

Controlling Thermal Emission for Cooling Applications

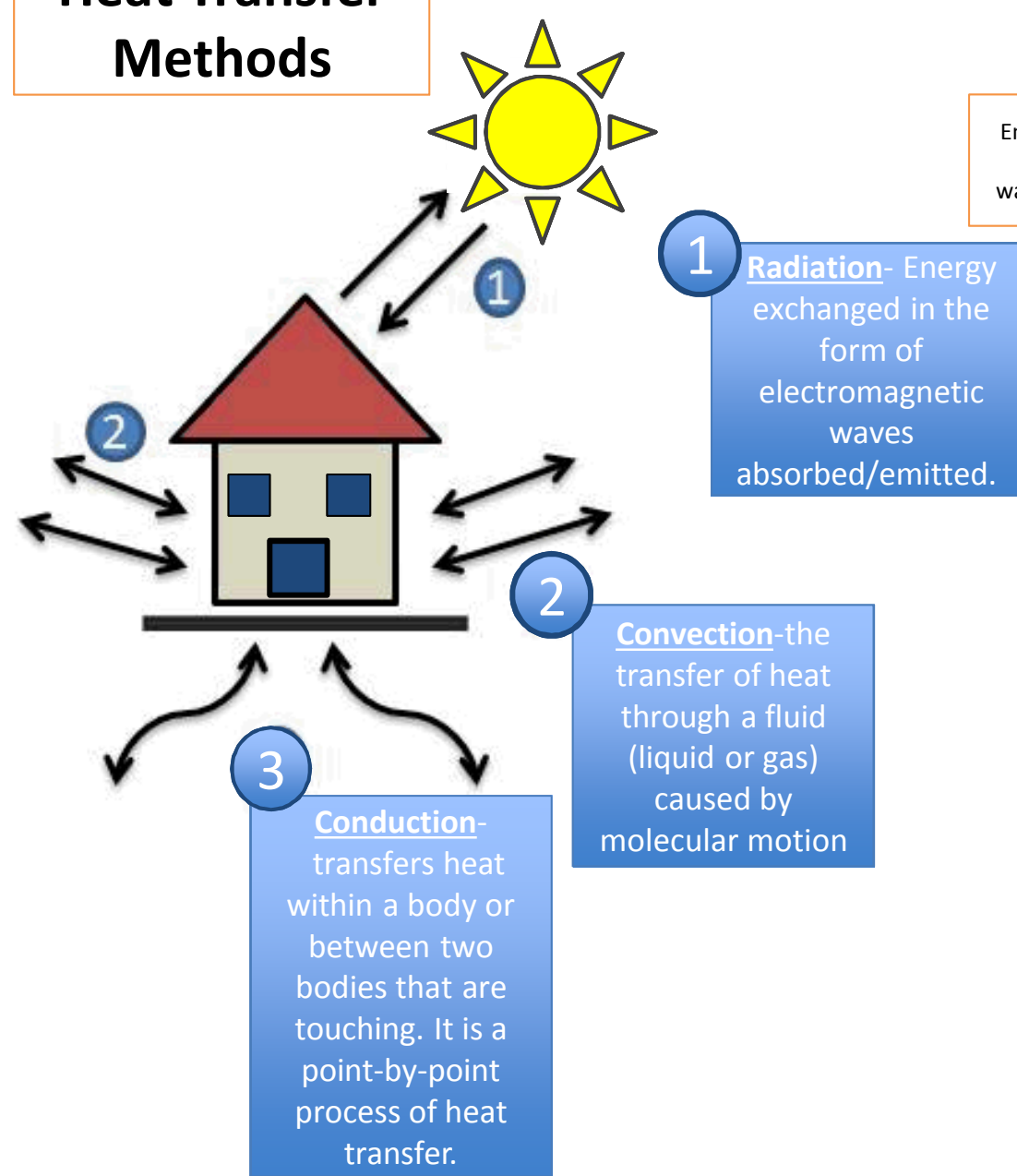
Abstract: The aim of this experiment is to see if structuring a surface can control both the directional and spectral emission from that surface. Micro-structured surfaces consisting of infrared waveguide arrays were fabricated and characterizing using an HDR. Measured reflection maps demonstrate both directional and spectral control of emission.



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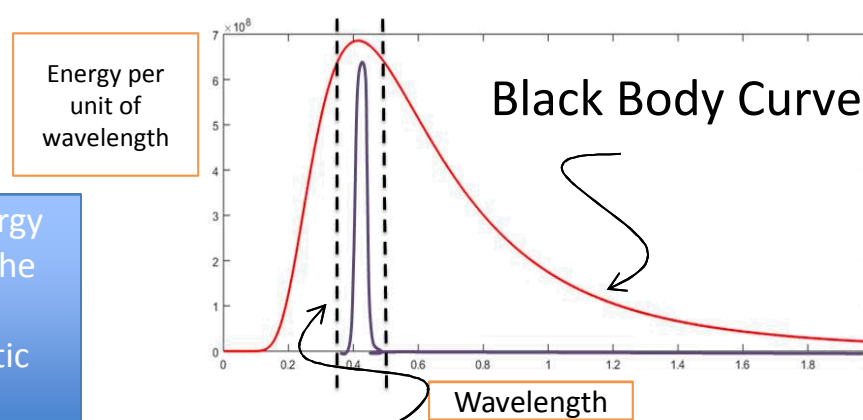
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Heat Transfer Methods



Basic Idea: By altering how a surface emits/absorbs radiated energy, we can hopefully create structures which can passively cool by radiating heat into deep space, while rejecting heat from warm bodies like the sun. Radiative transfer is important in terrestrial applications, but is critical in space-based applications

Spectral Control



$$B_{\lambda}(T) = \frac{2 h c^2}{\lambda^5} \frac{1}{e^{\frac{h c}{\lambda k T}} - 1}$$

Planck's Law is used to explain the spectral-energy distribution of radiation emitted by a blackbody and in thermal equilibrium.

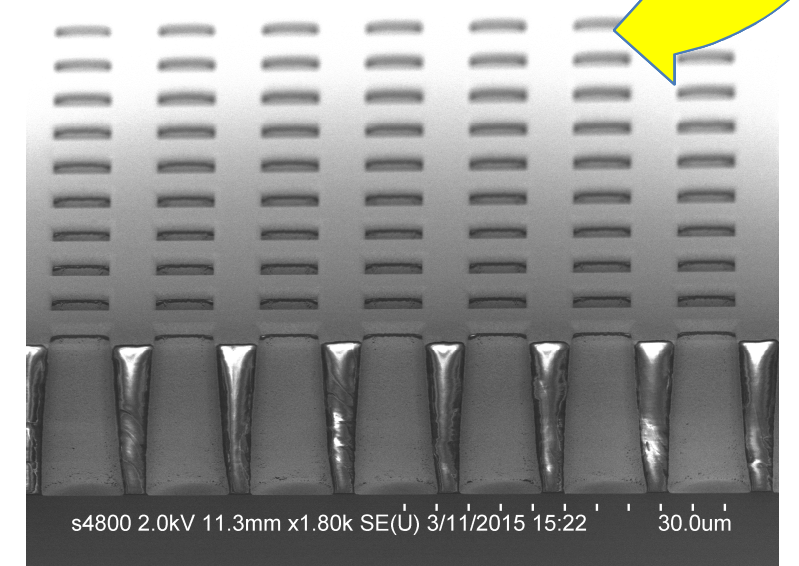
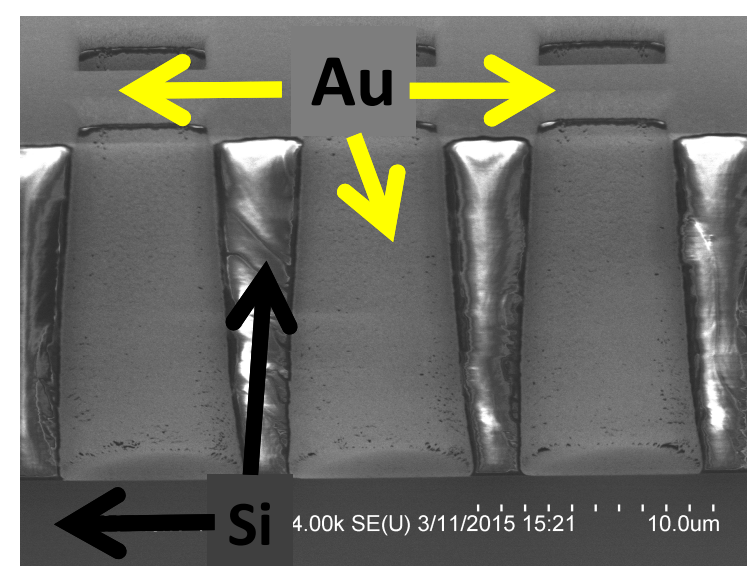
Desired narrow emission peak

Emission from a planar surface: Planar surfaces emit/absorb at all angles.

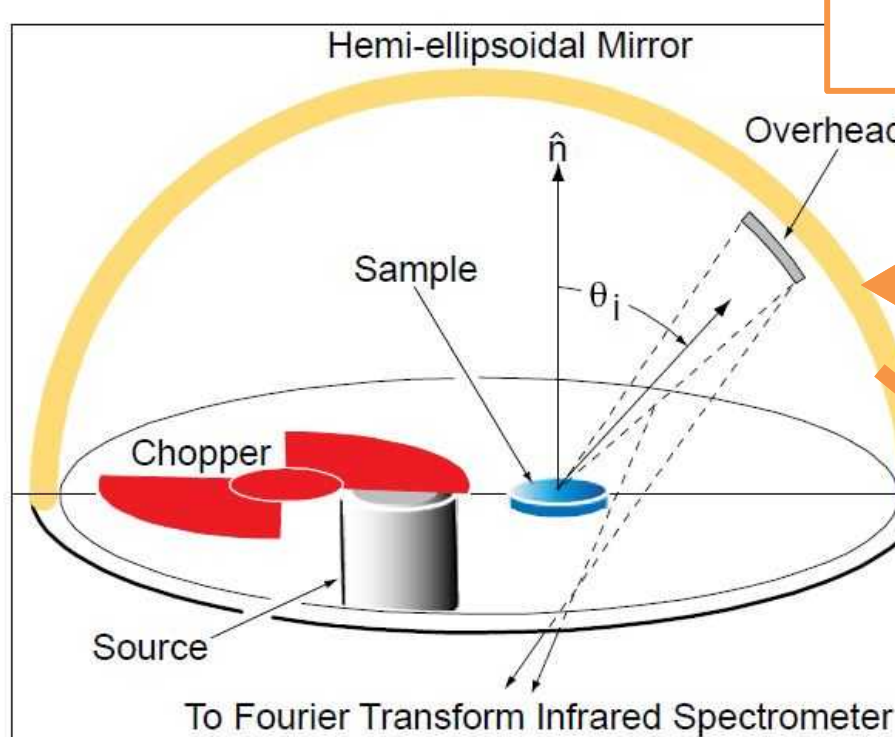
Directional Control

Emission from a structured surface: structured surfaces can restrict the allowable emission/absorption angles.

SEM Pictures of Structured Surfaces:



HDR



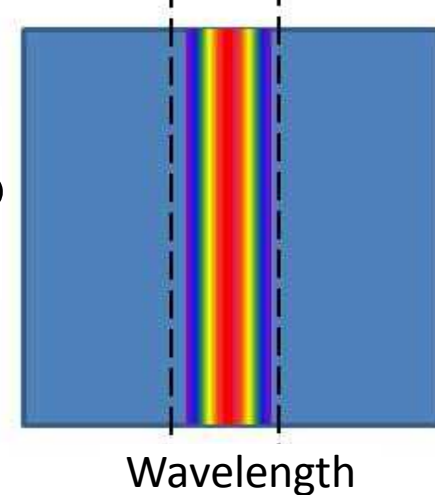
Inside

Hemispherical Directional Reflectometer (HDR) is an instrument for measuring the hemispherical directional spectral reflectance. Data is displayed in a reflection map (R-Map) plotting absorption strength as a function of angle and wavelength.

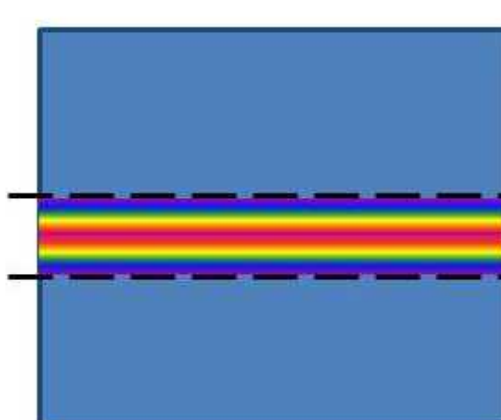
Sample R-Maps

Angle

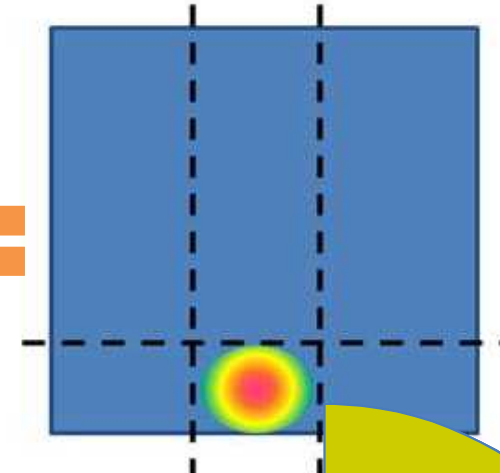
Spectral Control



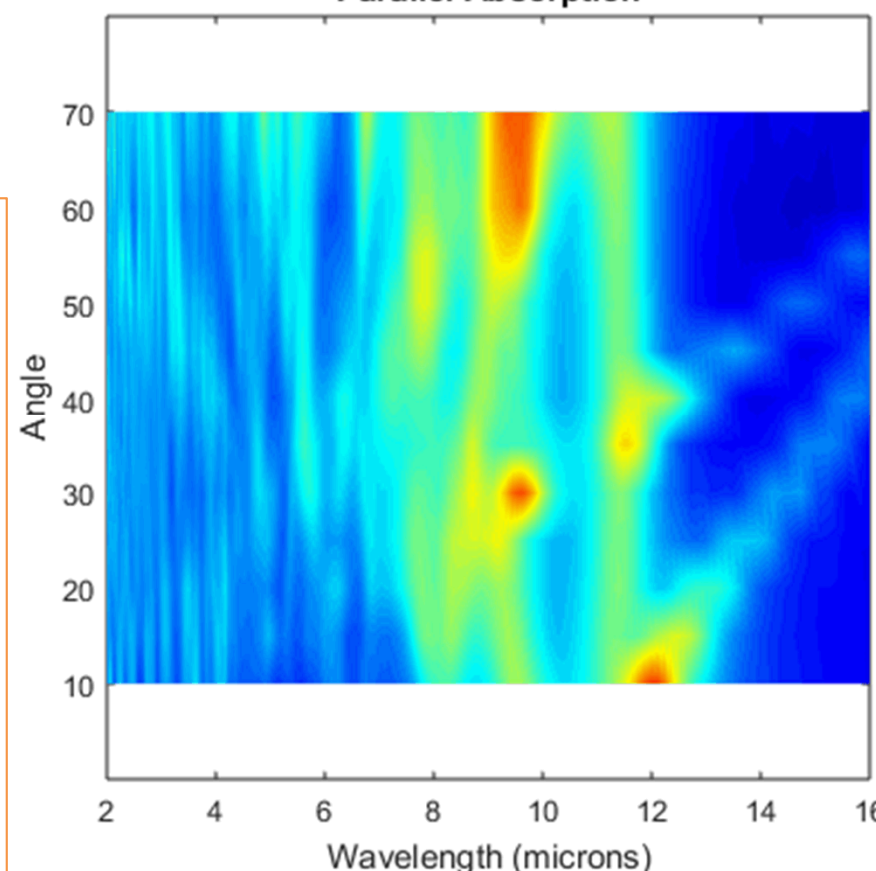
Directional Control



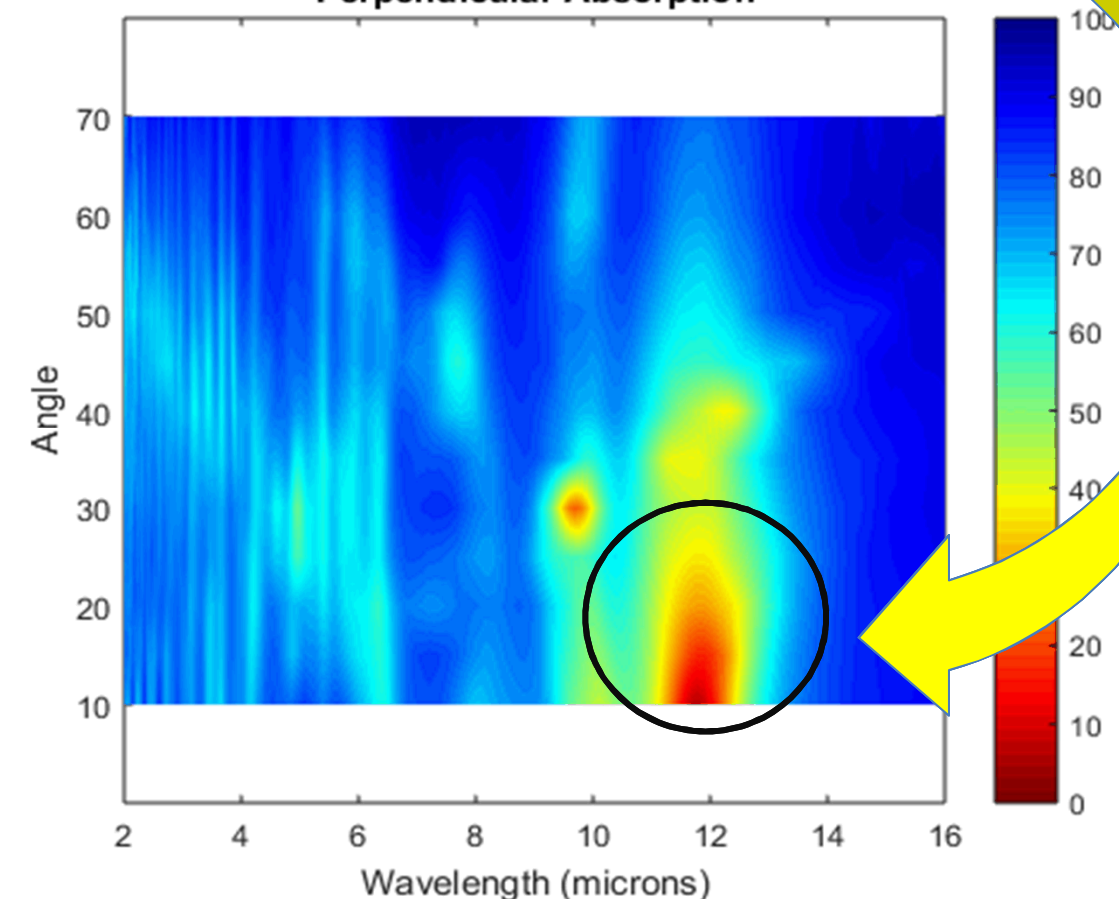
Both Spectral and Directional Control



Parallel Absorption



Perpendicular Absorption



Conclusion: We have demonstrated both spectral and directional control (normal to the surface) of thermal emission which could lead to potential cooling applications. Further work includes improving the performance of these surfaces and pursuing emission in oblique directions from the surface.