Managing Thermal Emission: Subwavelength Diffractive Optics Technology in Support of SOF

LDRD
LABORATORY DIRECTED RESEARCH & DEVELOPMENT

Sandia National Laboratories
Photonic Microsystems Technologies
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Coherent Thermal Emission Through Photonics/Plasmonics

A uniform surface has emission that is Lambertian: light is emitted in all directions

Adding texture to a surface can lead to coherent, and consequently, directed emission with wavelength selectivity

Combination of the two effects is currently unexplored

Why Do Sandia National Laboratories Care?

Applications:

- Thermal emission mitigation
- Microsystem passive heat sinking/sourcing management

New science:

- Quantify and Optimize Plasmon/Photon coupling through materials and configurations
- Capitalize on emerging technology through Sandia's world-class fabrication facility and numerical capabilities

Hypothesis

Coherent thermal emission can occur if we have at least these two conditions:

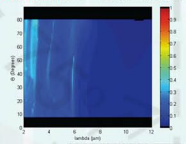
- A material can support a surface-plasmon polariton (for metals) or a surface-phonon polariton excitation (for polar materials).
- There is a mechanism (a grating) to couple the surface plasmons to photons.

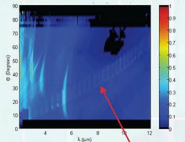
Process

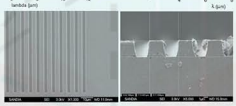
1. Thermal energy excites plasmons in the applied materials.
2. A grating in the material provides a phased-coupling mechanism between the plasmons and emitted photons
3. The grating parameters determine the angular and wavelength "shape" of emission.

Simulation and Measurement : Nickel with Grating

Simulation : 1 – Total Reflection **Measurement** =1 – Total Reflection



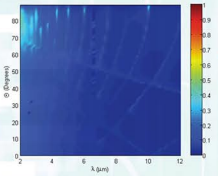


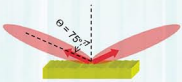


Note: blurred measurement artifact

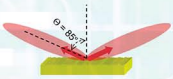
Next Component: Nearly Planar, High-Angle Emission

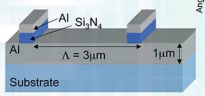
Simulation of Λ=30μm on Ni



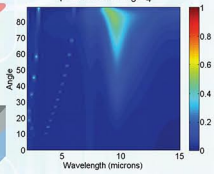


Following Component: Nearly Planar, High-Angle Emission Component





Emission Simulation of Λ=3 μm on Al/Si_3N_4



Following Component: Nearly Planar, High-Angle Emission Component

How do we implement this technology?
The underlying physics gives us a practical, realistic answer.

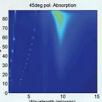
- The effect is based upon plasmons and their characteristic propagation length, which is small (~100 microns).
- The elements can be this size, like glitter.
- Dispersed in a liquid, the elements may be painted on and will conformally coat an object.

Cylinder emission without plasmon paint

Cylinder emission with plasmon paint

Summary

- We are designing, fabricating, and characterizing diffractive structures that couple plasmons to photons for emission management.
- We expect that if a high absorption location is near a plasmon mode and the mode propagates efficiently, the coherent emission will be significant in that wavelength regime.
- We plan to implement this technology as a conformal paint.



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