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NORTHROP GRUMMAN

SLI-T Integrated Photonic Spectrometer

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Approved for public release; NG 17-1224 dated 6/8/17.

Photonic Spectrometer Overview

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- Approach and component demonstrations
- ESTO study – EVEREST simulations
- ESTO SLI-T status

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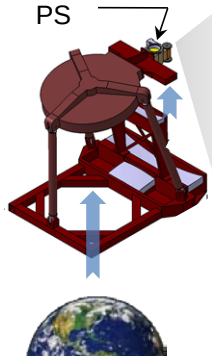
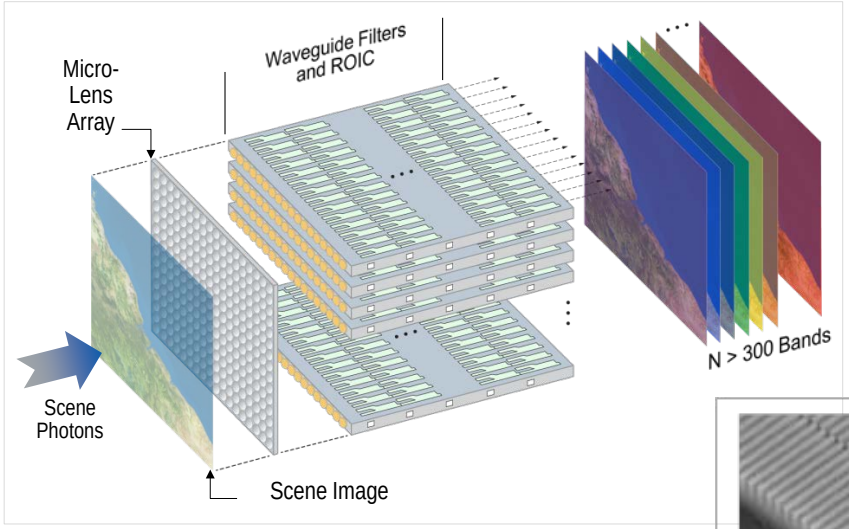
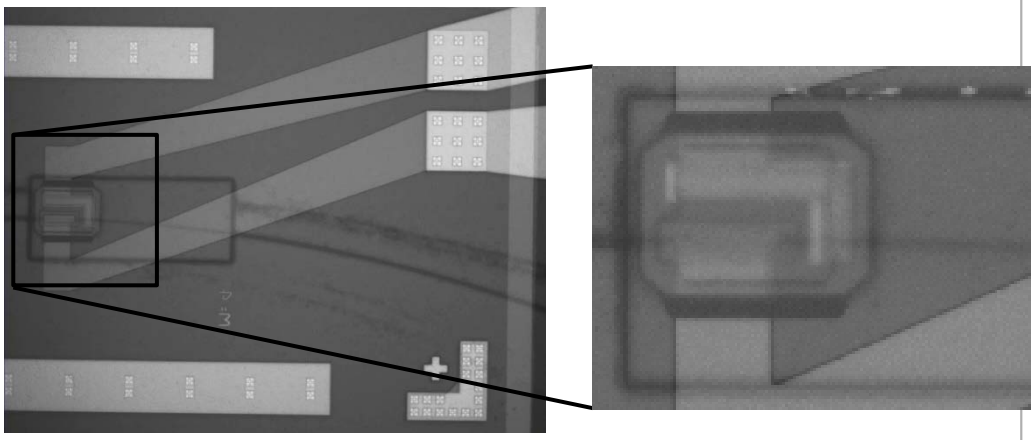
Photonic Spectrometer Approach

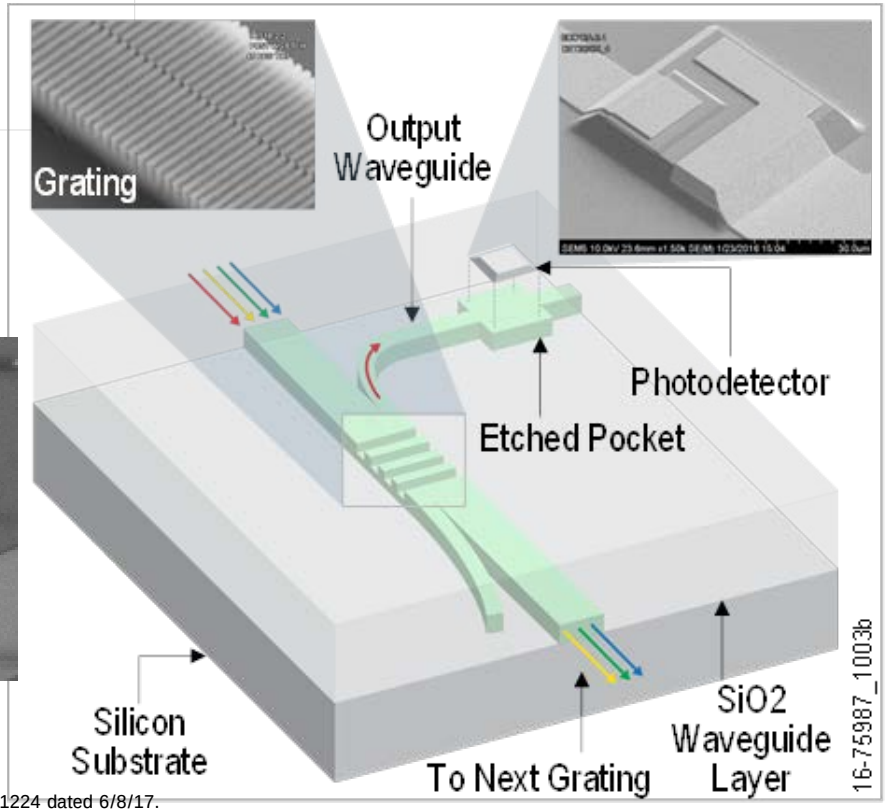




- Micro-fabricated photonic filters and DAHI integrated photodetectors replace free-space optics
- Enables new image acquisition modes (staring, TDI)



DAHI Integration



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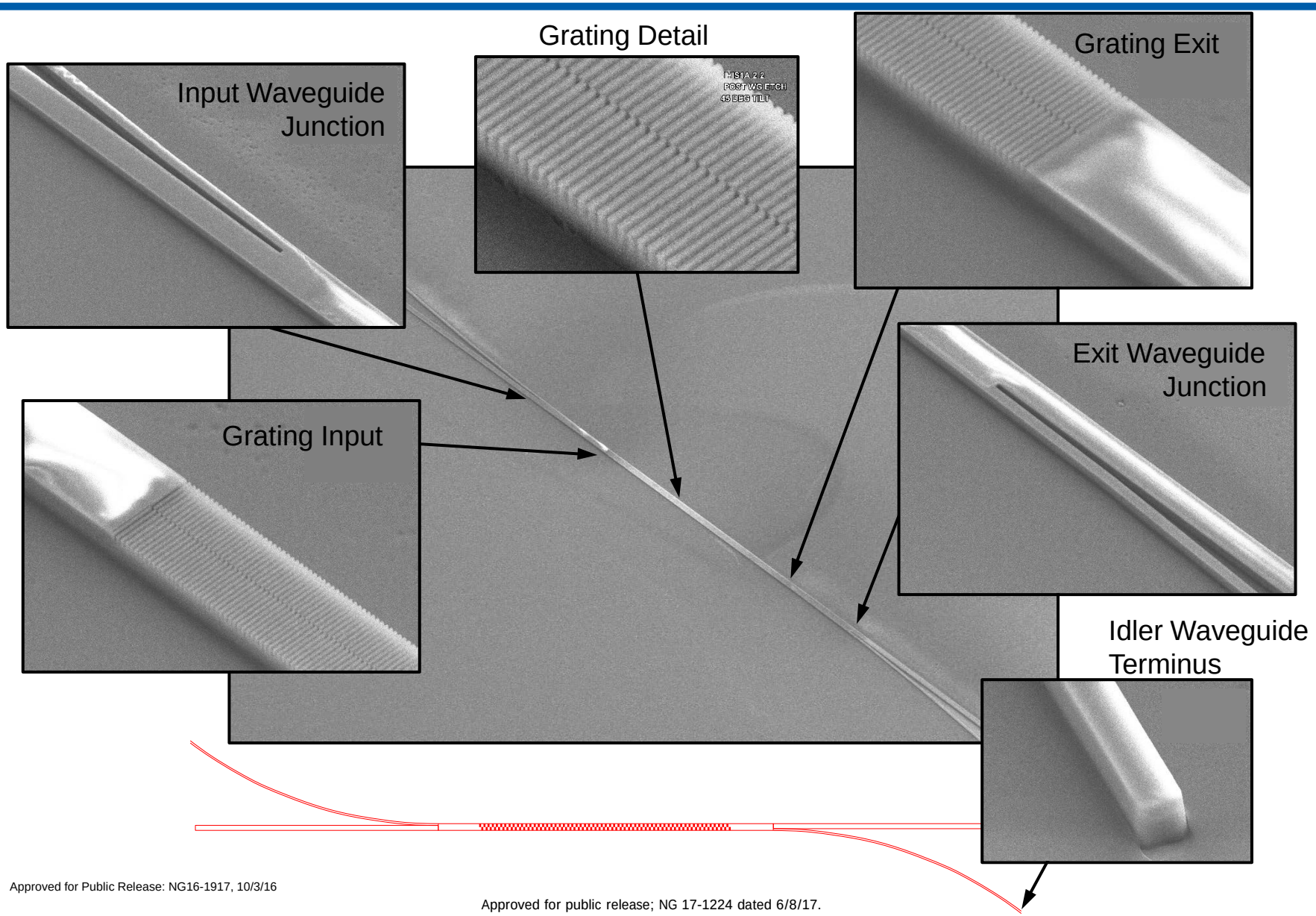
NGAS Program for Waveguide Filter Development



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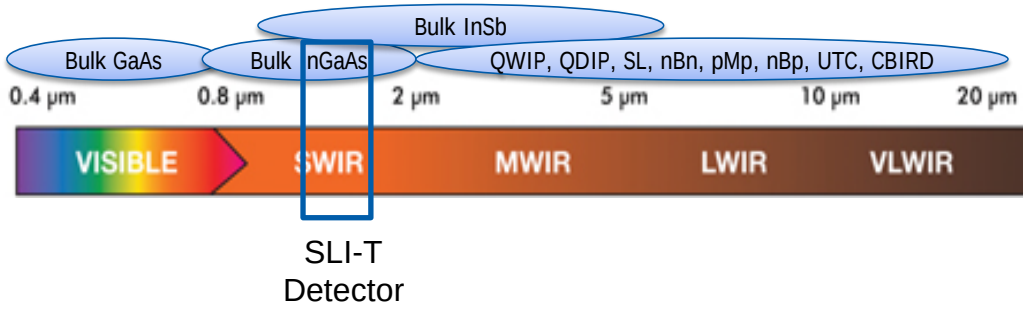
NG Detector and Integration Capabilities

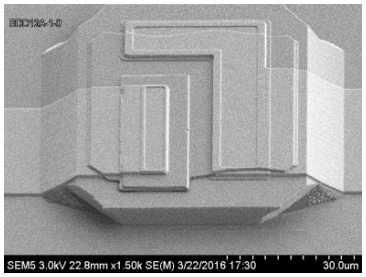
	NG Demonstrated
Device type / configuration	• **PIN photodiodes** • Schottky diodes • Avalanche photodiodes • Photo-transistors • Quantum wells and graded superlattices • Type-II tunnel diodes • Waveguide filters and gratings
Material systems	Lattice-matched, strained, and metamorphic materials: • **InP/InGaAs** • GaAs/AlGaAs • InP/InAlAs/InGaAs/InAlGaAs/ InGaAsP/InGaAsSb • InAs/GaSb/AlSb/AlGaSb/InAlA

	NG Demonstrated
Device layout	• Mesa diode • Surface normal coupled with front- or back-illumination • **Edge coupling to diode or waveguide** • Discrete and array of diodes
Integration capabilities	• **DAHI integration** • Monolithic integration through epitaxial design • Regrowth of multiple epitaxial device structures on same substrate

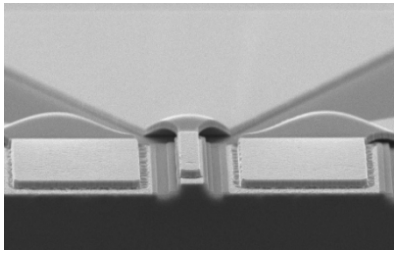
Spectrum Coverage



SLI-T PIN Photodiode



Waveguide Photodiode



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Black Diamond: Waveguide-Detector Integration

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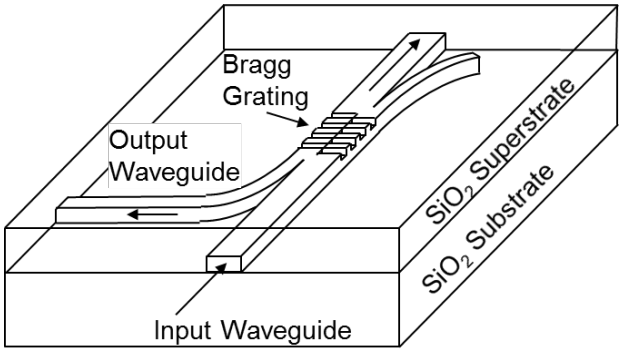
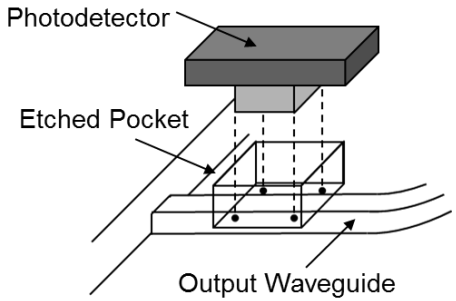
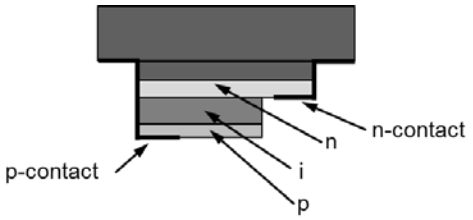
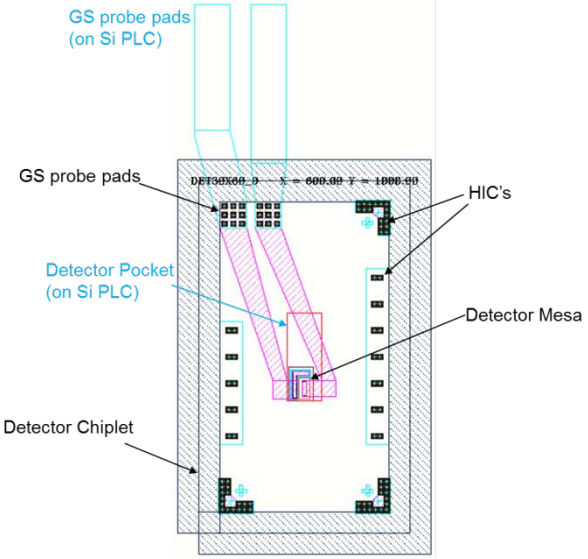
- Black Diamond program demonstrated waveguide/detector integration using NG heterogeneous integration processes

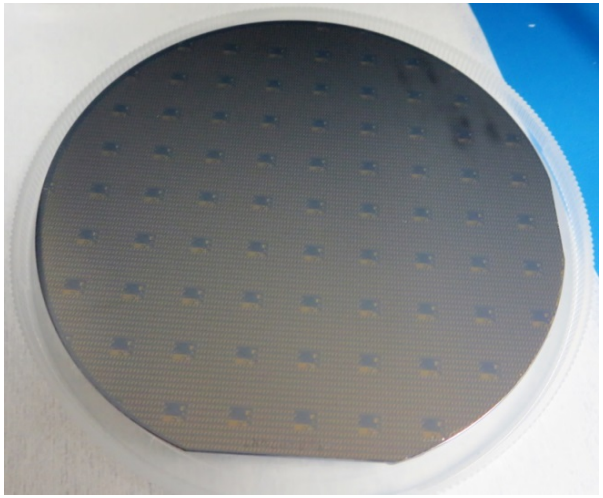




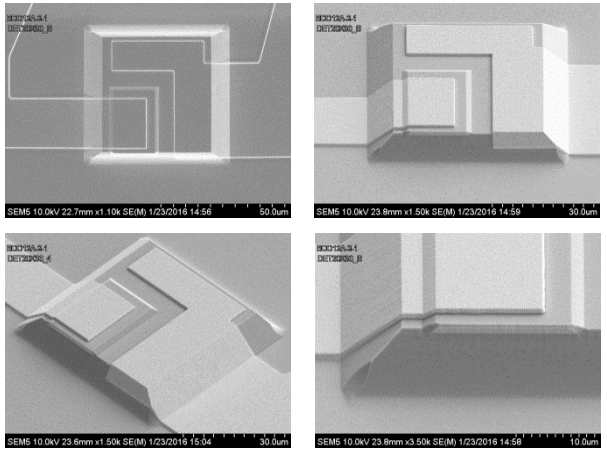




Photodetector chiplet layout



BDD12A-2-1: short-flow minesweeper lot using 100mm GaAs mechanicals



SEMs – detector topology

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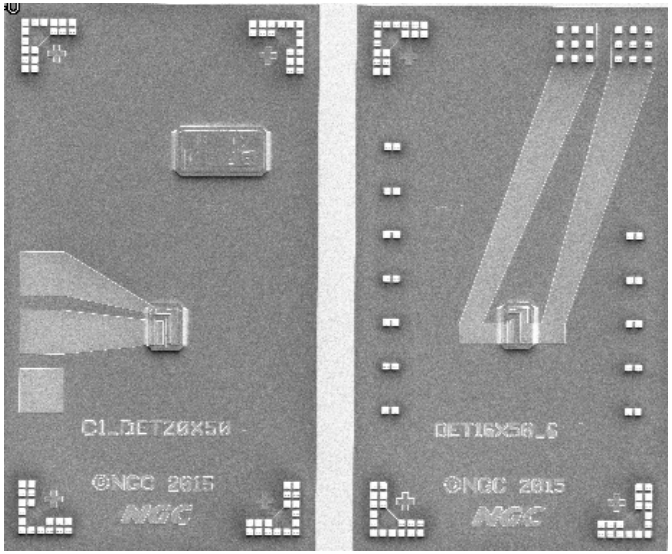
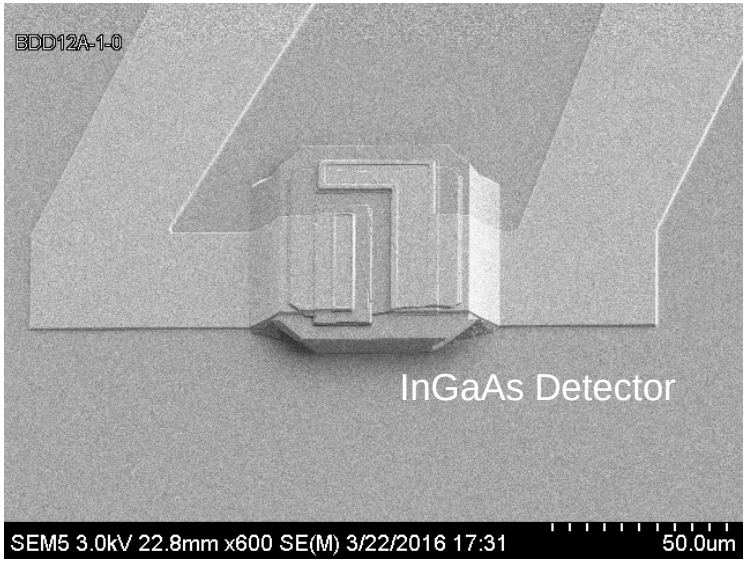
Detector SEM Image

Detector MMIC





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Initial Integration of Detector on Si Waveguide

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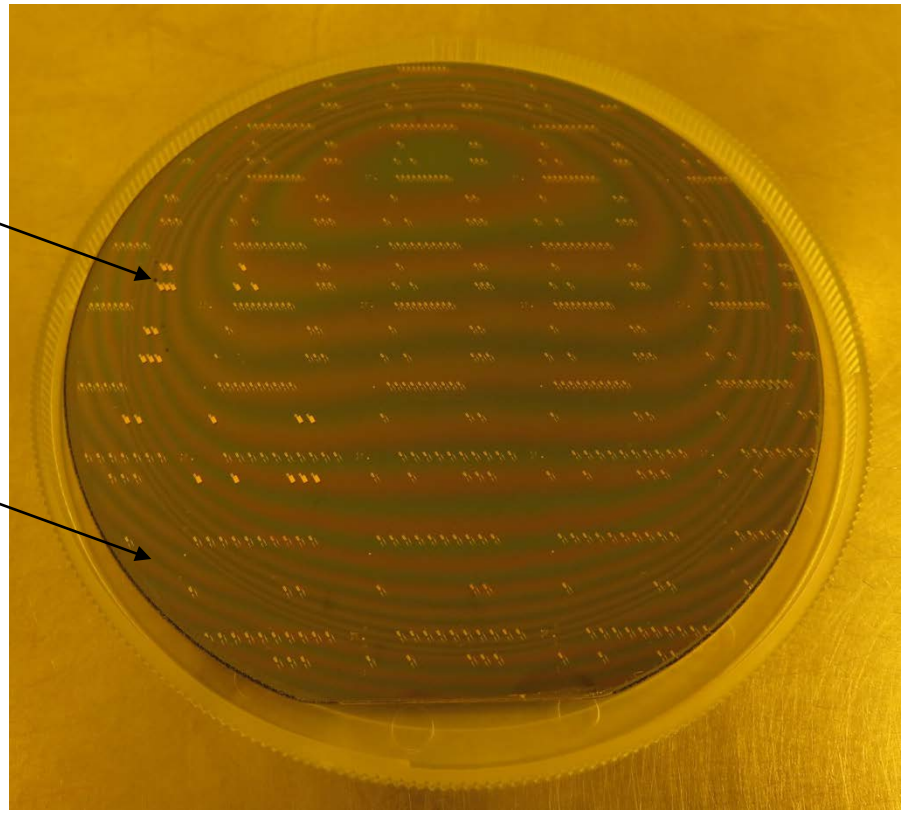
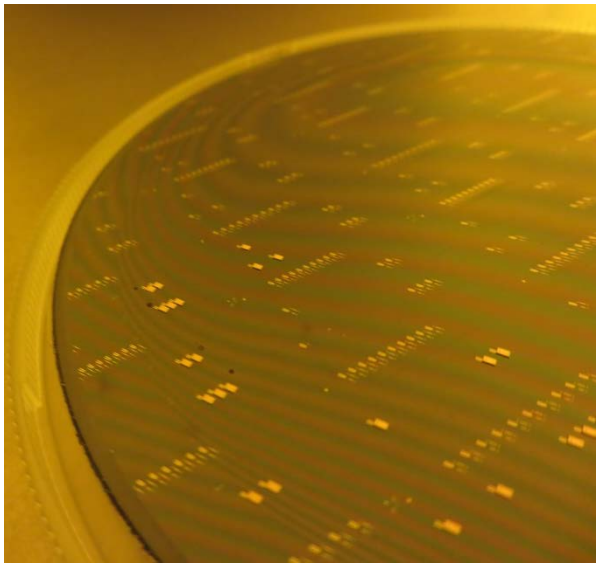
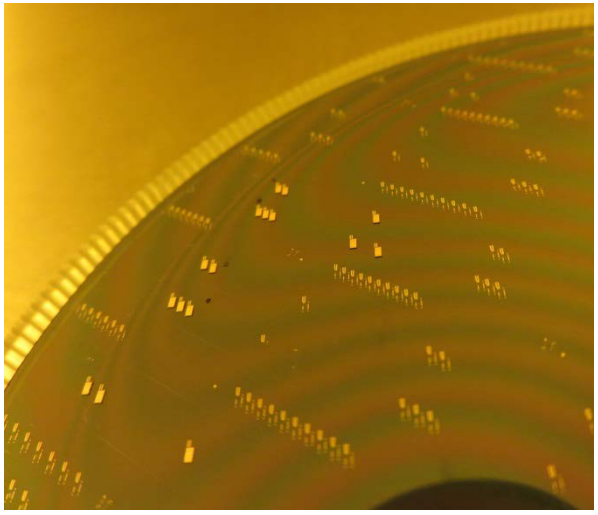
3-mil InGaAs Photodetector Chiplets

100mm Si Waveguide wafer







Successfully integrated photodetector chiplets on to the Si waveguide wafer

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Photodiode Integration Demonstrations

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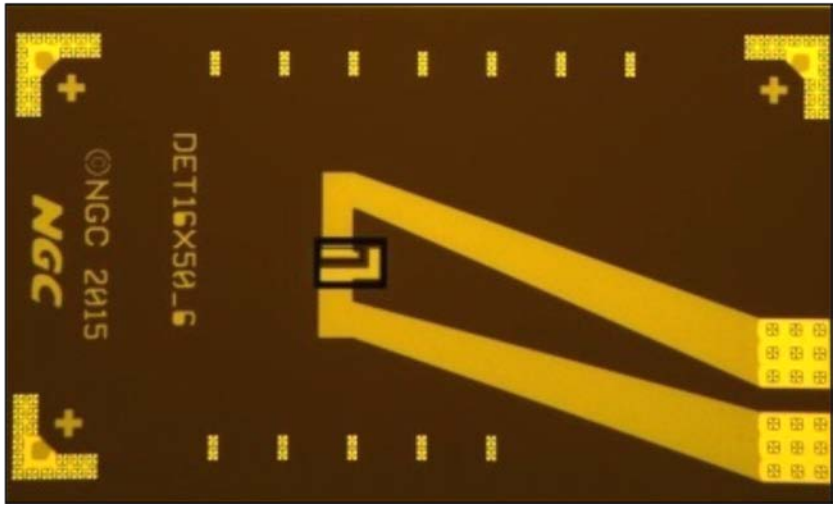
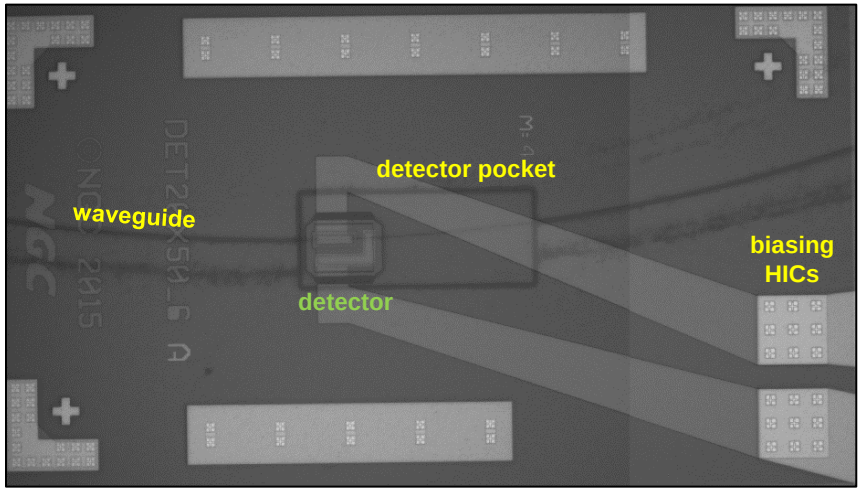
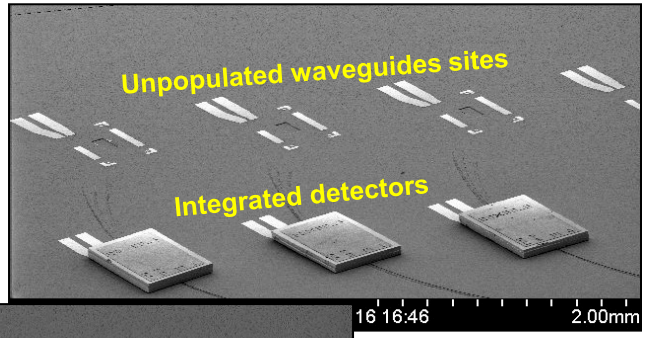
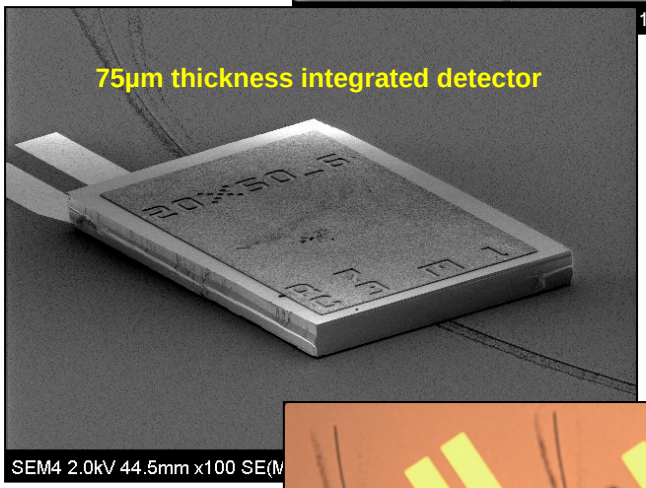
Photodiode Microscope Image

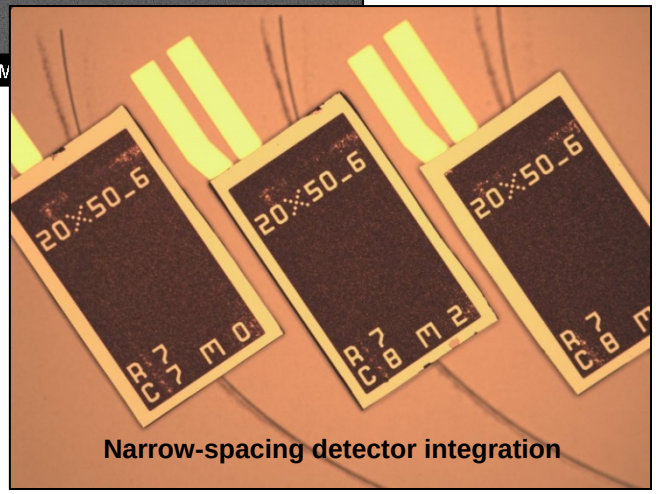


Detector-Waveguide Overlay Image









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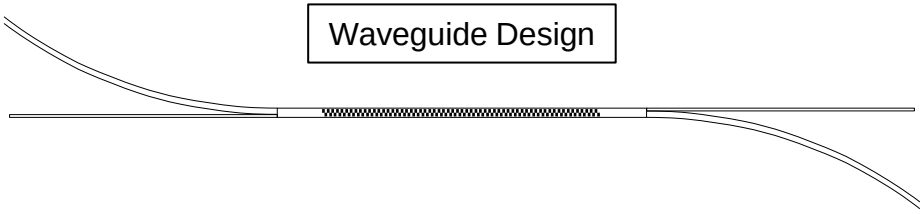
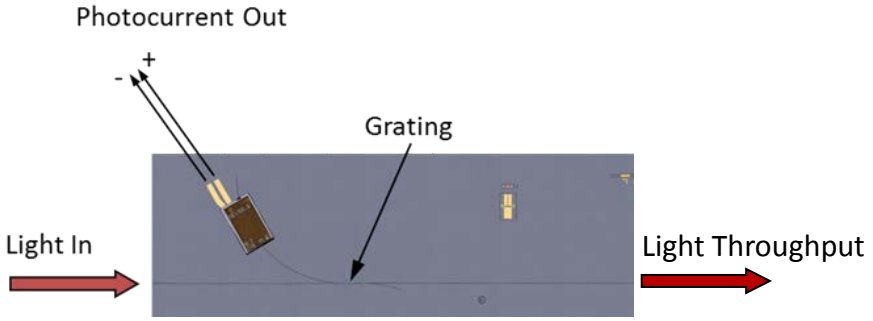
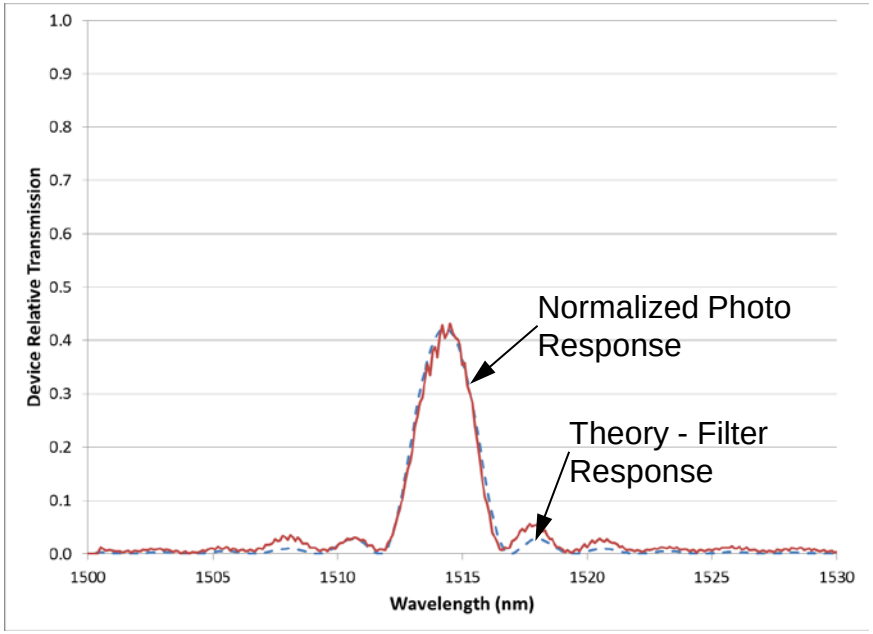
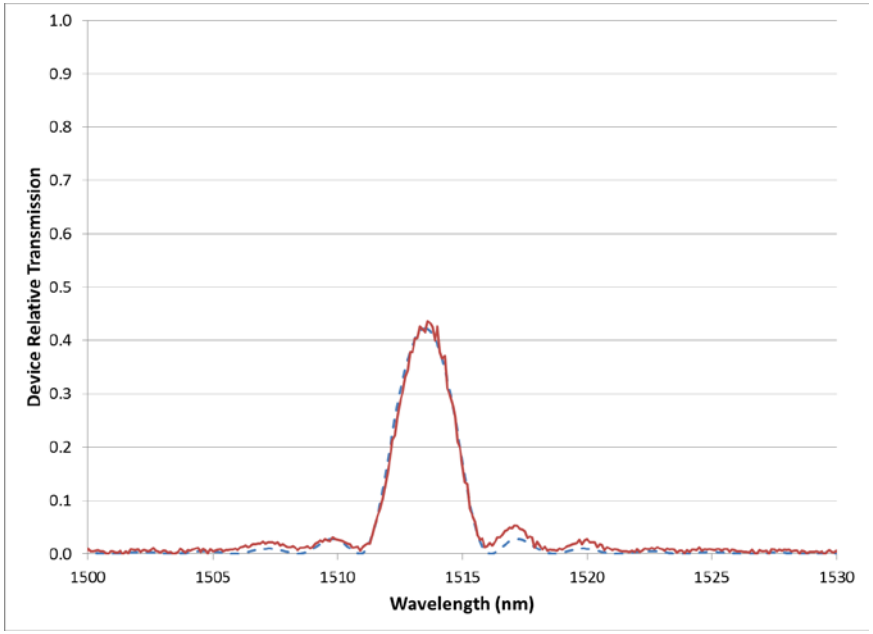
Filter Response for Single-Filter Devices







Device W10-v-3-A



Device W10-v-1-A

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ESTO Rapid Response Study

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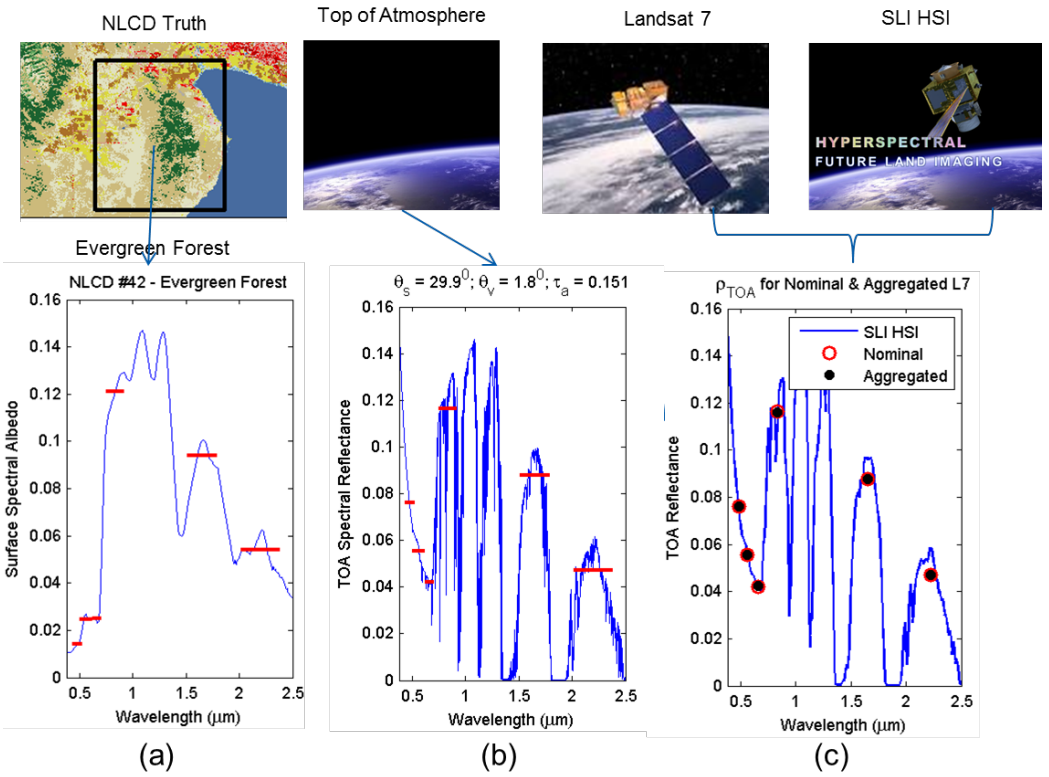
- Study focused on developing designs and performance estimates for key system elements:
  - Telescope
  - Coupling efficiency as a function of wavelength and lenslet focal length
  - Optical throughput and system Signal-to-Noise
  - NGAS band aggregation algorithms

EVEREST HSI Band Aggregation Simulation



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NGAS Core Mission Evaluation Capability

Environmental Verification and Remote Sensing Testbed

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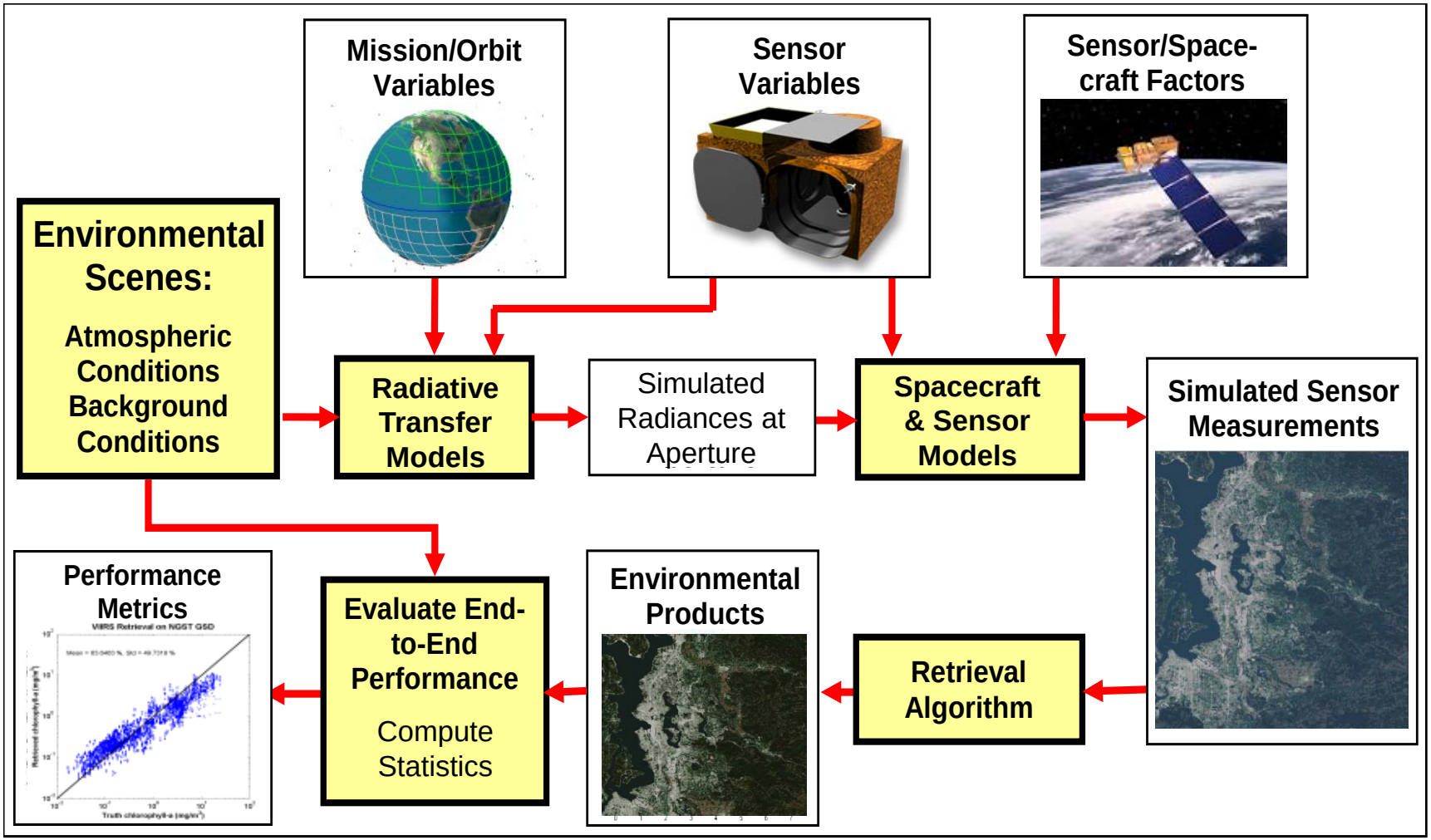

EVEREST is a Core Capability to Support Mission Concept Evaluation and System Development

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EVEREST for Land Imaging
Basis for High Value End to End Simulations

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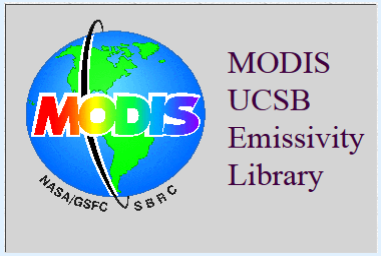
Surface



Atmosphere

- NCEP Global Data Assimilation System (GDAS) P, T, RH, Ozone
- NASA MERRA
- MODIS 8-Day Aerosol Product Climatology
- NGAS Cloud Scene Simulation Model Clouds

Radiative Transfer Model

- Modtran5
- Successive Order of Scattering (SOS)
- 6S(V)
- $\cos\theta \frac{dL(z,\theta,\phi,\lambda)}{dz} = \ldots$ HYDROLIGHT
- DISCORD & ISBRDF Snow/Ice

TOA / SDR Characteristics

- Flexible Sensor Observation Geometries
- Observation Time Based on Orbit
- Spatial Scale Per NLCD
- Spectral Resolution < 1nm
- Spectral Range ~ 0.38-13um
- Landsat & HSI Detector RSRs

NGC EVEREST Leverages Many Community Standards

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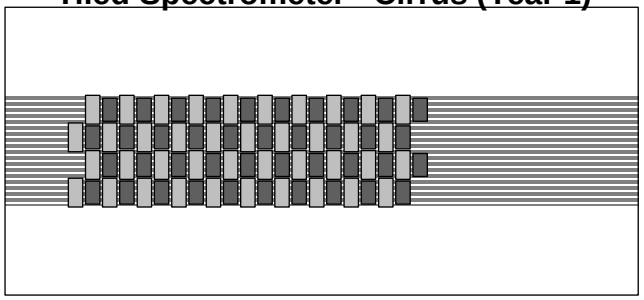
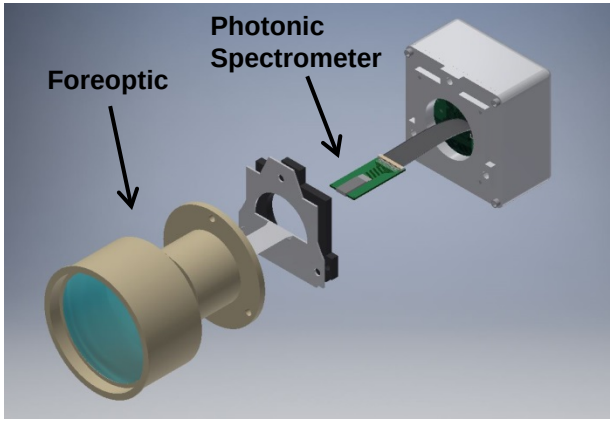
SLI-T Program

- Currently in first year of a 5-year development program funded by NASA ESTO to build and test a heterogeneously integrated photonic instrument
  - Covers two SLI bands: Band 9 (1.36 – 1.39µm at 3nm resolution) and Band 6 (1.56 – 1.66µm at 6nm resolution)
  - Scalability to SLI VNIR and SWIR bands
  - Integrate NGAS novel ROIC
  - Radiometric performance estimates and testing
- Planned exit TRL = 6

Tiled Spectrometer - Cirrus (Year 1)



- **Spectral range 1360 to 1390 nm**
- **Δλ = 3 nm, 10 filters per pixel**
- **# of x-track pixels 128, Pixel spacing 30µm**
- **Active area: 3.84mm x 13.1mm**



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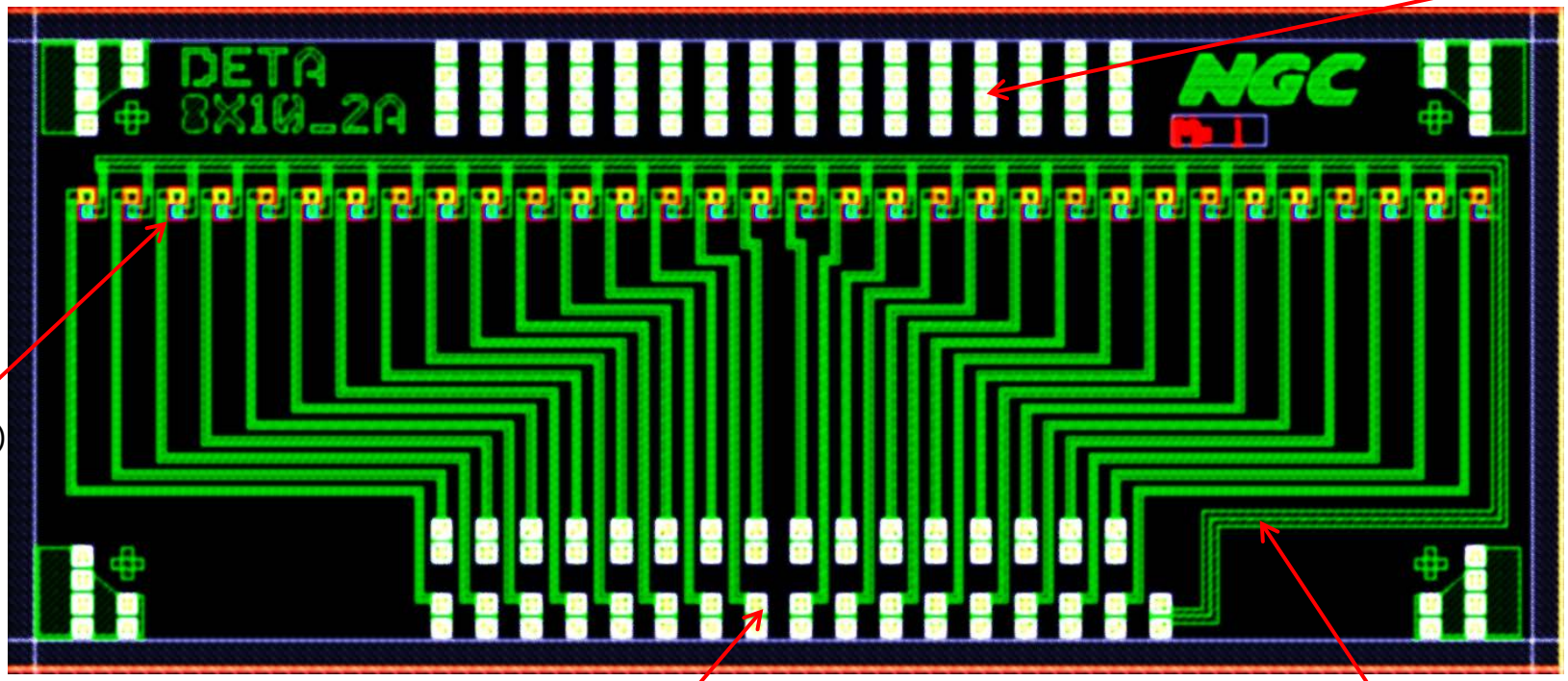
Detector Chiplet Design

- Detector chiplet fabrication initiated
  - Each chiplet contains 32 detectors, metal interconnect, HICs, alignment marks
  - Multiple versions of chiplet per wafer with different detector sizes and offset



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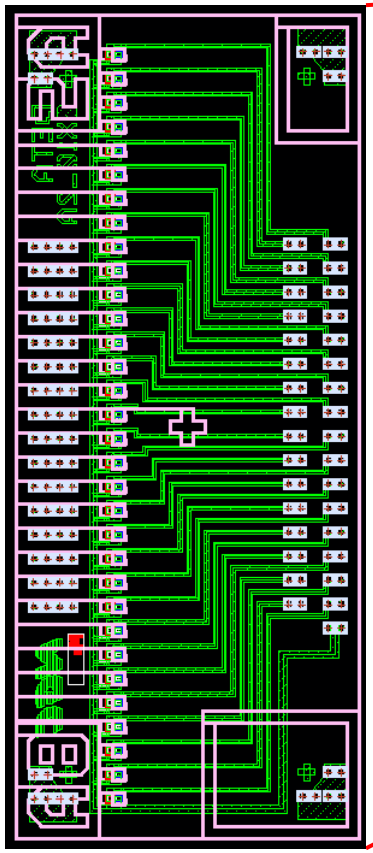
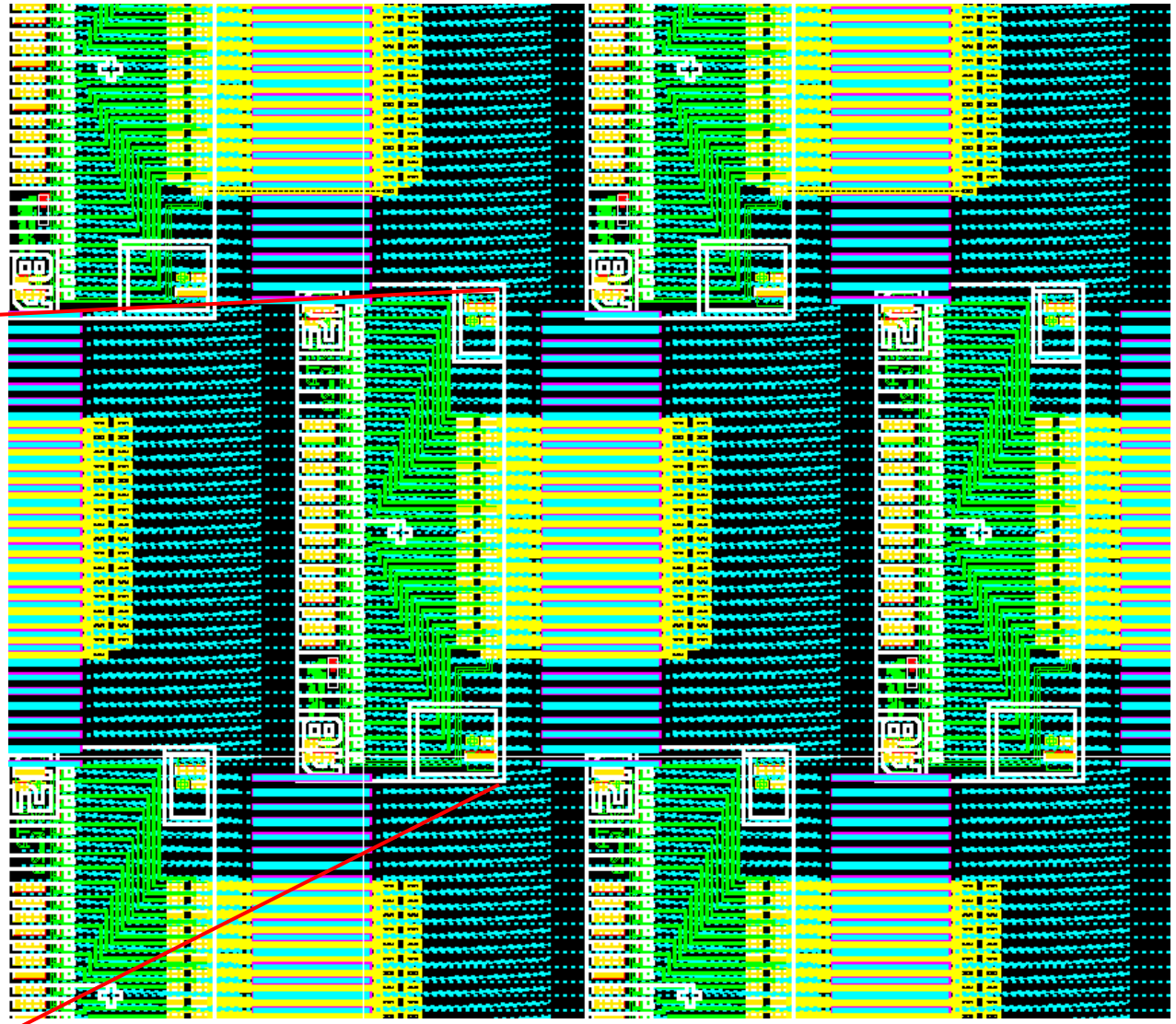
Detector Tiling Pattern

- SLI-T waveguides in fabrication
- Next step is waveguide/detector integration





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