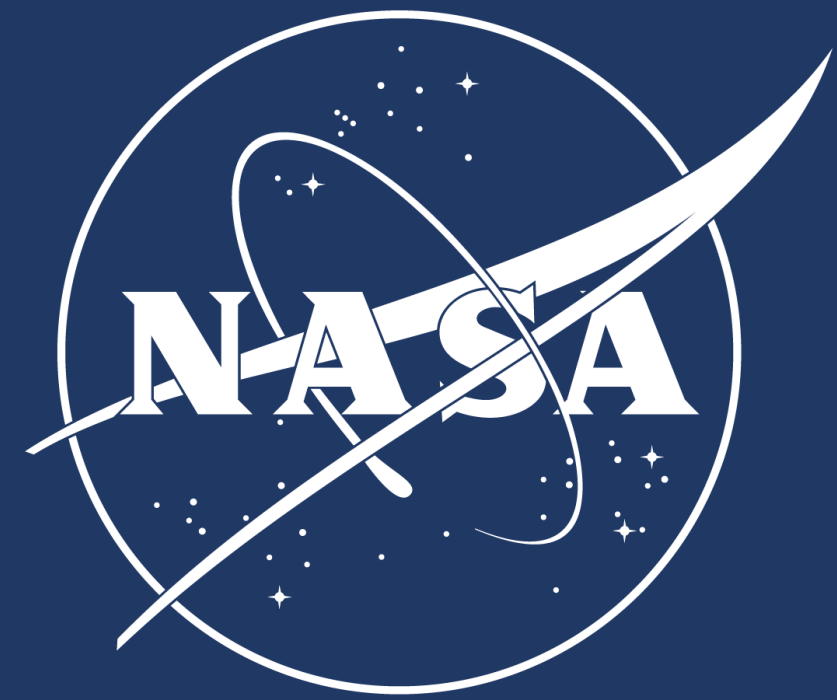


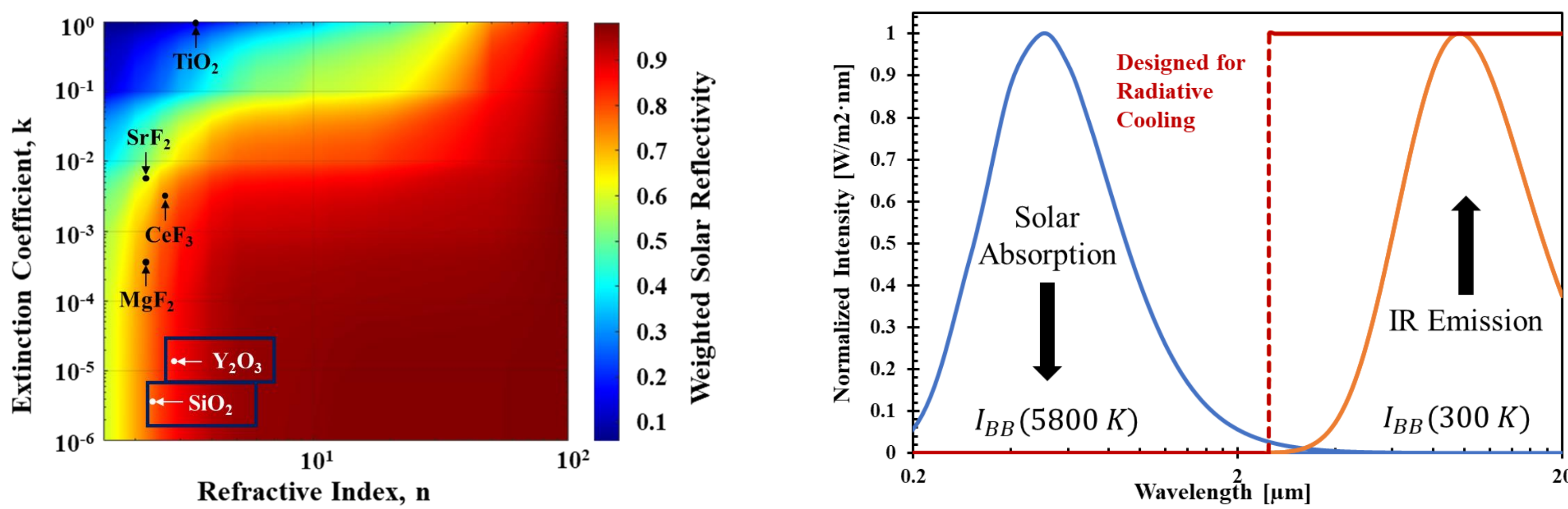
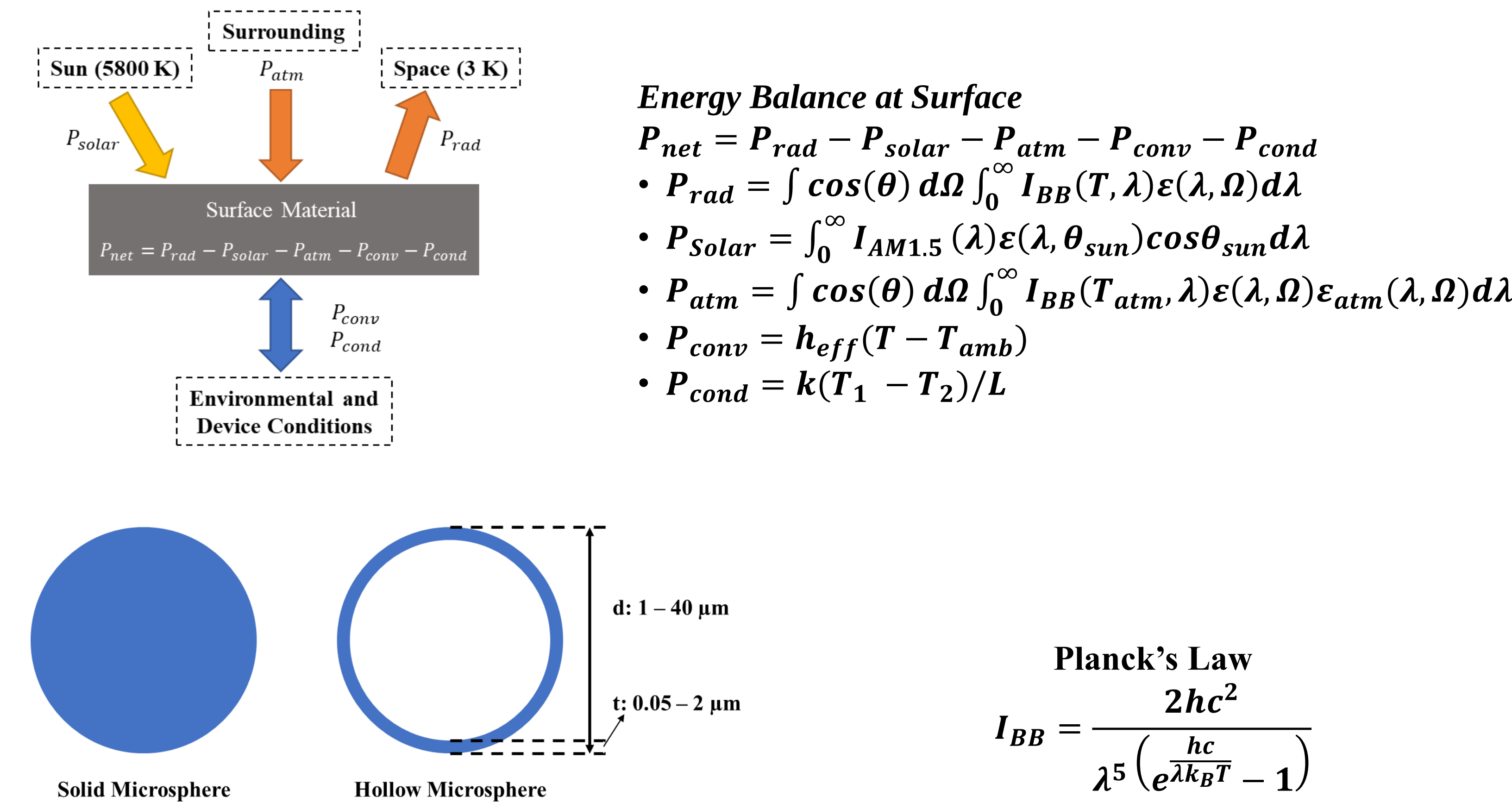
Thermal Radiation Control in Space using Hollow Microsphere-based Coatings



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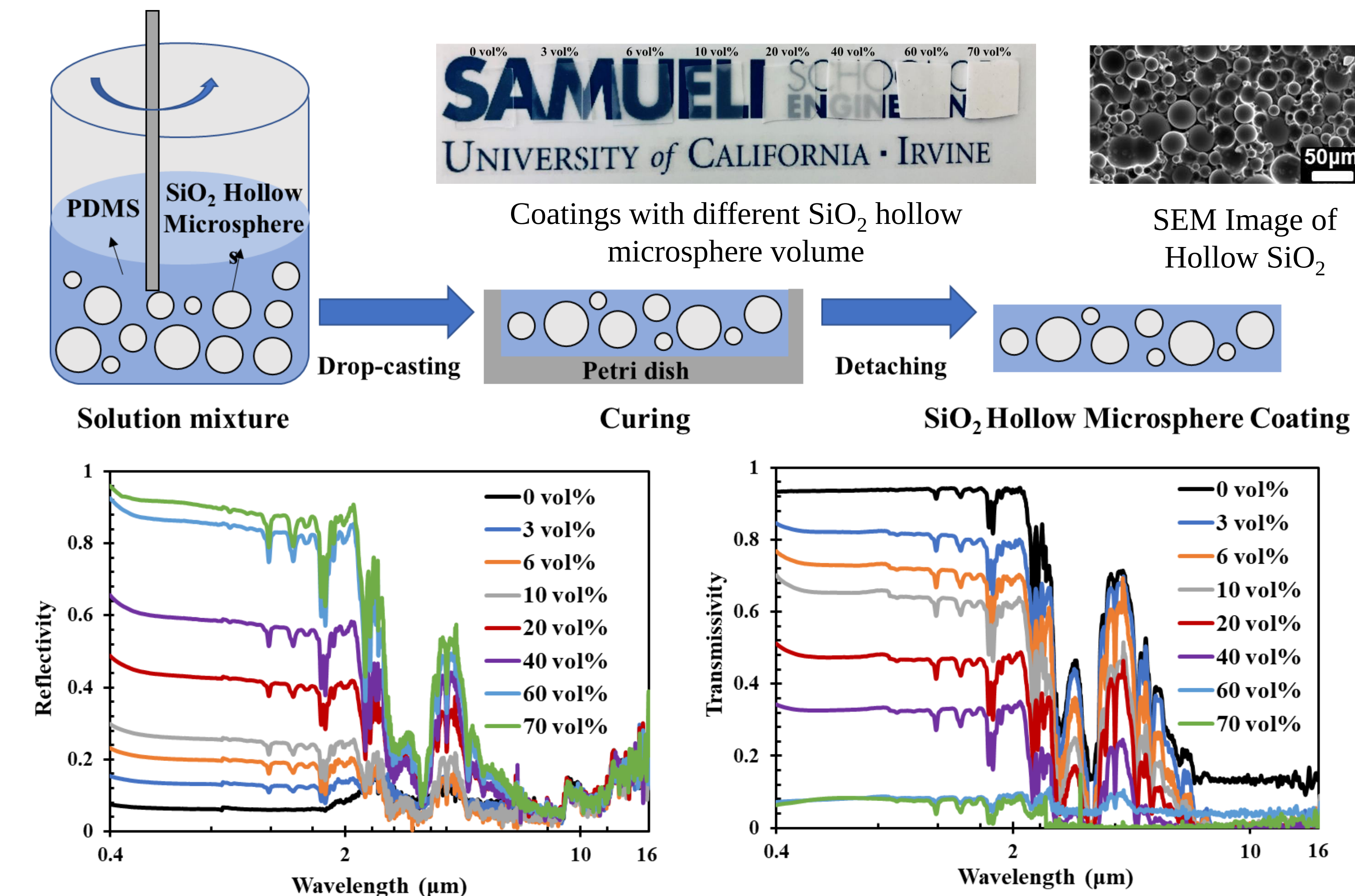
Introduction

Thermal radiation control is a crucial method of thermal regulation in space, where the dominant means of heat transfer is radiation. To maintain optimal temperature in space, the surface needs to reflect sun light and release thermal radiation. For such reason, hollow microspheres are suitable for thermal radiation control, since they exhibit high solar reflectivity and IR emissivity. Herein, we experimentally present sprayable hollow microsphere coating, including their optical and thermal properties. These coatings have potentials to offer thermal management in space via thermal radiation control.



- Distinct wavelength ranges allowed for solar absorption and thermal emission offer unique opportunities for surface materials to control temperature via radiation.
- Hollow microspheres are more reflective due to high scattering efficiency due to the high refractive-index contrast^[1]
- High refractive index (n) and low extinction coefficient (k) is desired for high solar reflectivity
- Y₂O₃ hollow microsphere has higher refractive index and lower extinction coefficient than SiO₂ hollow microsphere^[2]

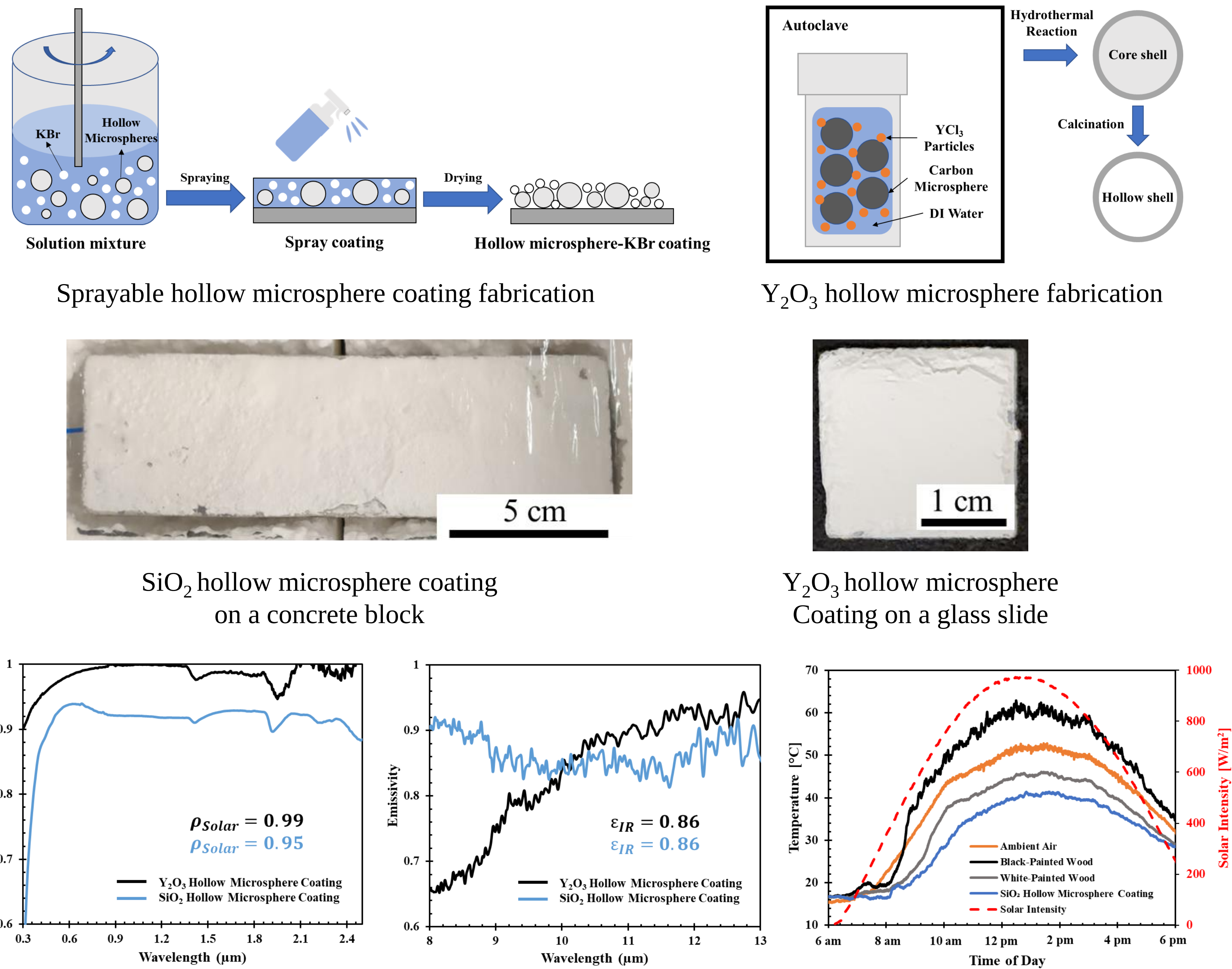
Drop-casted SiO₂ Hollow Microsphere Coating



Demonstration of drop-casted hollow microsphere coating^[3]

- Consisting SiO₂ hollow microsphere in PDMS binder
- Higher SiO₂ hollow microsphere volume yields higher solar reflectivity
- $\rho_{solar} = 0.92$ and $\epsilon_{IR} = 0.85$

Sprayed Hollow Microsphere Coating



Demonstration of sprayed coating shows:

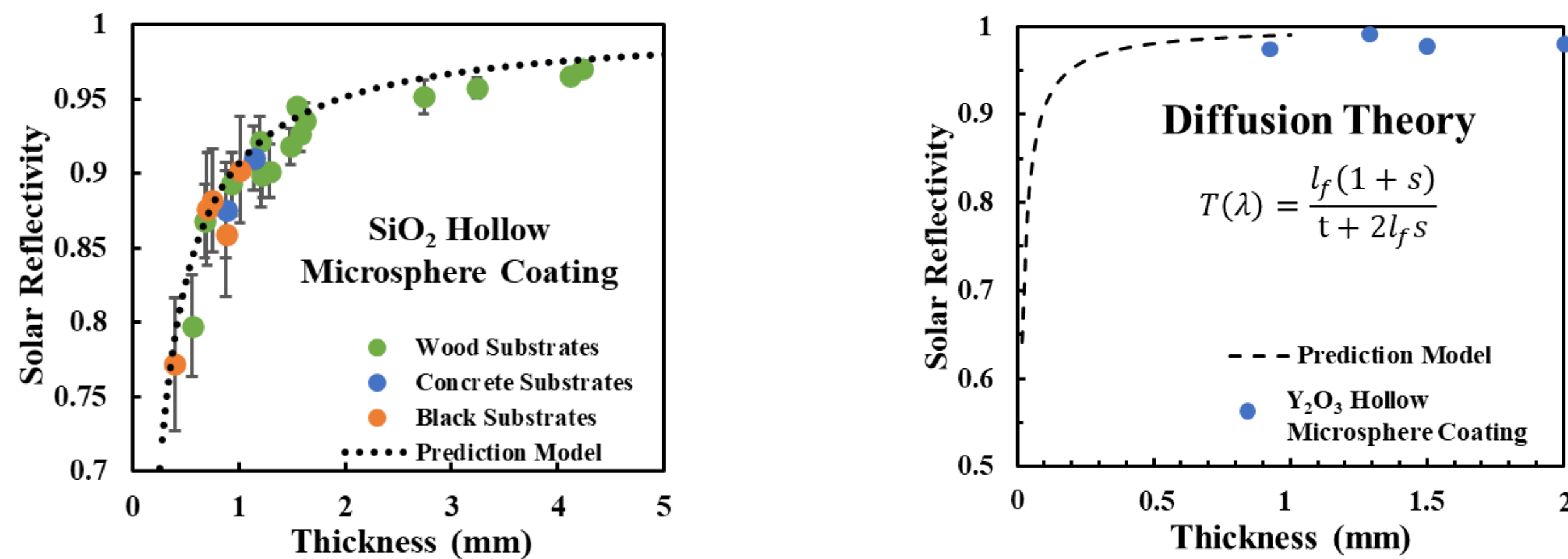
- Simple and scalable fabrication method
- KBr has lower NIR absorption than PDMS
- More than 10°C sub-ambient cooling

SiO₂ Sprayed Coating Tech-economic Analysis

- \$0.008347/W
- \$0.5062/m²
- 0.009224 kg/m²

Cooling Power: 117 W/m²
@ T_{amb} = 40°C, h = 10 W/m²K

Thickness-dependent Solar Reflectivity



Solar reflectivity of coating depends on thickness

- Reflectivity can be predicted using diffusion theory^[2]
- Reflectivity of Y₂O₃ hollow microsphere coating in the solar spectrum is predicted to reach 0.99 at 1 mm

Conclusion

- ❑ Drop-casted SiO₂ hollow microsphere coating shows solar reflectivity (ρ_{solar}) of 0.92 and IR emissivity (ϵ_{IR}) of 0.85
- ❑ Sprayed hollow microsphere coatings show higher solar reflectivity and IR emissivity
 - ❑ SiO₂ hollow microsphere coating has $\rho_{solar} = 0.95$ and $\epsilon_{IR} = 0.86$
 - ❑ Y₂O₃ hollow microsphere coating has $\rho_{solar} = 0.99$ and $\epsilon_{IR} = 0.86$
- ❑ Solar reflectivity of the coating increases with thickness based on diffusion theory
- ❑ Hollow microspheres has high potential for thermal radiation control in space

References and Acknowledgements

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2. Nie, X., Yu, Z., Jackson, E., & Lee, J. "Refractive Index and Extinction Coefficient of Hollow Microspheres for Solar Reflection." Applied Physics Letters, vol. 118, no. 21, 24 May 2021, p. 211907.
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