SAND2008-4545C

Simulation, Fabrication, and Measurement of Infrared Frequency Selective Surfaces

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July 16, 2008

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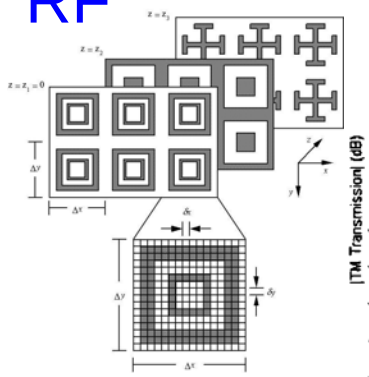
Introduction

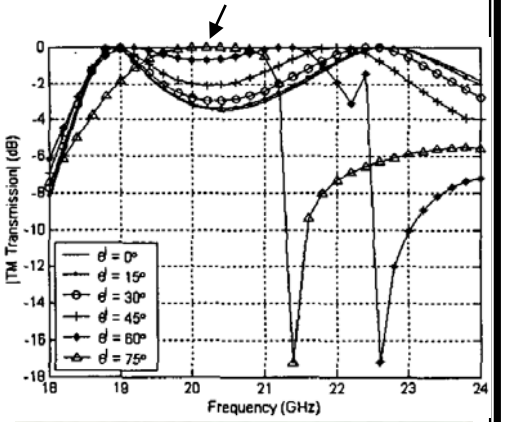
Used in radomes and other RF applications, the surface allows near 100% transmission over a broad angular and spectral range.

We will show the fabrication of a frequency selective surface (FSS) that allows high optical transmissions over relatively broad frequencies or angular bands.

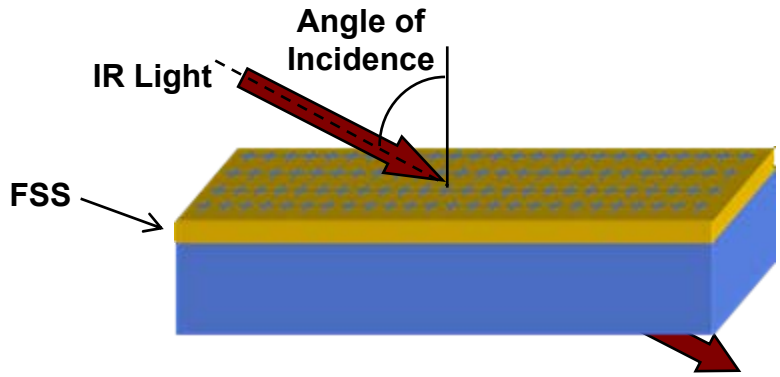
Allows a conductive surface with high transmission.

RF





IR



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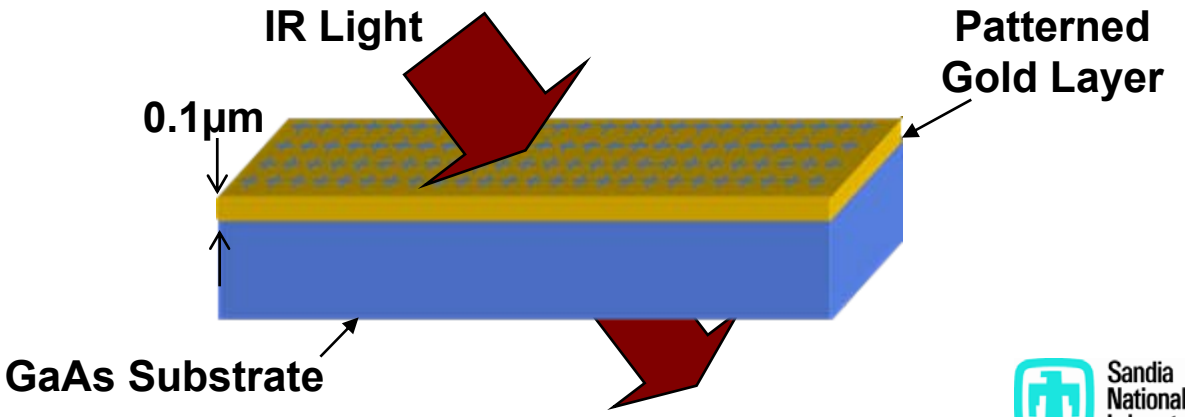
Introduction

- We are investigating single metal layer and metal layer + dielectric cover layer structures that show significant transmission over a large angular range.

- Unlike most free-standing RF structures we are looking at creating FSS's on windows, so must consider the substrate in the design.



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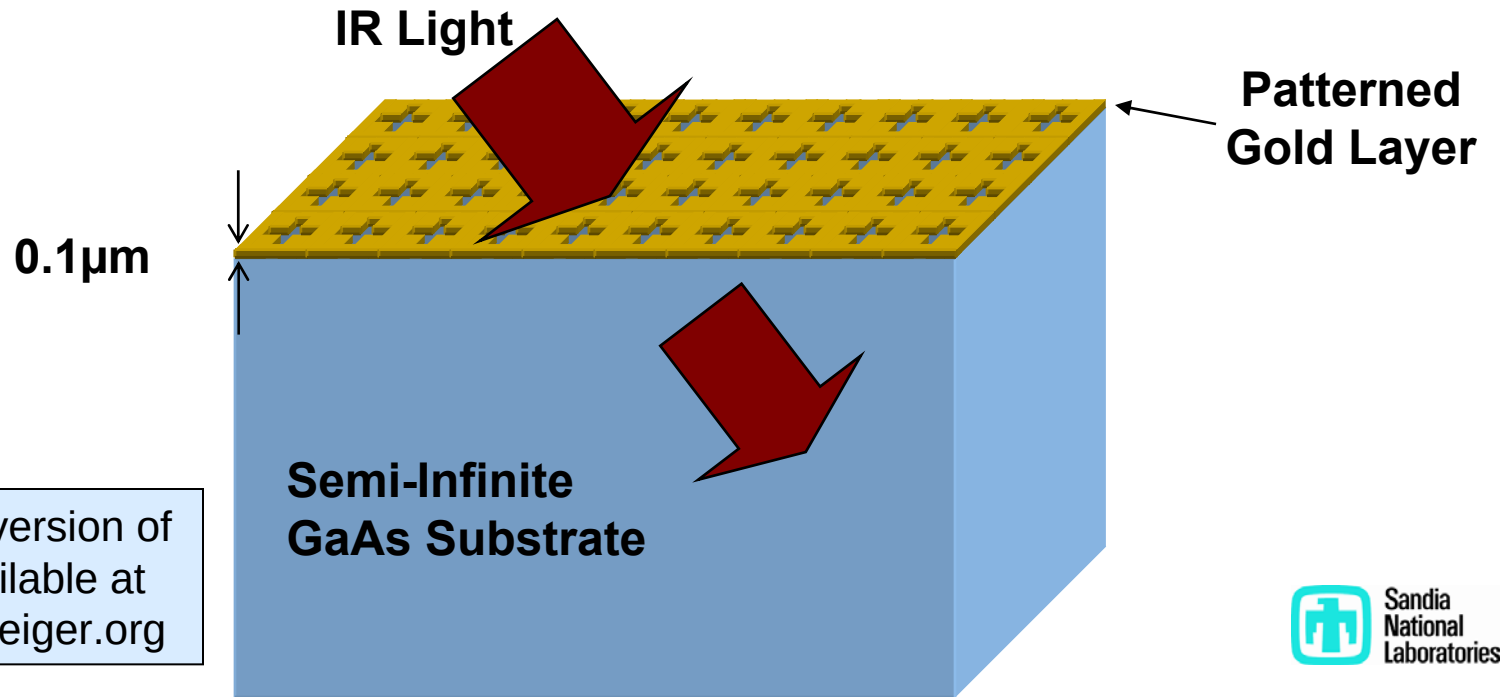
Modeling & Design with EIGER™

- Design and modeling were performed using Electromagnetic Interactions GenERalized (EIGER™), the frequency-domain integral equation code maintained by Sandia and the University of Houston.
- The EIGER™ model incorporates finite conductivity and dispersion of bulk gold.



An open-source version of EIGER™ is available at http://www.code-eiger.org

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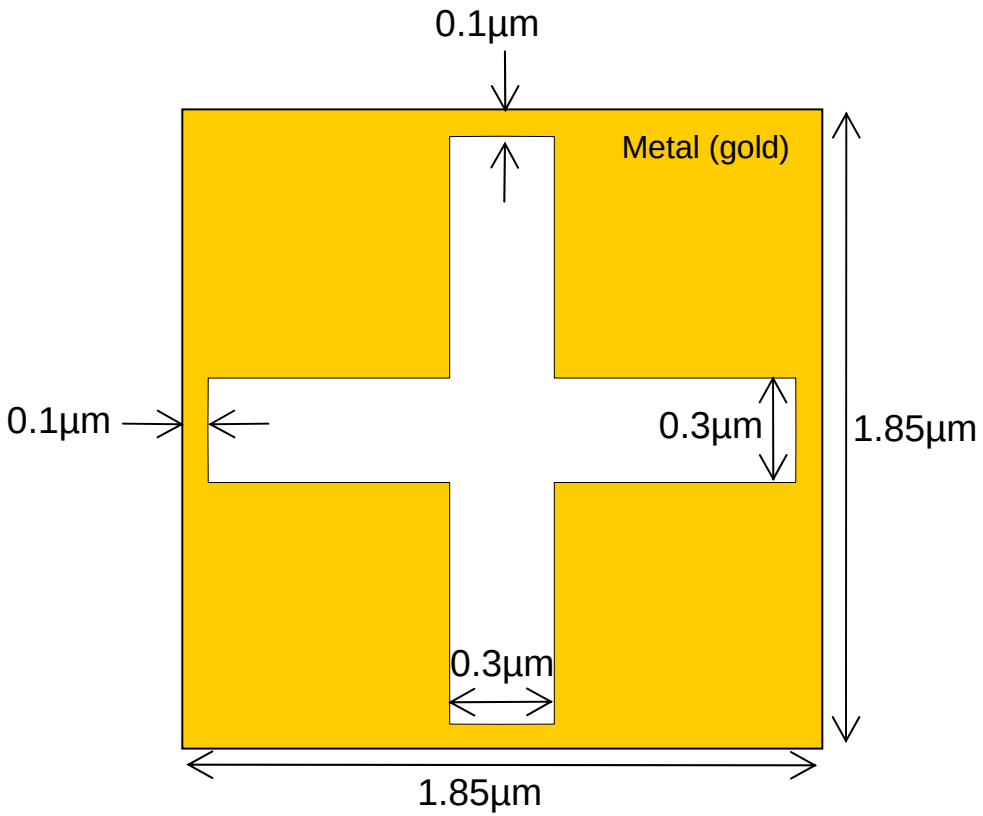
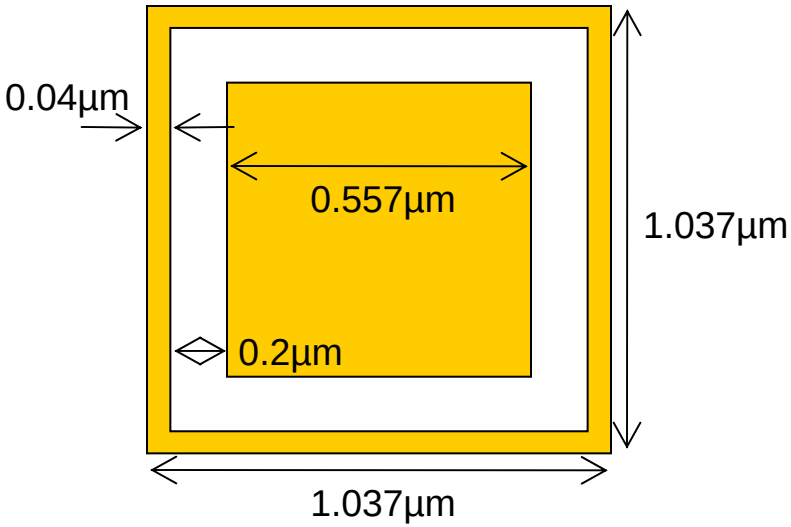
Modeling & Design: EIGER™ Unit Cells

Design 1



Design 2



Periodic boundary conditions used in the lateral dimensions.

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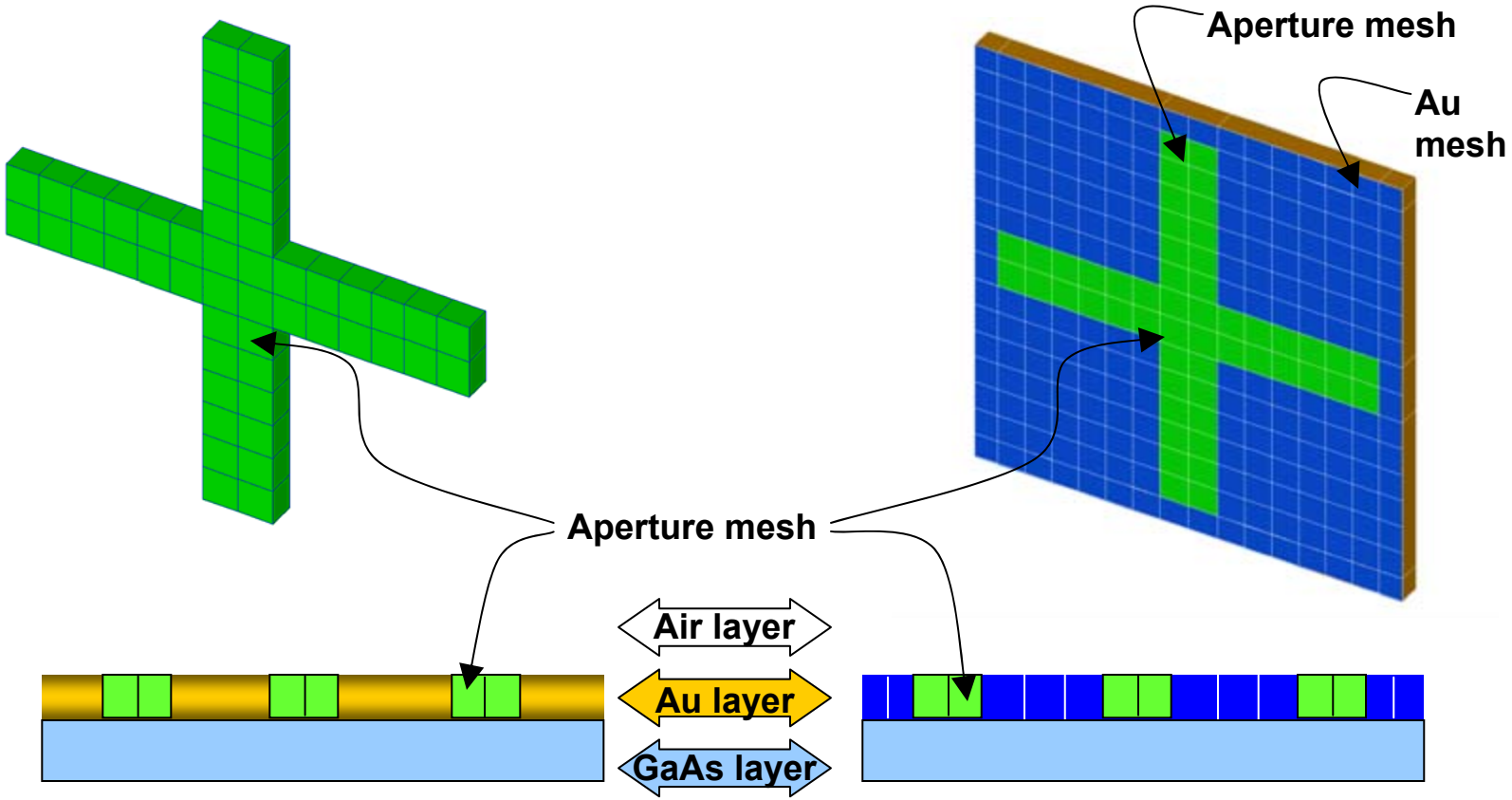
Modeling & Design: EIGER™ meshing options

Aperture Mesh

(used with a layered-media Green's Function)

Explicit Unit-Cell Mesh

(used with a homogeneous Green's function)



Fewer mesh points in this configuration leads to faster execution times.

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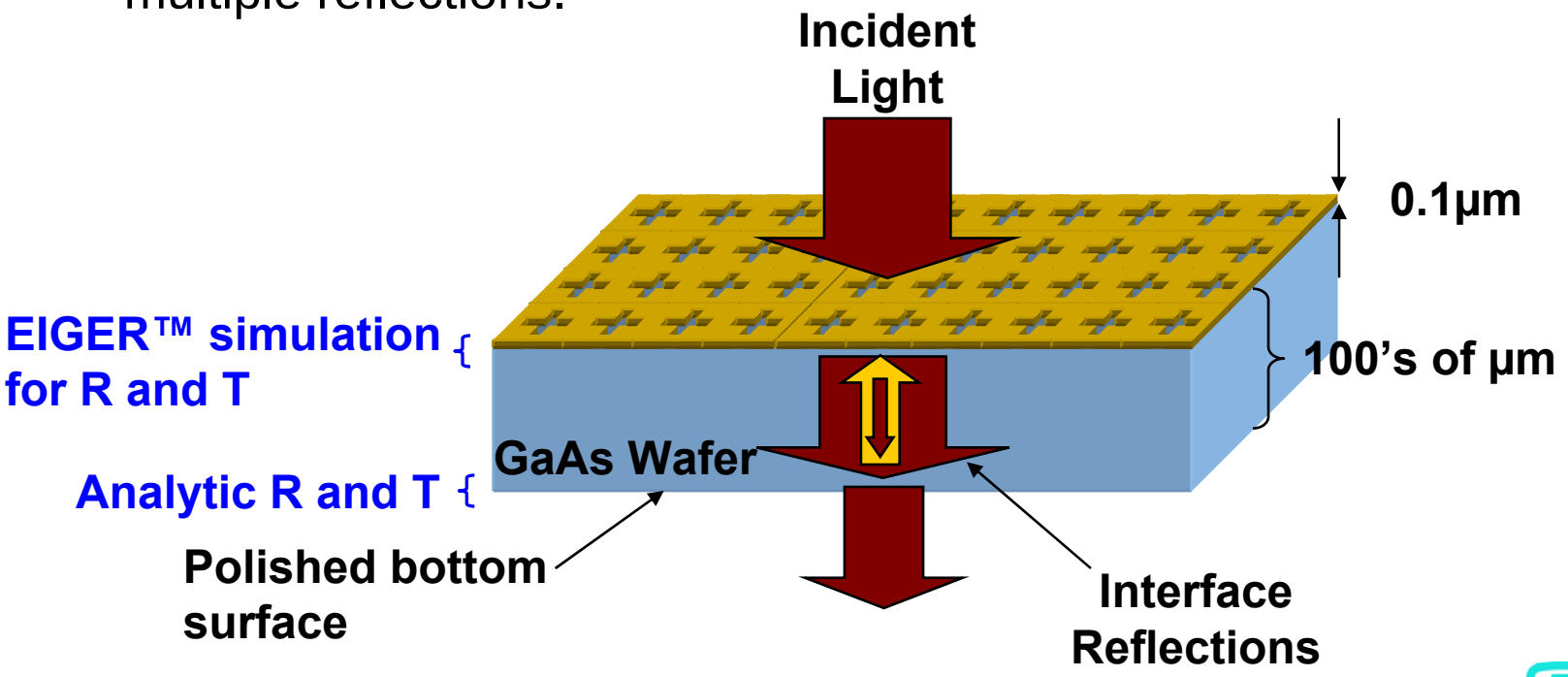
Modeling & Design:
Accounting for back surface reflections

- The actual fabricated part has a back surface that leads to more reflections.
- Reflections from the polished back surface of the wafer are easily calculated using Fresnel's equations and accounting for multiple reflections.



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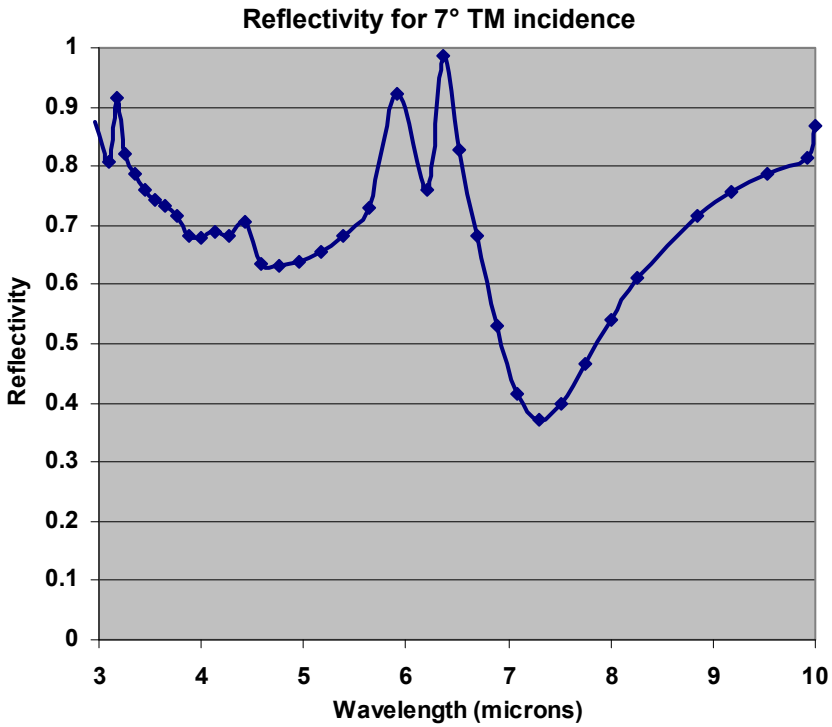
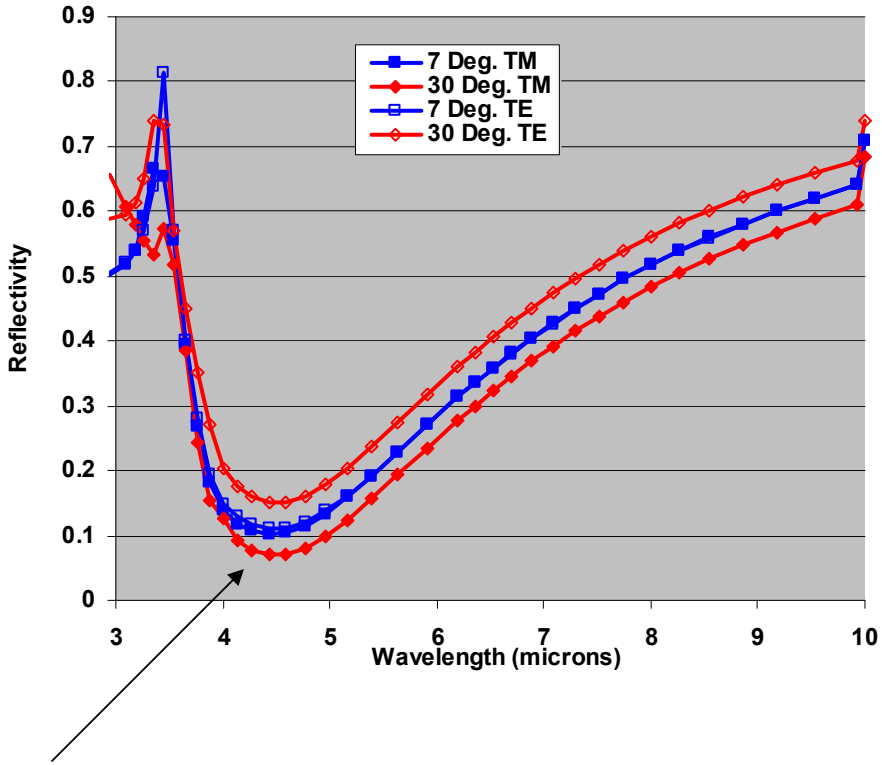
Calculated Reflectivities

Simulation of Design 1



Simulation of Design 2



Square-loop device has significantly better performance.

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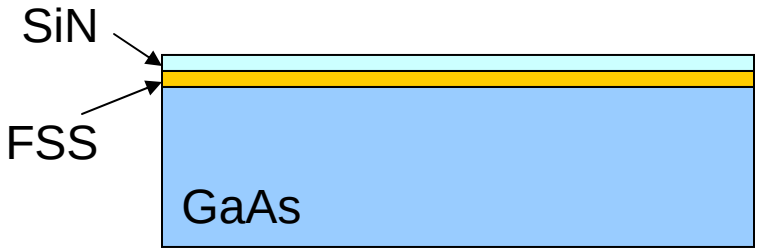
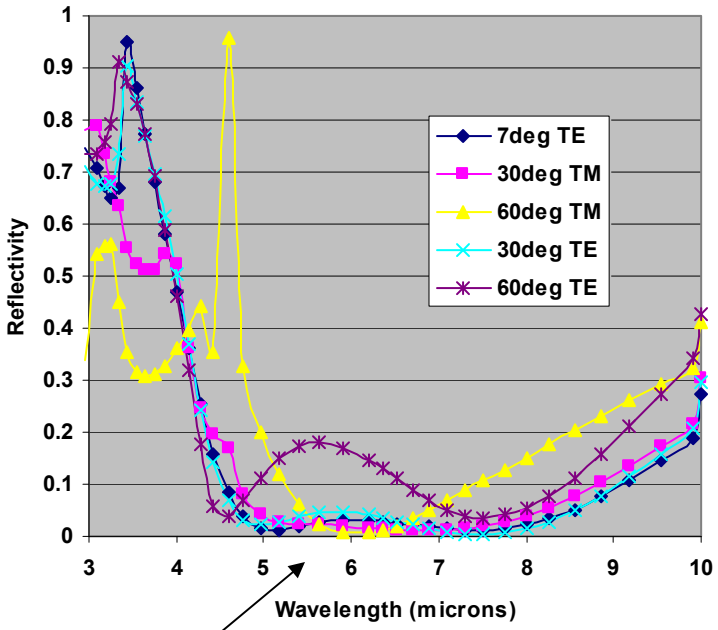
Reflectivity of Square-Loop Design with Added Matching Layer

Simulation of Design 2
with cover layer of 0.9μm
of SiN





Very low reflectivity for both polarizations over a broad angular range.

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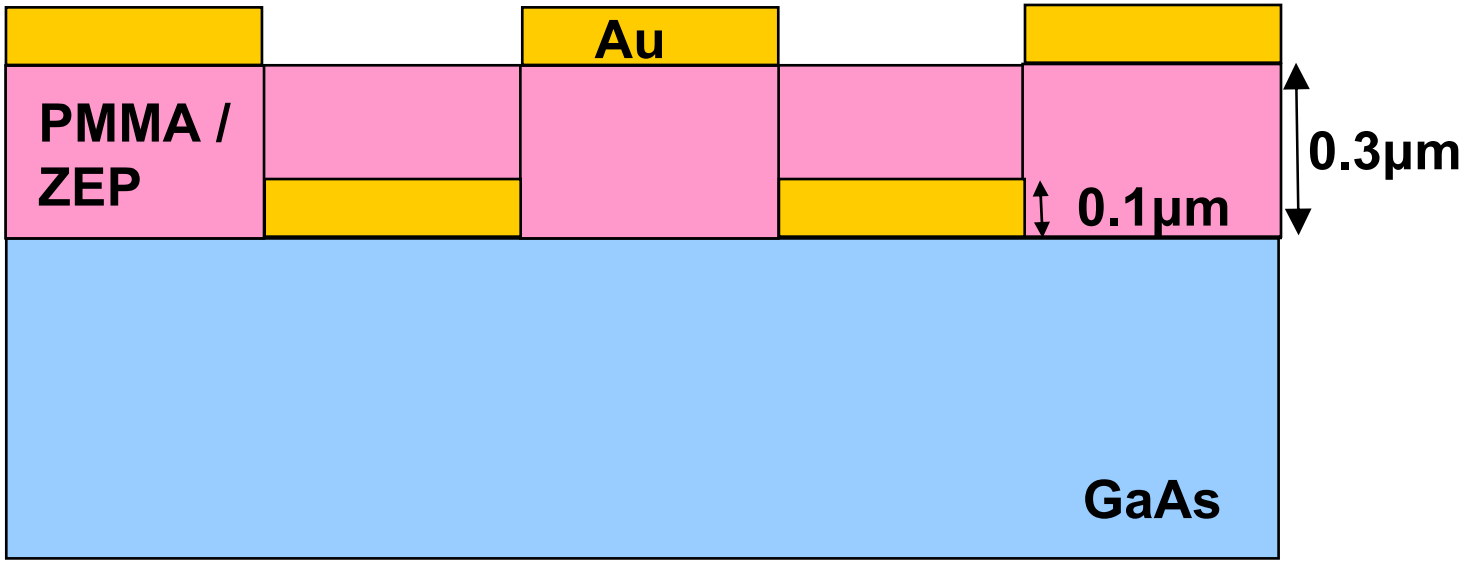
Fabrication Steps

- Spin PMMA (Design 1) or ZEP520A (Design 2) on top of GaAs.
- E-beam write the pattern.
- Evaporate 0.1µm of gold on top a GaAs substrate with/without a Ti adhesive layer.
- Perform liftoff to obtain the desired pattern.



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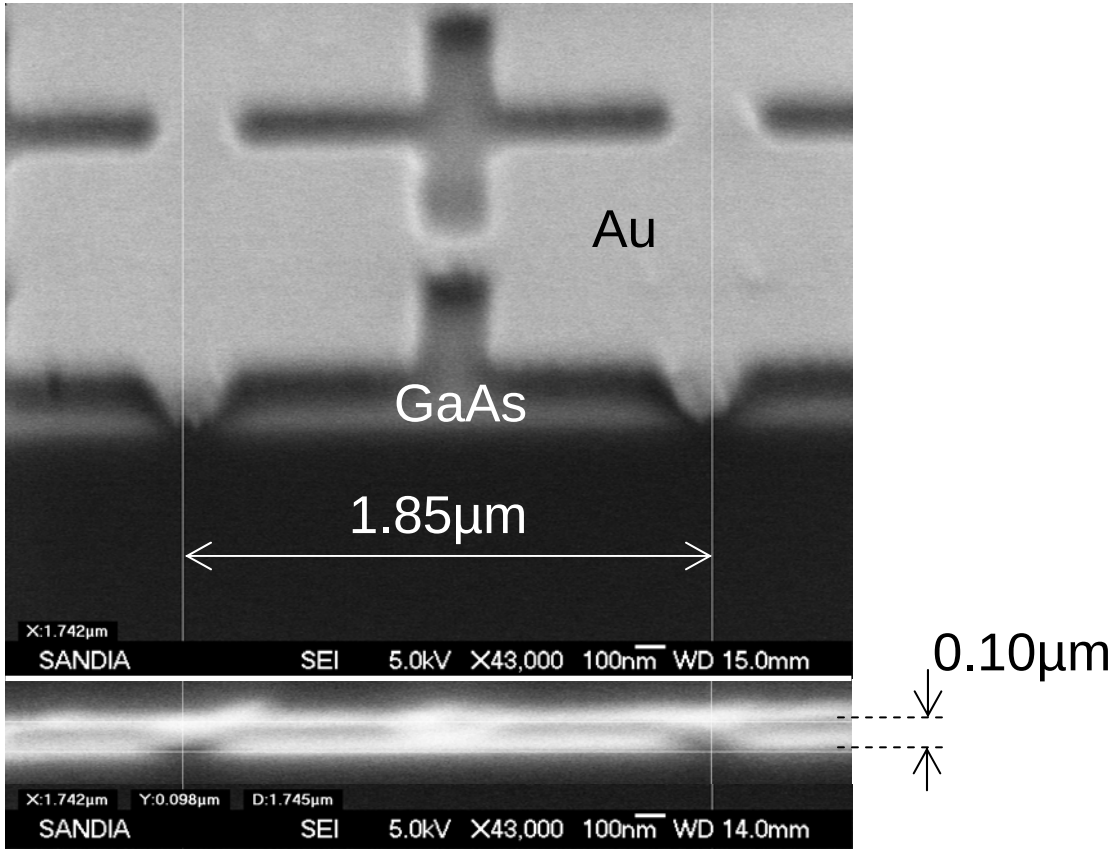
Fabrication

Isometric View

Side View



The metal layer is optically thick across the waveband of interest.

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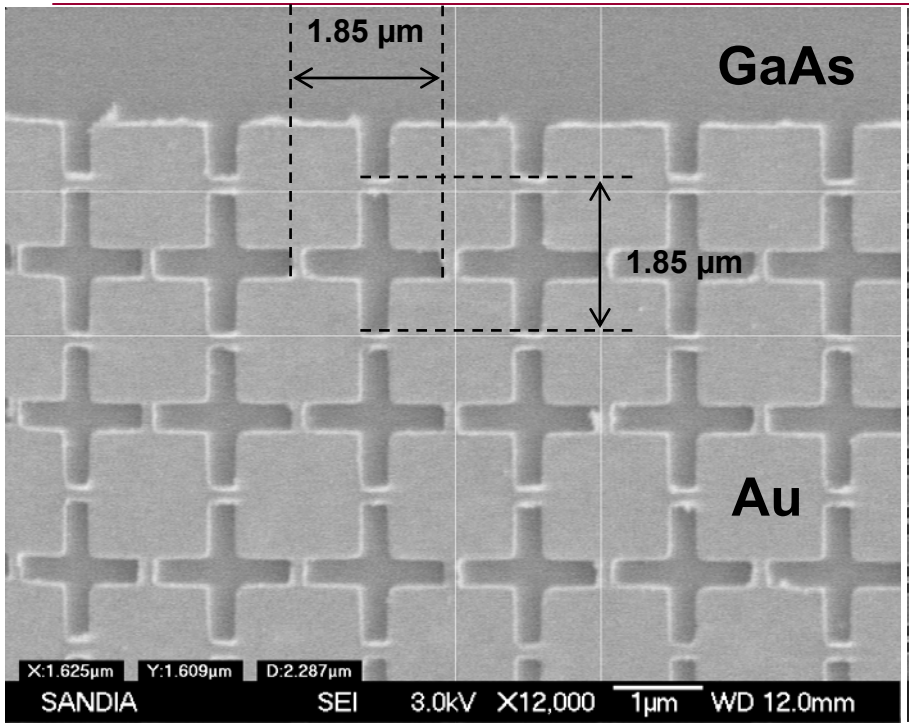
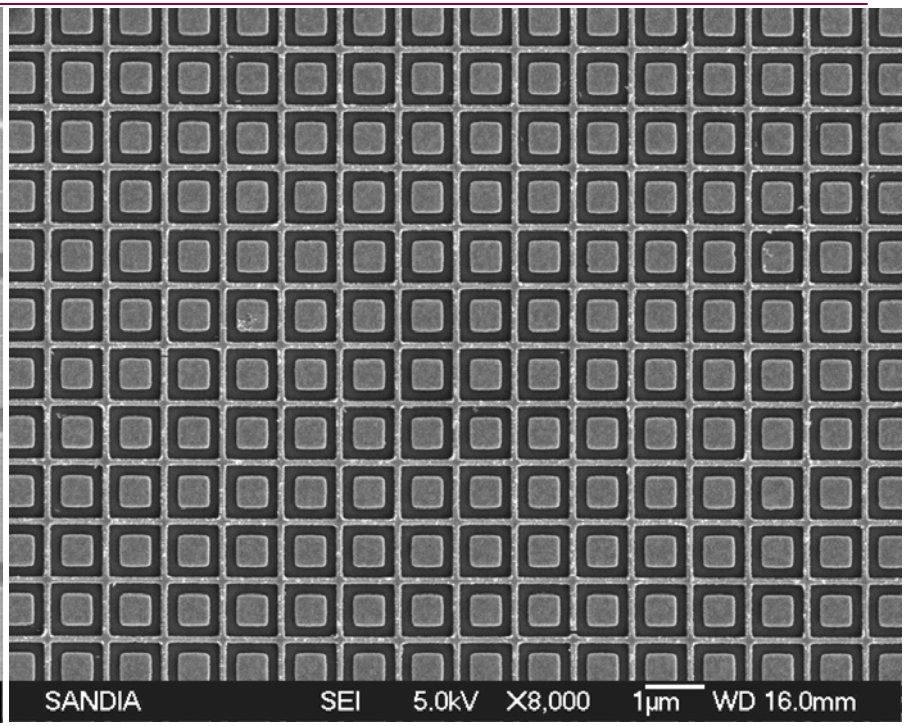
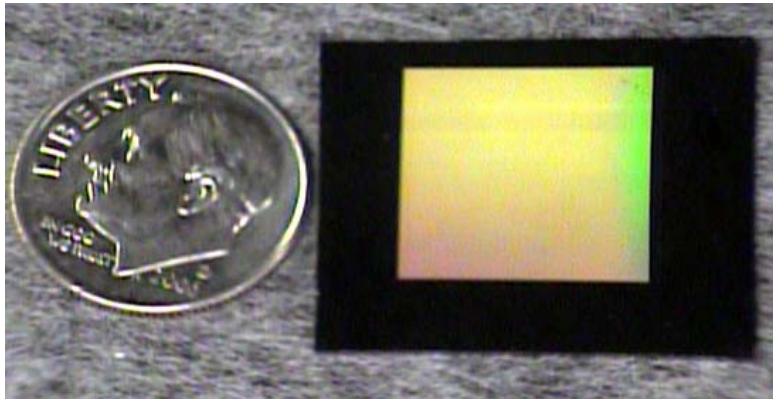
Fabricated Designs





Overall device size is dictated by the requirements for measuring far off-axis R and T.



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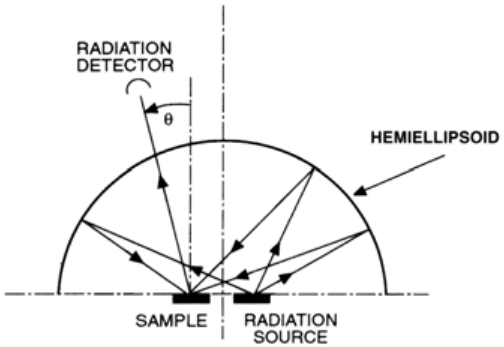
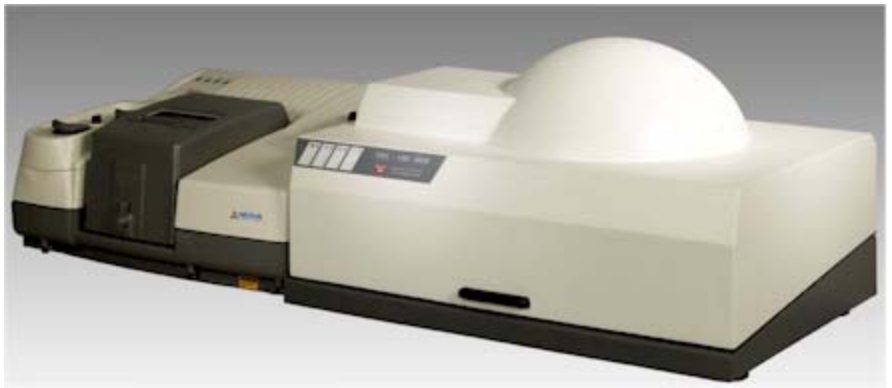
Measurement System

- Fabrication: E-beam, using both positive and negative resists and variable doses depending on the pattern.
- Test and measurement: We use a hemispherical directional reflectometer (SOC-100) that can give us broadband and broad angle reflection and transmission measurements.





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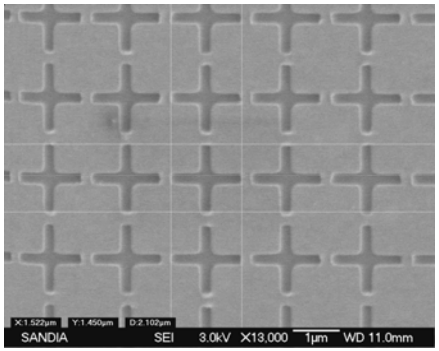
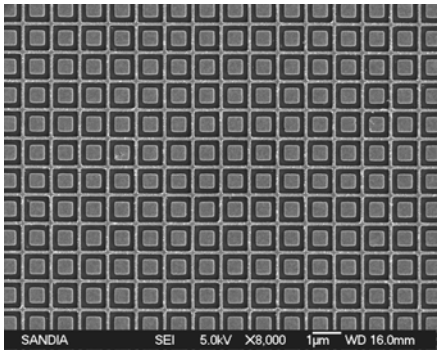
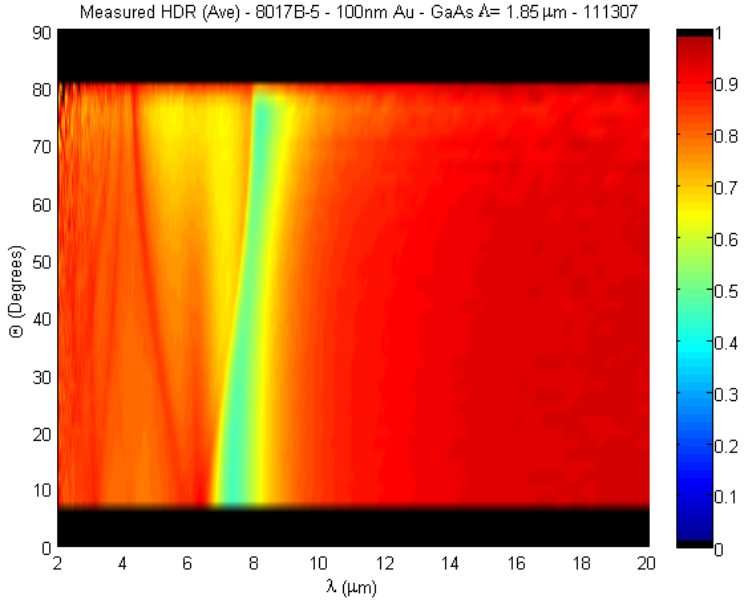
Comparison of the Results from the Two Designs

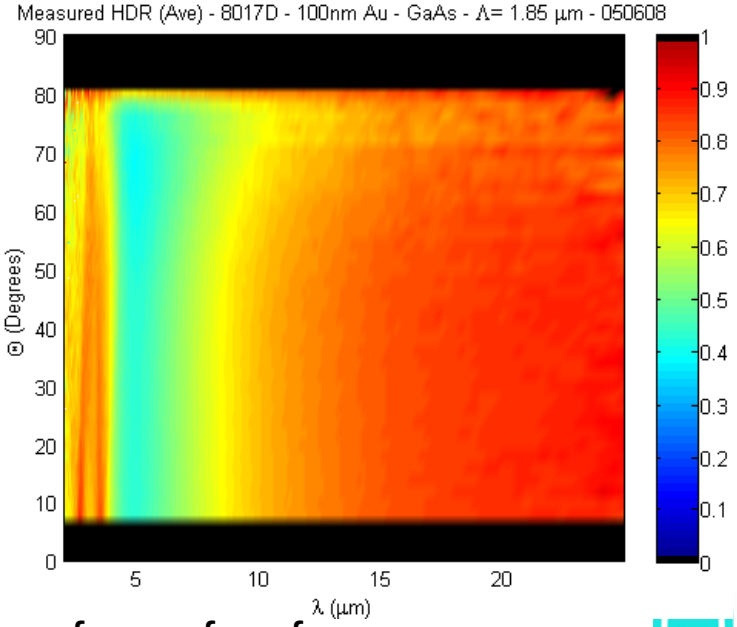
Design 1



Design 2







Measurements include reflections from back surface of wafer.

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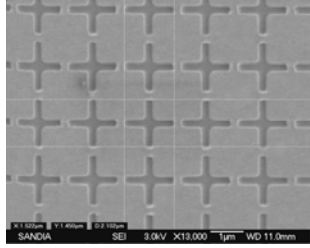
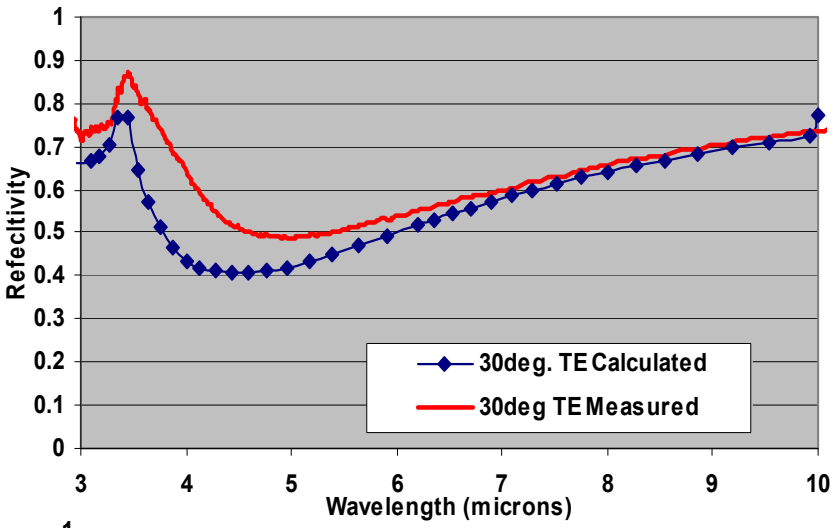
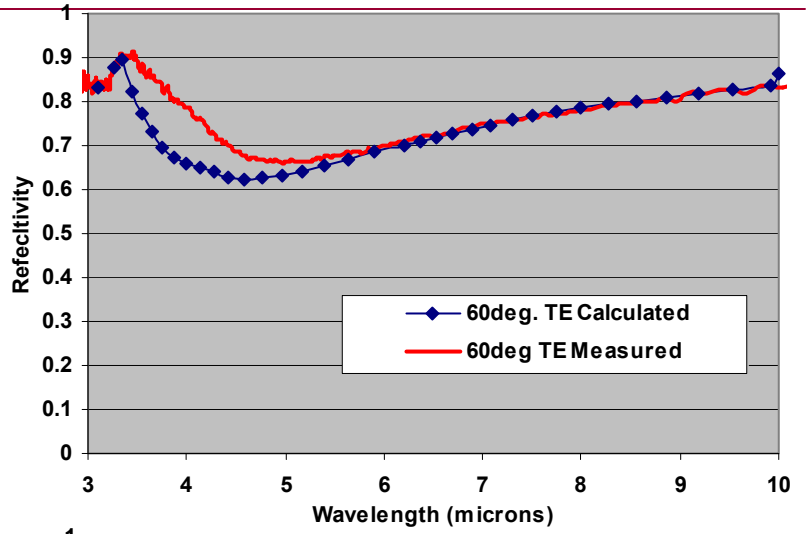
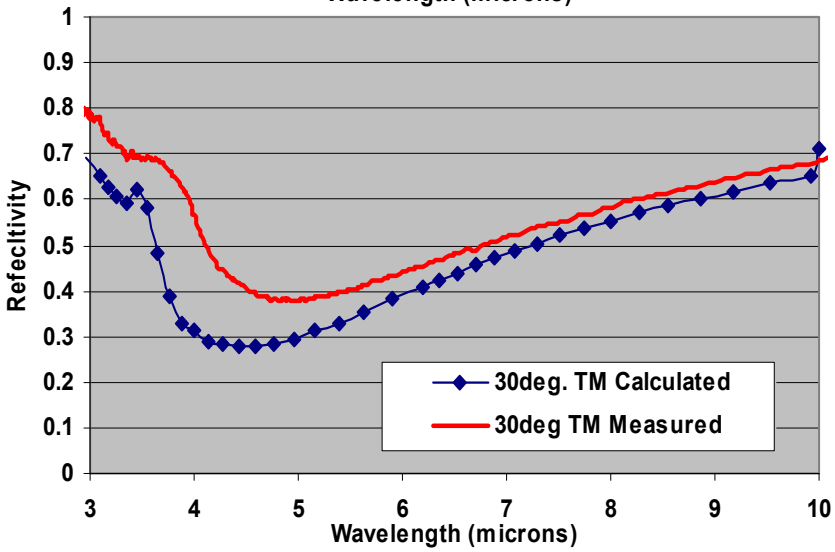
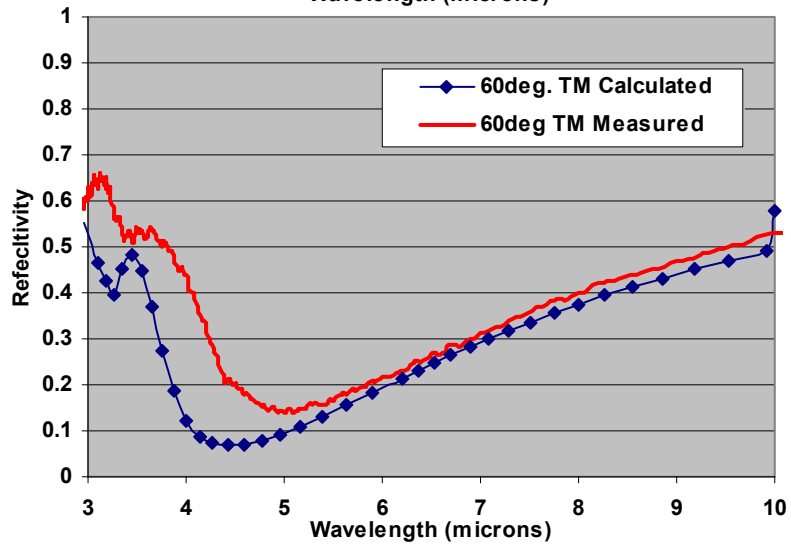
Good Agreement between Reflection Measurement and Simulation











Design 2 without cover layer and accounting for back surface.

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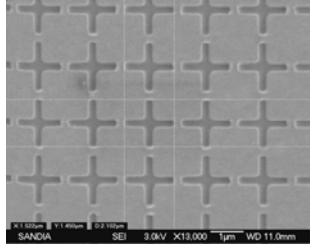
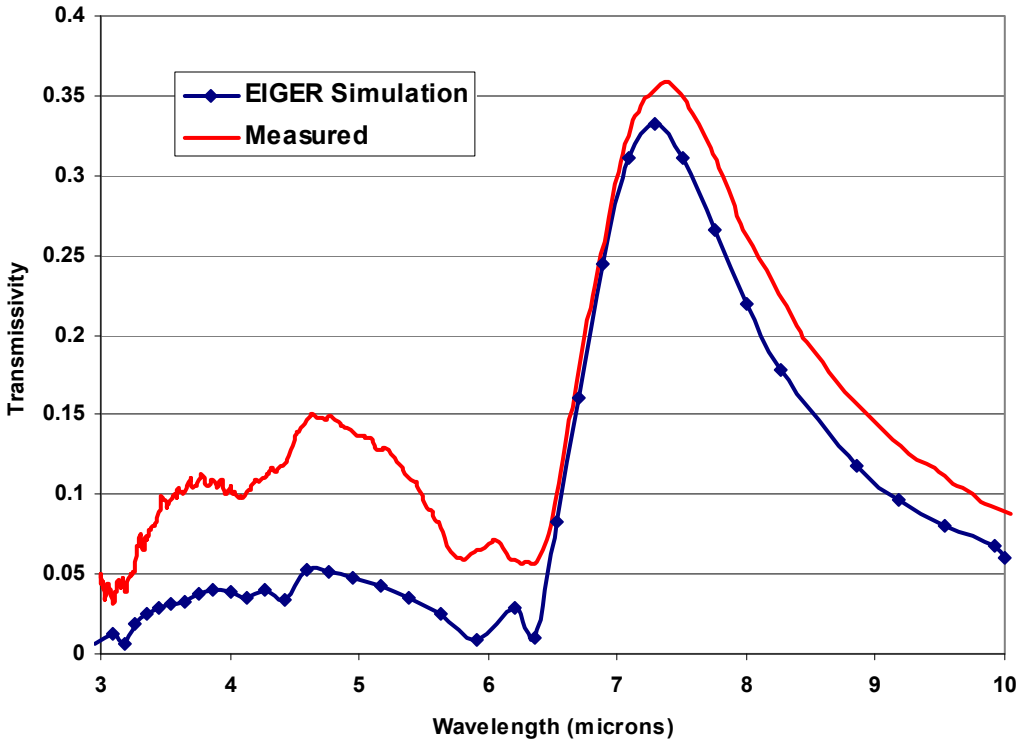
Transmission Measurement Comparison to Model





We are continuing to investigate the reason for the differences at the higher frequencies.

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Summary

- Modeled and designed FSSs using EIGER™ including finite conductivity and dispersion of the metal.
- Fabricated and tested two designs.
- Demonstrated broad angular range transmission through a largely metallic surface in the MWIR.

Acknowledgements

William A. Johnson	Code Developer
Lorena I. Basilio	Simulations
Alvaro A. Cruz-Cabrera	Measurements
Joel R. Wendt	E-Beam Lithography
Shanalyn A. Kemme	Fabrication Coordinator
Sally Samora	Device Fabrication

Supported by the Laboratory Directed Research and Development program at Sandia National Laboratories, a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy, under contract DE-AC04-94AL85000

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