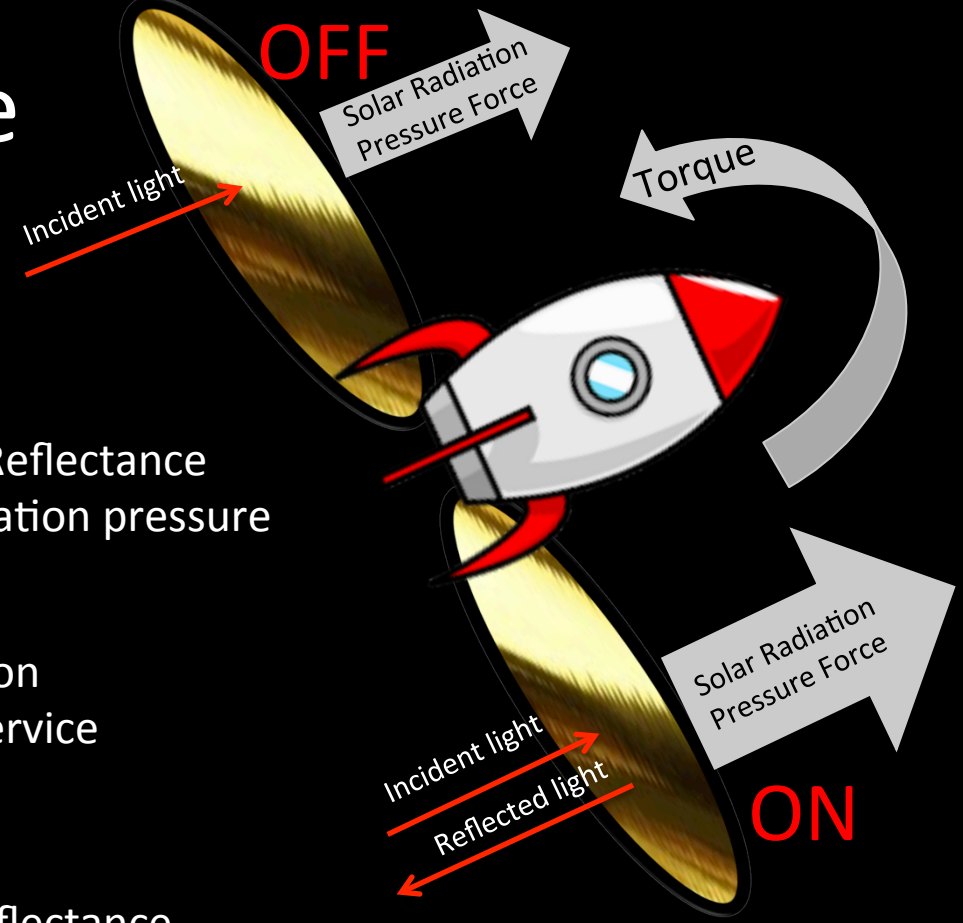
Facts

- Uses solar radiation pressure
- Microscale propulsion
- Attitude control

Advantages

- No need to bring fuel
- Long lasting

Utilizing pressure difference



Absorption radiation pressure = ½ Reflectance radiation pressure

Off State = Absorption
- Perfectly black service
- No reflection

On State = Reflectance
- Appears like a mirror
- Reflects all wavelengths
- No absorption

Differences in pressure causes torque
- Attitude control

Radiation Pressure Equation

$$P = \frac{1}{C}\int_{0.5\ \mu m}^{4\ \mu m} \mathrm{I}(2\mathrm{R} + \mathrm{A})d\lambda$$

I = Solar extraterrestrial AM 1.5 Spectrum

R = Reflectance

A = Absorption

C = Speed of light

T = Transmittance

Opaque

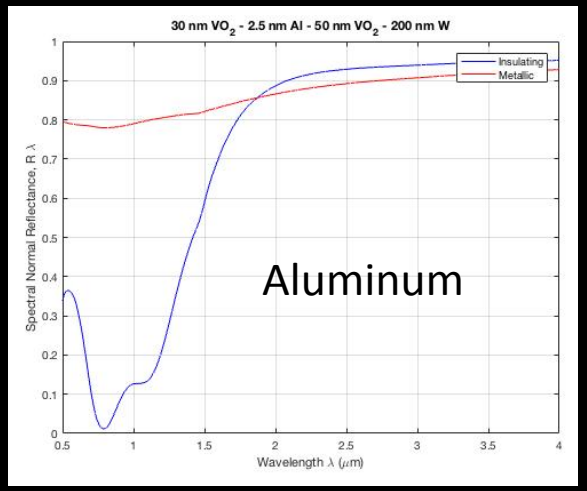
0

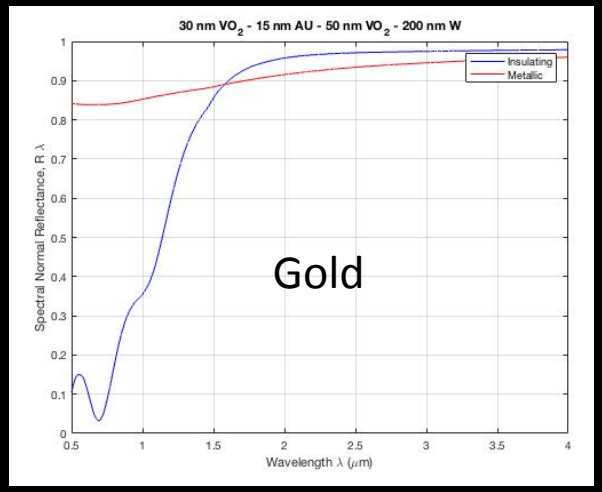
$A + R + \cancel{T} = 1$

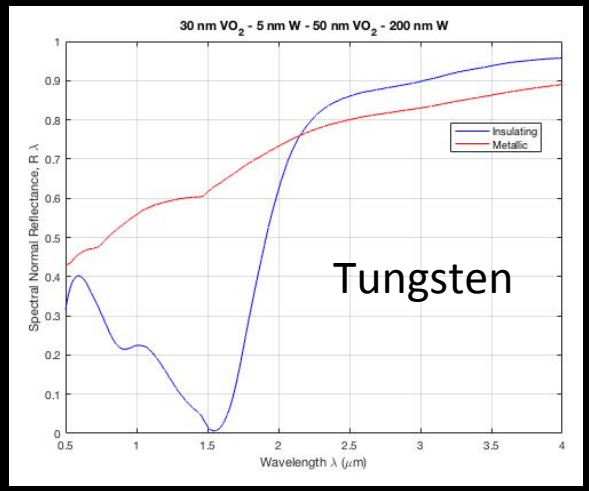
$A = 1 - R$

Results

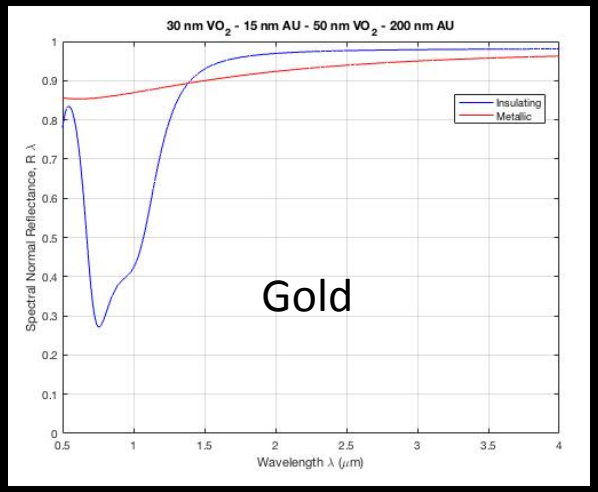
Top mirror metals

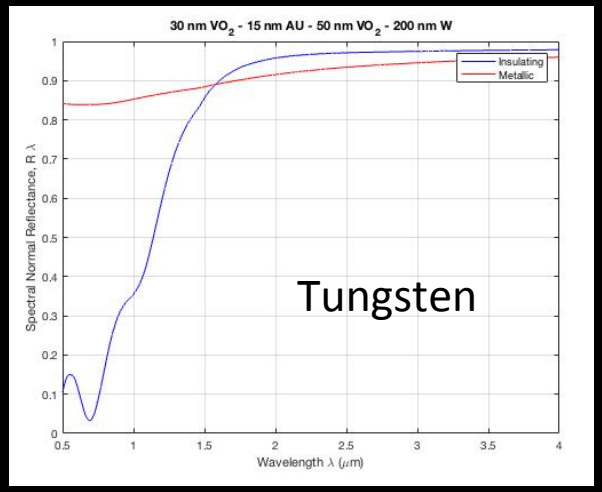


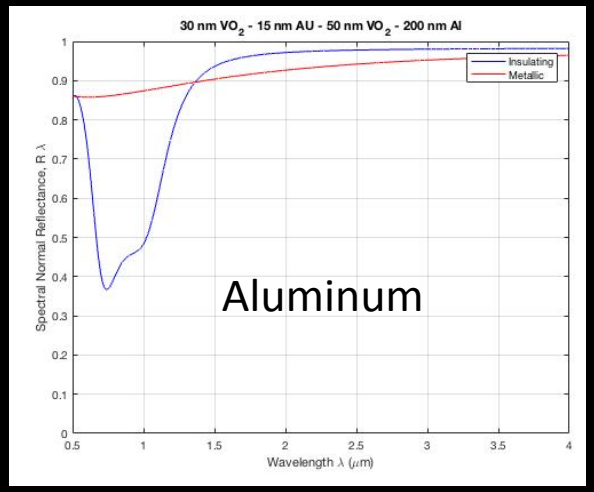




Bottom mirror metal

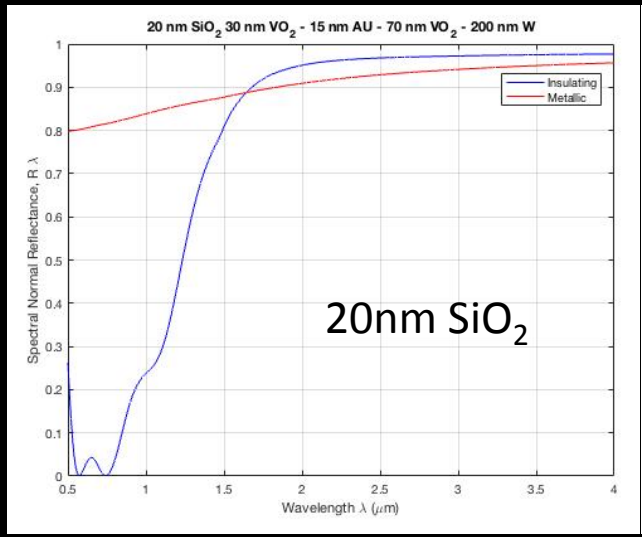


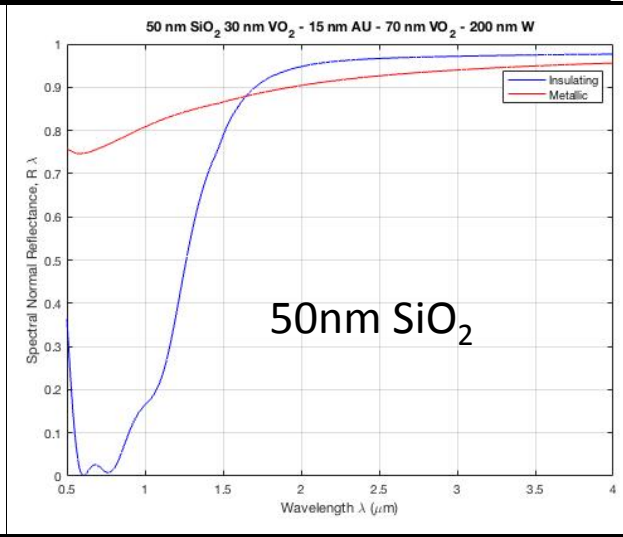


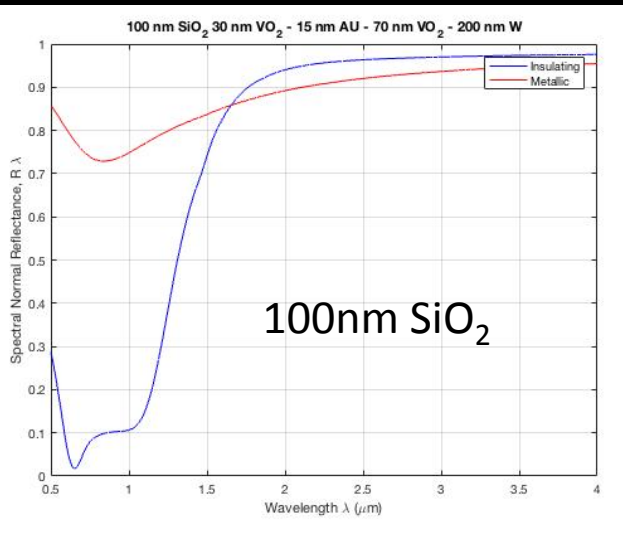


Results

Anti-Reflective coating SiO_2







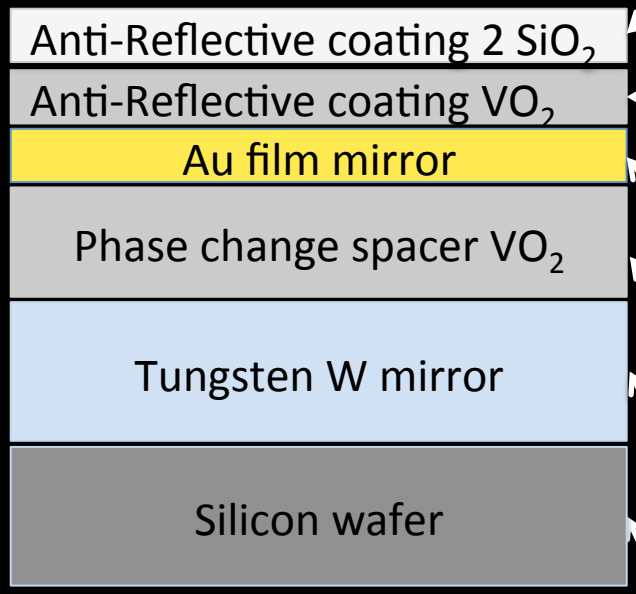
$n_i = 1$

- Anti-Reflective coating SiO_2
- Anti-Reflective coating VO_2
- Au film mirror
- Phase change spacer VO_2
- Tungsten W mirror
- Silica wafer

Reflection

$$R = \left| \frac{n_1 - n_2}{n_1 + n_2} \right|^2$$

Fabrication



- 6) Anti-Reflective coating SiO_2 using Chemical Vapor Depositions
- 5) VO_2 Using that same method
  - Electron Beam Evaporation
  - Furnace annealing to oxidize
- 4) Au Gold via Electron Beam
- 3) VO_2
  - Electron Beam Evaporation
  - Furnace annealing to oxidize
- 2) Tungsten added via Sputtering
- 1) Starts with a Silica Wafer

Future plans

- Characterize the interaction between thermochromic and electrochromic responses
- Verify model experimentally
- Redesigns for electrical measurements

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References

Taylor, Sydney, and Liping Wang. “Vanadium Dioxide-Based Variable Reflectivity Radiation Coatings for Optical Propulsion Applications.” *International Astronautical Congress*, vol. 67, Sept. 2016.