Spectral control with *one-dimensional non-periodic metal-dielectric media* for parabolic solar trough applications

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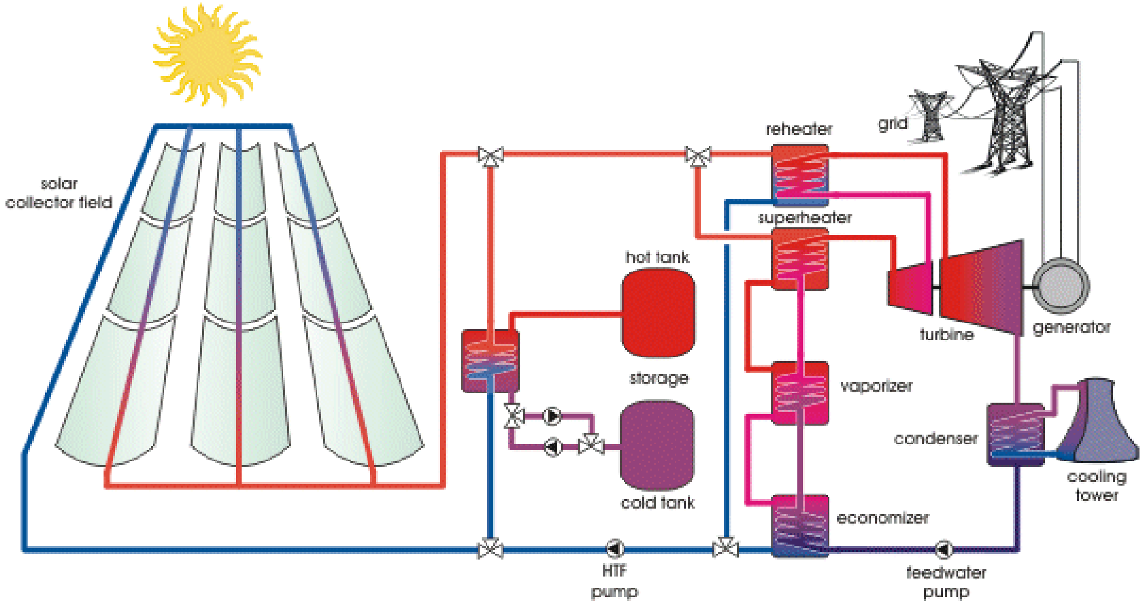
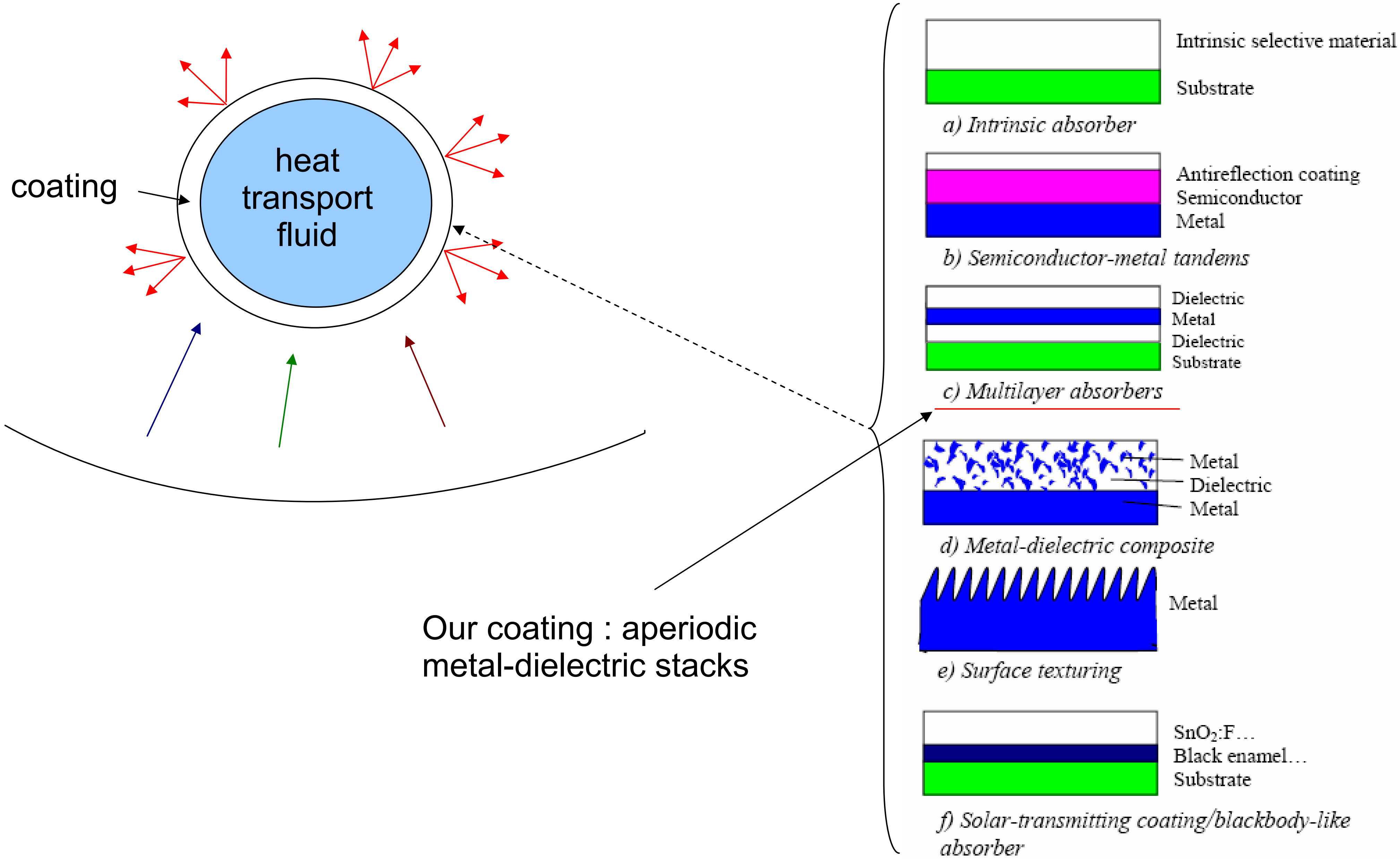
Concentrated Solar Power (CSP)



- How can we increase system efficiency working on the receiver ?
  - Increase fluid throughput
  - Use higher temperature for better Rankine cycle efficiency

Credit : Nevada Solar One, Volker Quaschning

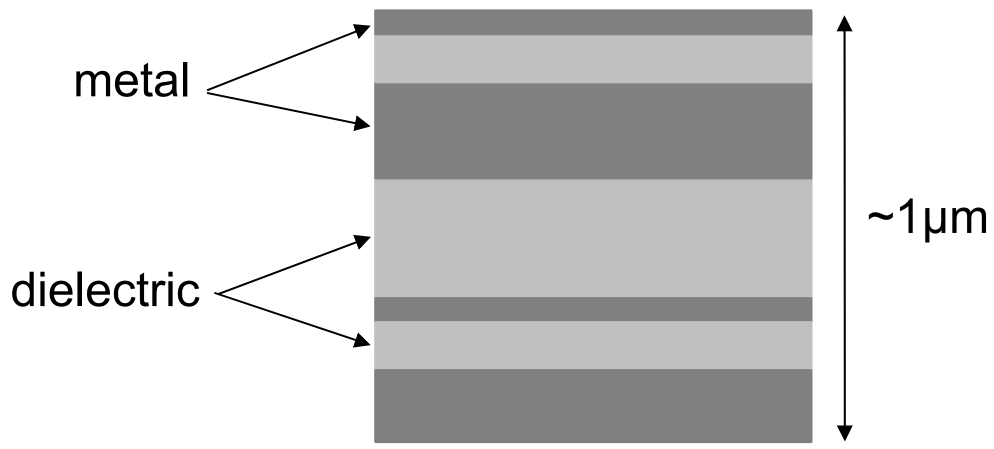
Heat collection element



Source : NREL

Aperiodic metal/dielectric stacks

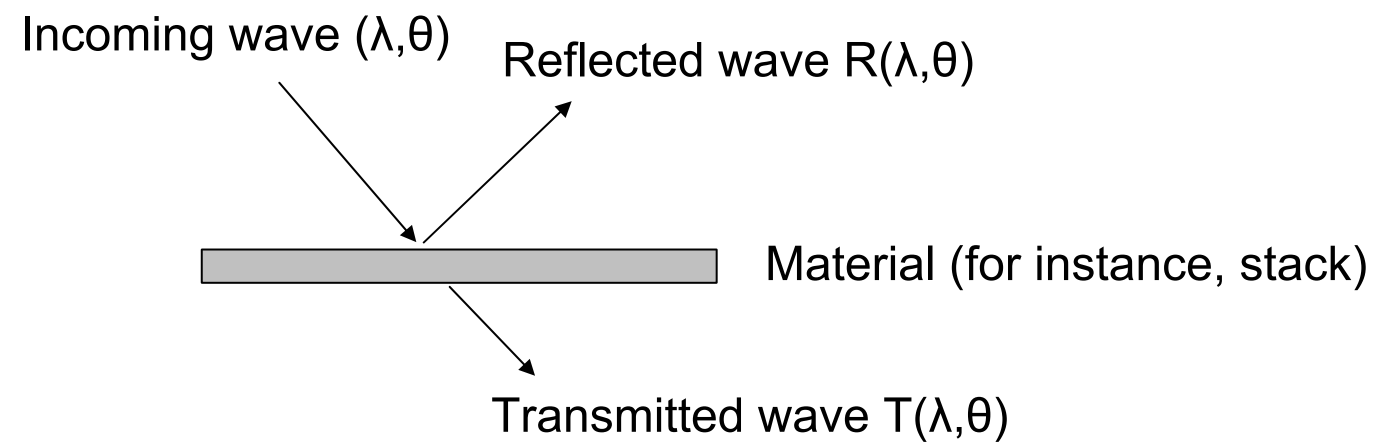
- What they are
  - Thin-films (~1 micrometer) made of layers of metal and dielectric
  - Typical number of layers : 10-20 → tough design challenge
  - Can contain several different metals, several different dielectrics



- Advantages
  - Tuneable
  - 1D : easy to produce, no codeposition
  - Thermally stable? (May need diffusion barrier layers)

Aperiodic metal/dielectric stacks

- Kirchhoff's law

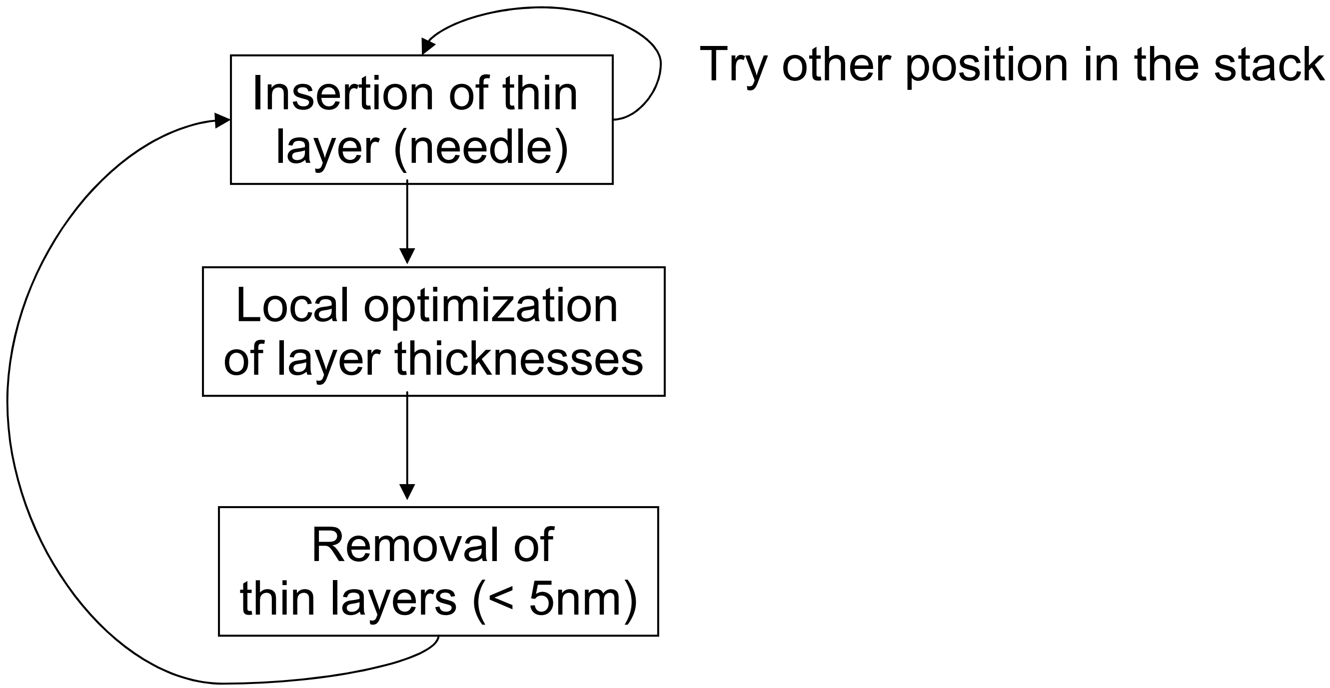


$$\text{Absorptivity}(\lambda,\theta) = 1-R(\lambda,\theta)-T(\lambda,\theta) = \textit{Emissivity}(\lambda,\theta)$$

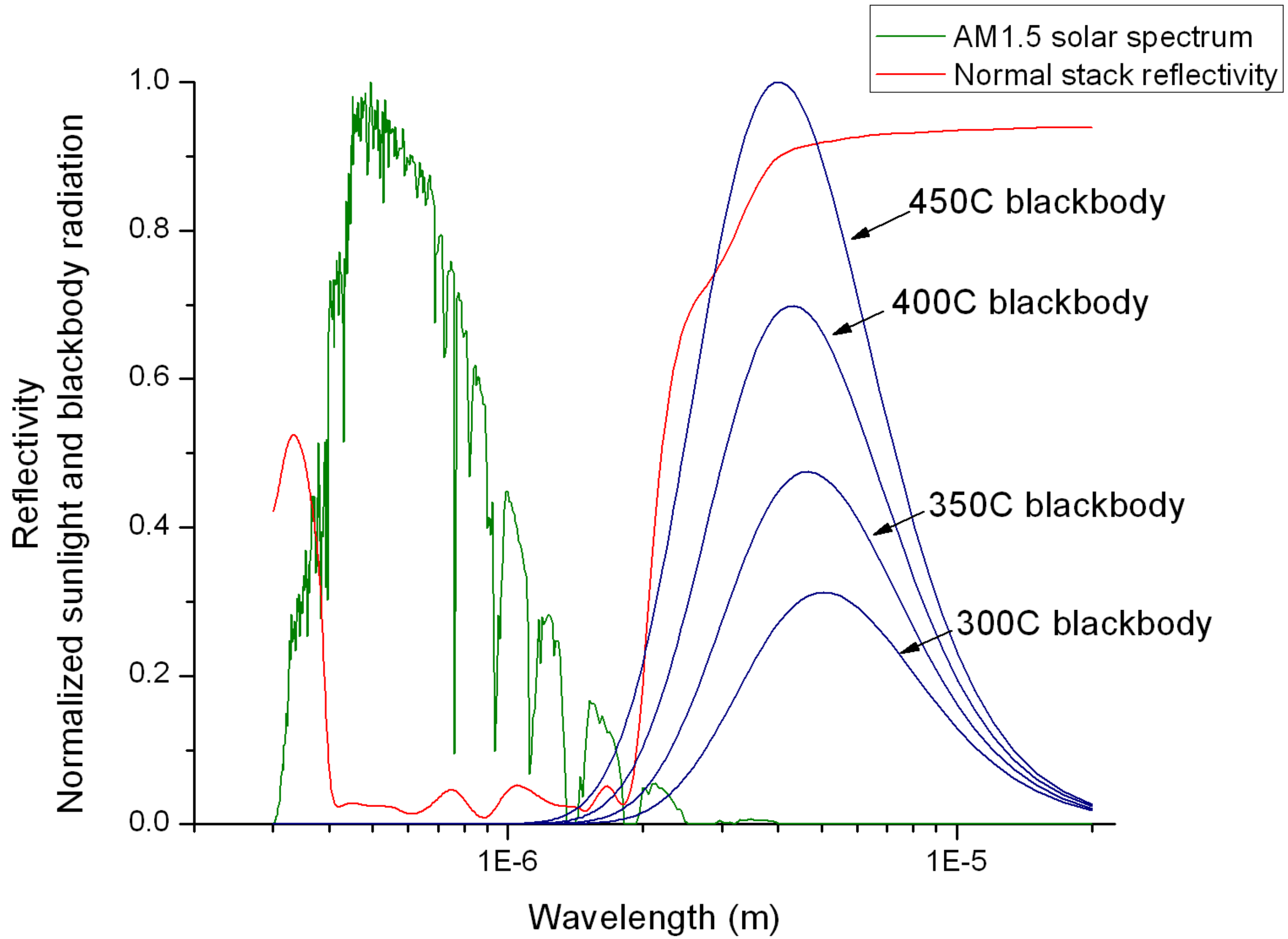
- Stacks allow for a better control over those spectra, by choosing thicknesses and materials.

Transfer Matrix + Needle Optimization

- Simulation
  - A stack's emissivity is estimated with the transfer matrix method
- Needle optimization

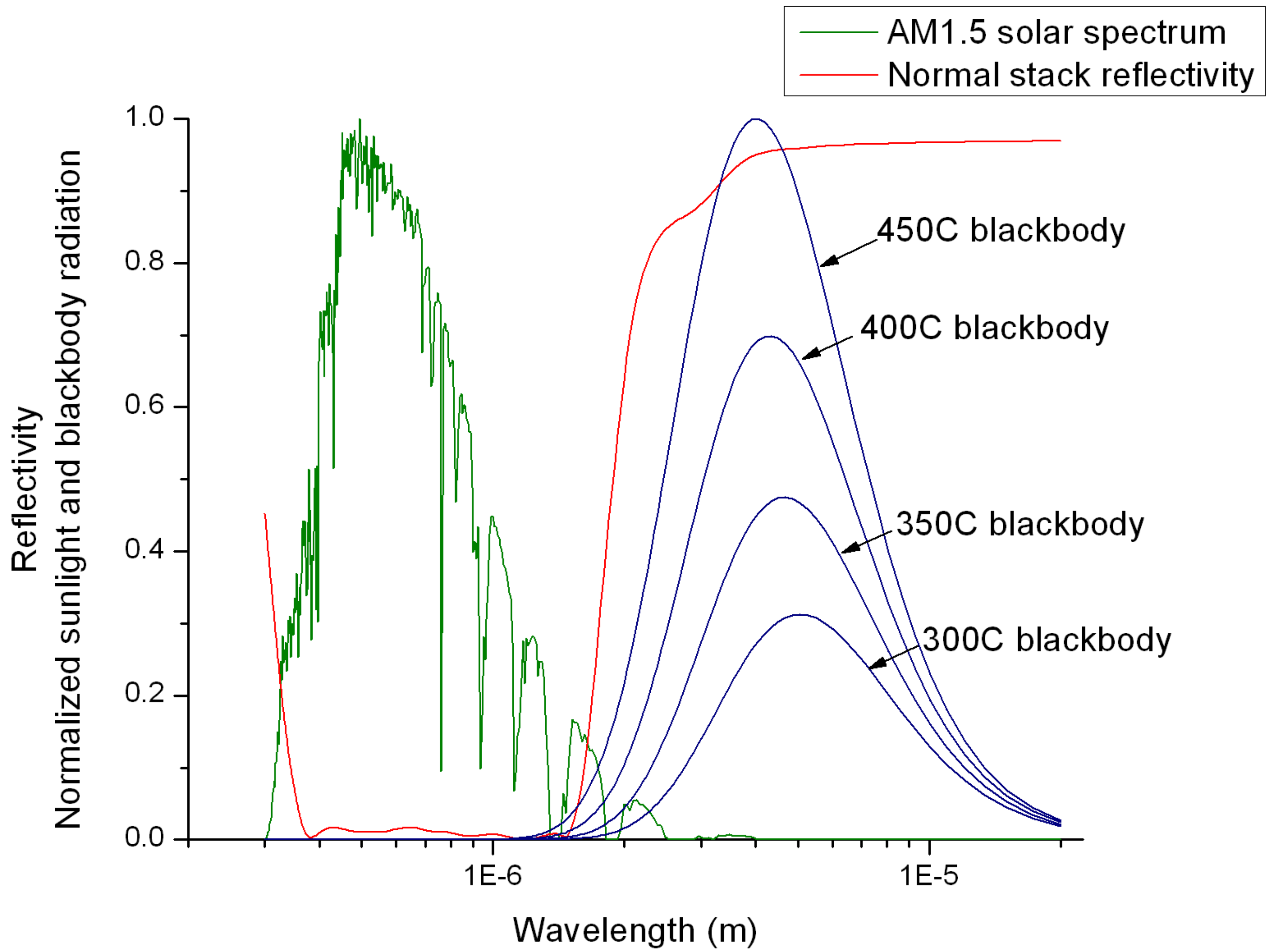


Optimized W/MgO stack



Normal reflectivity vs. wavelength. Stack has 14 layers.

Optimized $Ag/W/YF_3/TiO_2$ stack



Normal reflectivity vs. wavelength. Stack has 10 layers.

Comparison with competition

Overall	Original $Mo\text{-}Al_2O_3$ cermet	Improved Al_2O_3-based cermet	**W/MgO stack**	**Ag/W/YF_3/ TiO_2 stack**	NREL 6A
Absorptivity	0.938	0.954	**0.938**	**0.947**	0.959
Emissivity at 300C	0.118	0.107	**0.089**	**0.049**	0.048
Emissivity at 400C	0.146	0.134	**0.105**	**0.057**	0.061
Emissivity at 450C	0.162	0.149	**0.114**	**0.062**	0.070
Emissivity at 500C	0.179	0.165	**0.127**	**0.065**	0.082

Source : NREL

More beneficial at higher temperature

Challenges to tackle

- Resistance to oxidation
  - Thermal load
  - Atmospheric corrosion, humidity
  - Vacuum tube might be required
- Degradation by atomic diffusion
  - Degradation of the layer structure
  - Change in optical properties
  - Use anti-diffusion layers ?
- Durability problem

Conclusions

- 1D metal-dielectric stacks are well-suited to be CSP receivers
  - Tunable
  - Easy fabrication
  - High performance at high temperatures
- Next steps
  - More computational optimization
  - Fabrication and testing of stacks
  - Looking for cooperation to perform those tasks

- Questions ?