Breakthrough on III-V Sb-based Type II Superlattice Infrared technology in the United States

SET-241 9th NATO Military Sensing Symposium

May 31-June 2, 2017

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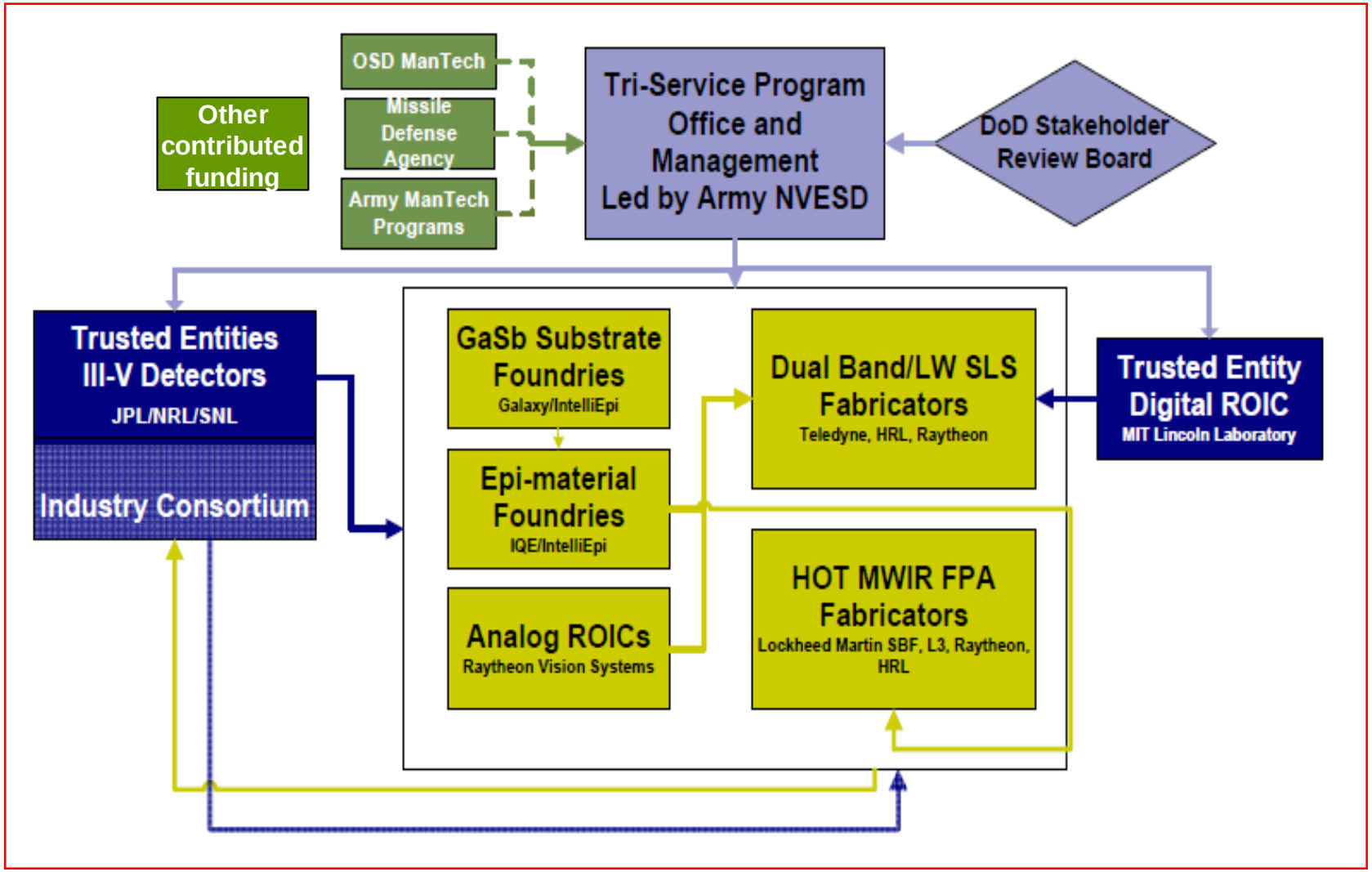
Outline

- Play VISTA Video
- VISTA Program Structures
- VISTA Performers
- VISTA Progress
- Summary

VISTA Model
Horizontal Integration with Trusted Entities



VISTA Program Management

- **An ASD(R&E) Effort with Tri-Service and DoD Agency participation**
  Led by Army NVESD, managed by the Services (Army, Navy, Air Force)

- **Stakeholder Review Board**
  - Dr. Don Reago, Army (Chair)
  - Dr. Karl Dahlhauser, ASD(R&E)
  - Ms. Teresa Puretz, ASD(R&E)
  - Dr. Jay Lewis, DARPA
  - Mr. Rich Matlock, MDA
  - Dr. Divyang Shah, NRO
  - Dr. Michael Eismann, Air Force
  - Dr. Tom Cooley, Air Force
  - Dr. Phil Perconti, Army
  - Dr. Whitney Mason, Army
  - Dr. Sam Wood, Army
  - Dr. Ravindra Athale, Navy
  - Dr. Michael Pollock, Navy
  - Dr. Craig Hoffman Navy
  - Ms. Mary Miller, Army ASAALT

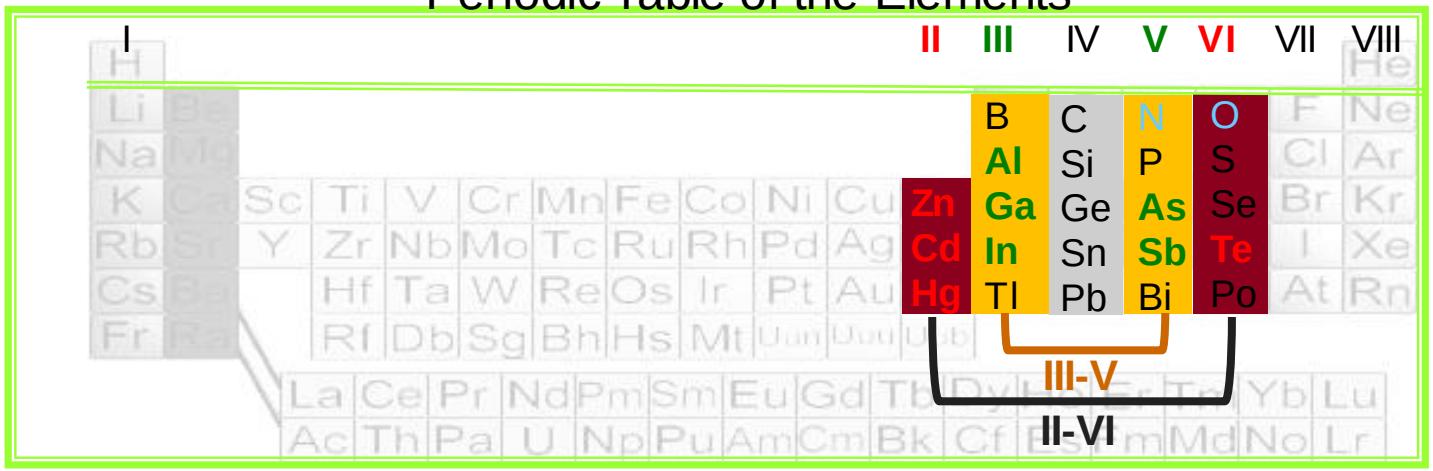
- **Program Management Office**
  - Dr. Meimei Tidrow, Army, PM
  - Mr. John Scheihing, AF, Deputy PM
  - Mr. Neil Supola, Army, Deputy PM
  - Mr. Robert Hintz, Navy, Deputy PM

- **NVESD Special Projects Office**
  - Mrs. Leslie Aitcheson, Operations and Acquisition Lead
  - Dr. Sumith Bandara, Technical Lead
  - Dr. Lucy Zheng, Technical Support
  - Dr. Craig Lennon, Technical Support
  - Mrs. Alicia Williams, Program Support

VISTA is an ASD(R&E) Program, Led by the Army and Managed by the Tri-Service.

What Is New?
VISTA Focused on III-V

Periodic Table of the Elements

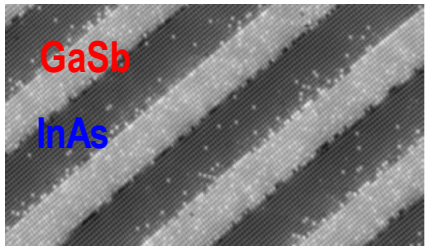


Traditional mercury cadmium telluride—a II-VI material, 50 yr, over $2B DoD funding

- Costly, low yield, difficult to process
- Relies on a single Japanese source for substrates
- No commercial products, solely depends on DoD to maintain the industry base

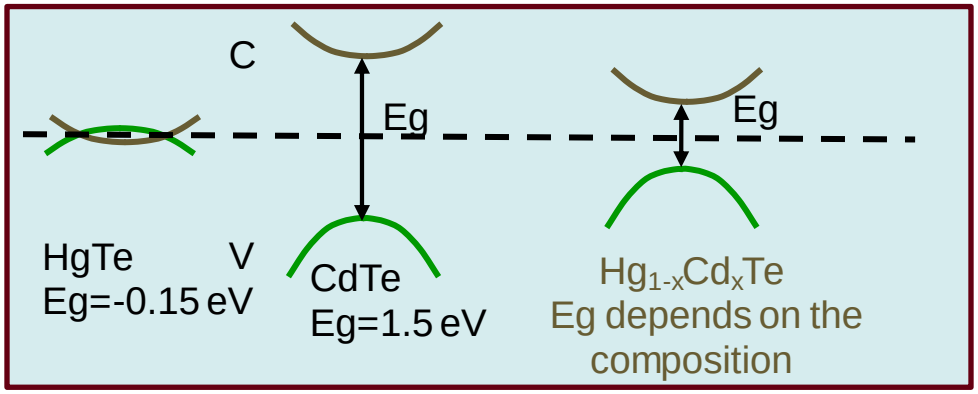
VISTA focus: III-V Sb-based superlattice

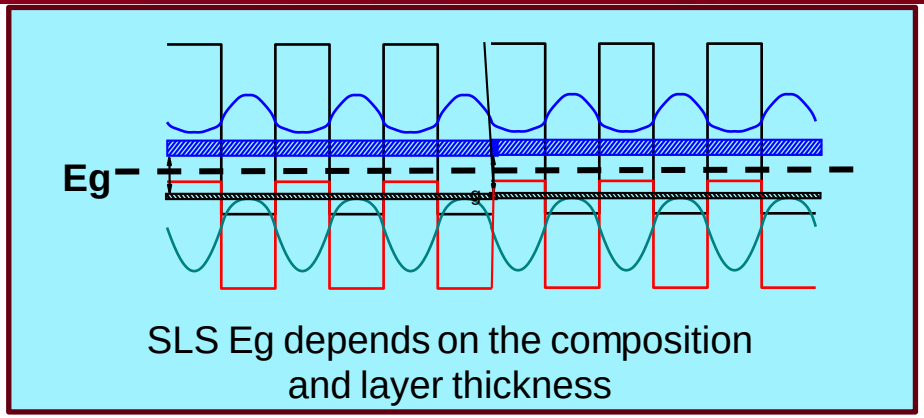
- Affordable, high yield, high performance, high temperature (= size, weight, power benefits)
- Uses commercial foundries, reducing Gov't need to support production/maintenance costs
- Leverage the big III-V opto-electronic industry base



Molecular Beam Epitaxy (MBE) reactor deposits atoms layer by layer to form super-lattices. Standard industry production—highly uniform.

Why SLS: Technical Advantages

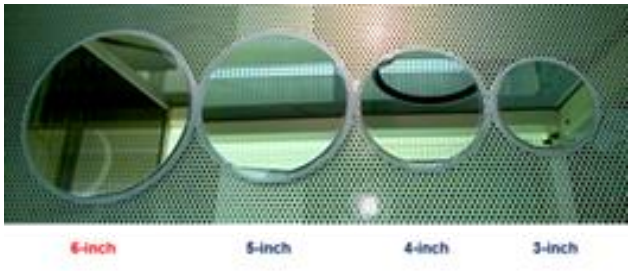




- **Sb based SLS is the only IR material that has theoretically predicted performance higher than MCT, or the same performance at higher operating temperatures**
- **Same as MCT**
  - wavelength tunable to cover from SWIR to VLWIR, and multiband in one FPA capability
  - high interband absorption for high QE
- **Better than MCT**
  - robust III-V material system with strong covalent bonds
  - more flexibility in device design with variation of x values and layer thickness
  - more immune to tunneling due to larger effective mass
  - reduced Auger recombination due to heavy hole and light hole band splitting (except for depleted MCT)
  - low defects: III-V SLS Epitaxial are Typically < 10/cm2, HgCdTe/CZT Epitaxial are ~1000/cm2)
  - More choices for nBn barriers to reduce surface current and g-r current for higher operating temperatures

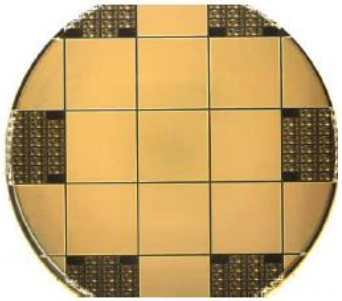
Why SLS: Production and System Advantages

- **Multiple domestic commercial sources for production**
  - Large Substrates
  - Multipe wafer production epitaxial growth
  - Multiple wafer focal plane array fabrication



- **High yield**
  - Multiple wafers processed in batches
  - High detector yield expected

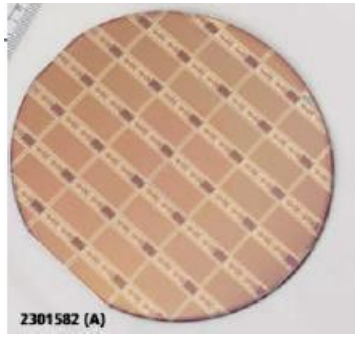
- **High-performance "ilities" for long range DRI:**
  - Operability: >99% in MW, LW, MW/LW
  - Uniformity: $\sigma VH/\sigma TVH<0.5$ in MW, LW, MW/LW
  - Stability: few blinkers, no 1/f noise. Very stable after 2-poi correction



- **Low SWaP**
  - high operating temperature makes cooler size smaller

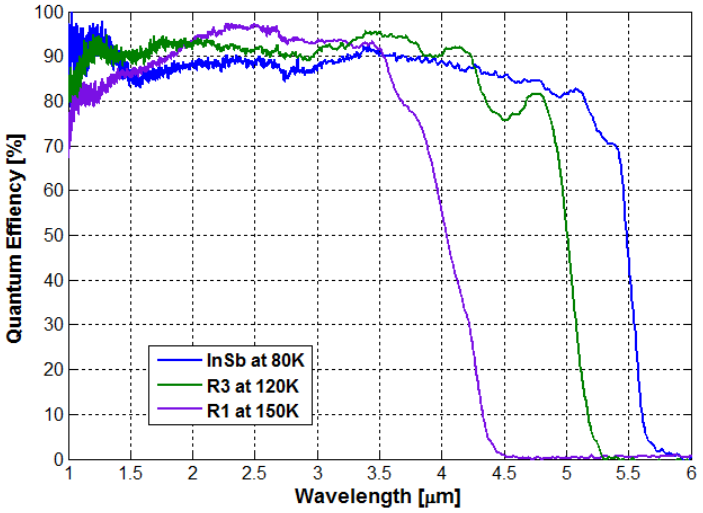
- **Low system operation cost**
  - longer cooler lifetime, reduce system lifecycle cost

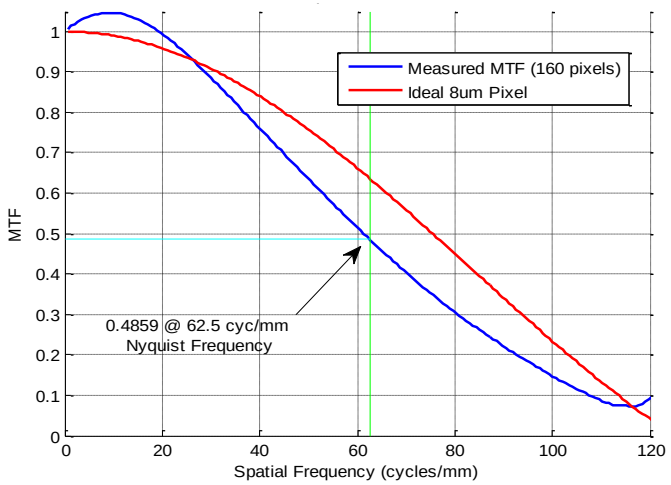
- **Low cost FPA and systems due to the above reason, plus**
  - Industry base not dependent on Federal funds to maintain
  - Facilities leverage other opto-electronic products
  - Potential large volume when covering the whole IR spectrum



nBn Detector

- **Tunable based on mission and application**
- **Baseline design has > 80% QE across MW1 & MW2, 100% fill factor**
- **77% diffusion MTF for high QE planar design**





High MTF & operating temp enables high resolution, low SWaP packaging

Pitch Scalability

- Thin detector structures require less etch depth than InSb
  - This allows small pixels with high fill factor
  - Several small pixel FPAs were produced during the VISTA program

2K×2K @ 10 µm

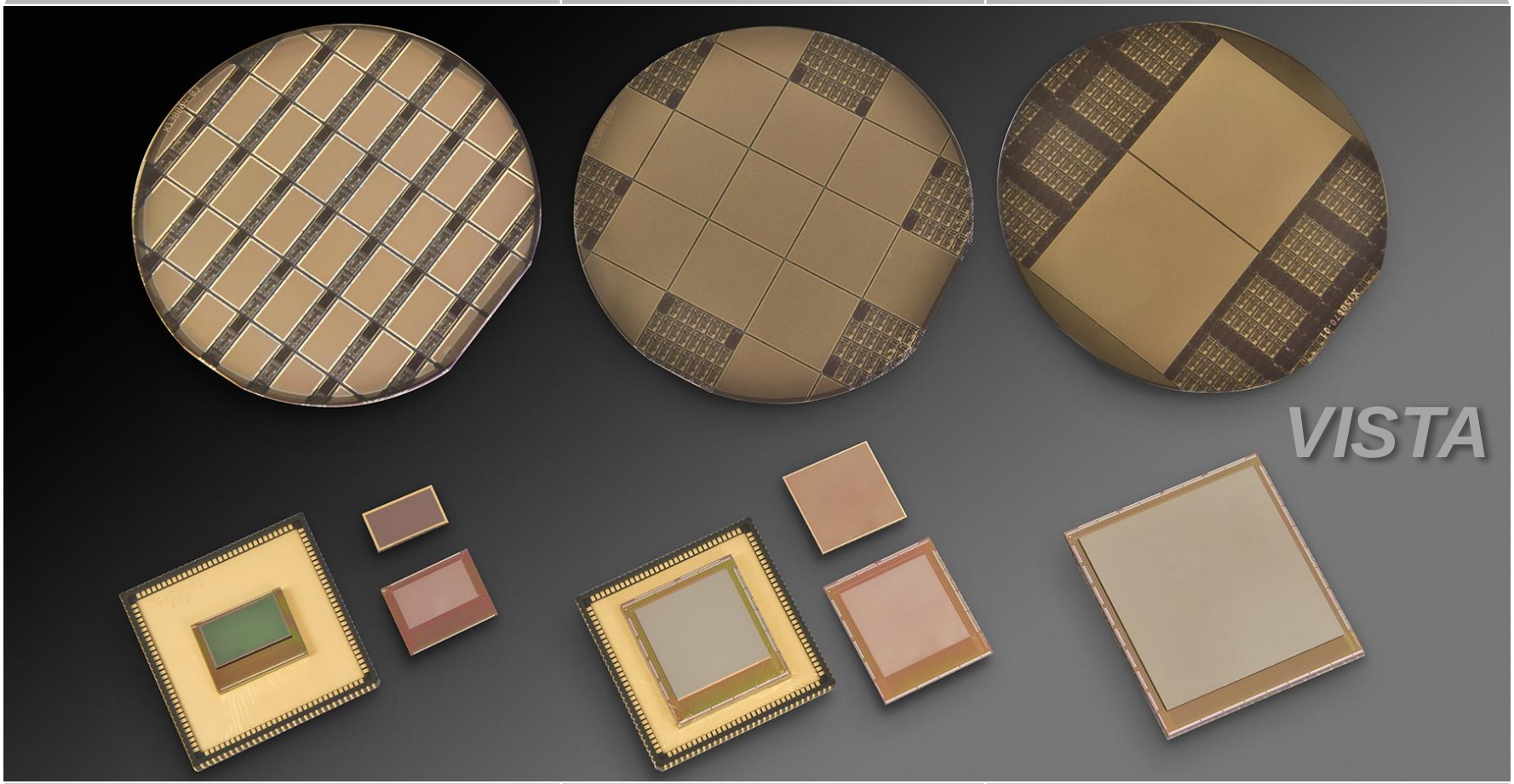
720p @ 8 µm

1280×1024 @ 7.5 µm
(15 µm centers)

Raytheon Has Fabricated and Demonstrated HOT MWIR and Dual-Band FPAs in Multiple Formats

Raytheon

1280 x 720, 12µm (720p) HOT MWIR or Dual-Band M/LWIR	2k x 2k, 10µm (4 Mpix) HOT MWIR	4k x 4k, 10µm (16 Mpix) HOT MWIR



SB-476 1280 x 720, 12µm (720p) FPA	SB-466 2k x 2k, 10µm (4 Mpix) FPA	SB-466 4k x 4k, 10µm (16 Mpix) FPA

NVESD Ft Belvoir 720p Dual-Band FPA Imaging

Raytheon

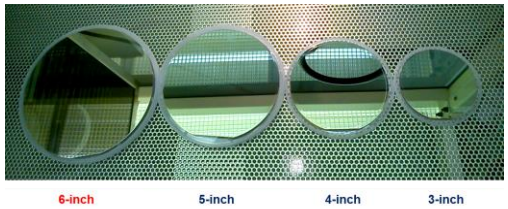
DB-122 Band 1 (MWIR)

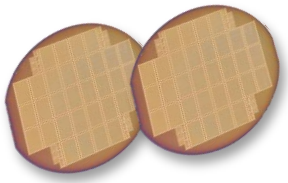
DB-122 Band 2 (LWIR)

* DB-122, 2501026C (VLM-SL18b)-75mm-RVS, PECVD SiO2
Temperature = 80K, F/3 FOV, Dual-Band Filter (3.6-5.1µm, 7.7-10.4µm), 30Hz

2016 April VISTA/ManTech Hardware Showcase

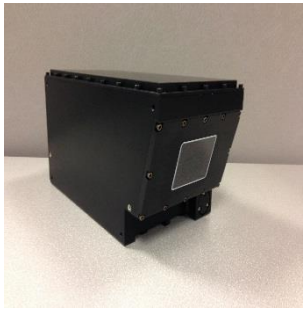
- A final VISTA event demonstrated III-V nBn/SLS cameras and display products
- At NVESD on 12-13 April 2016
  >20 Cameras on Building 305 Balcony, River View

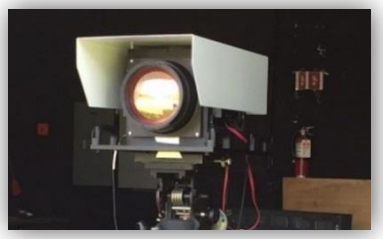


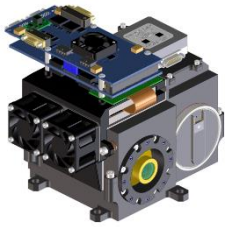


Showcase includes
- Large size GaSb substrates
- Large size Epi wafers
- Large format FPA chips
- **Cameras** with FPAs
  - HOT MW
  - Dual-Band MW/LW
  - Digital ROIC
  - Large format LW

Demo Participants
- Galaxy
- IQE
- Intelligent Epitaxy
- HRL Laboratories
- L3 Cincinnati Electronics
- Lockheed Martin SBFP
- MIT Lincoln Laboratory
- Raytheon Vision Systems
- FLIR Systems
- Cyan





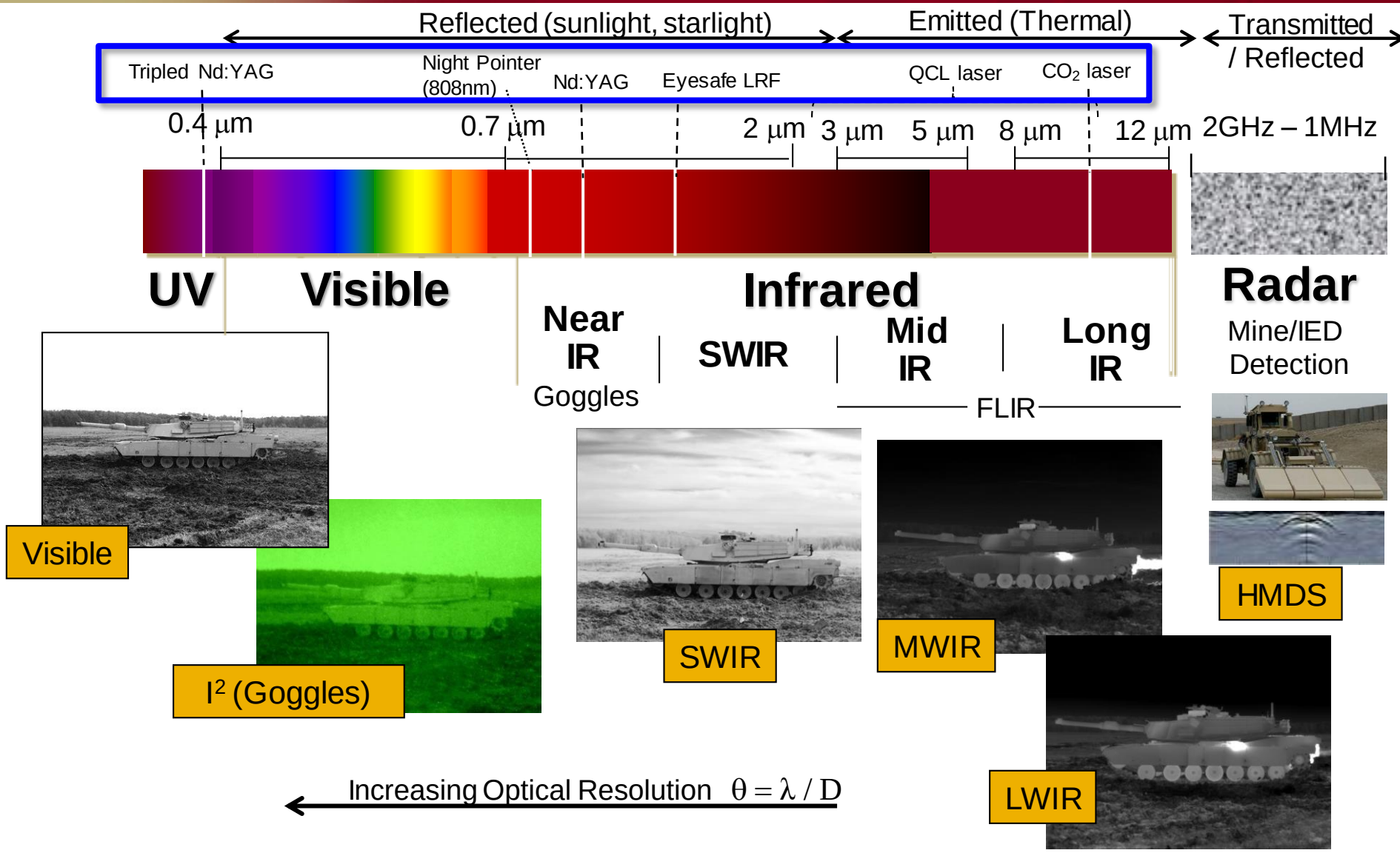


What Does III-V SLS Mean to the Army?

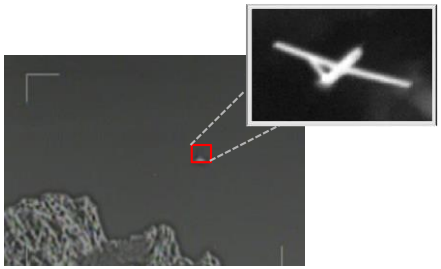
Army Needs

- Low cost
- High yield
- High performance
- Producible
- Low size weight and power
- Self support industry base

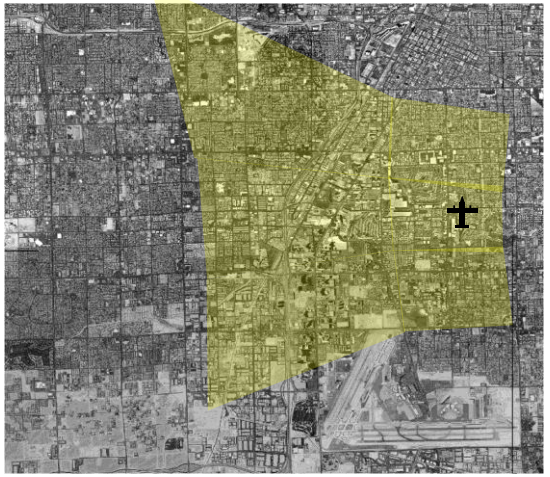
Sensor Spectrum



Applications of Passive EO/IR Imagers



- Reconnaissance & Targeting
- Wide Area Search
- Intelligence & Surveillance
- Navigation, Maneuver, Pilotage
- Perimeter Defense
- Aircraft Survivability



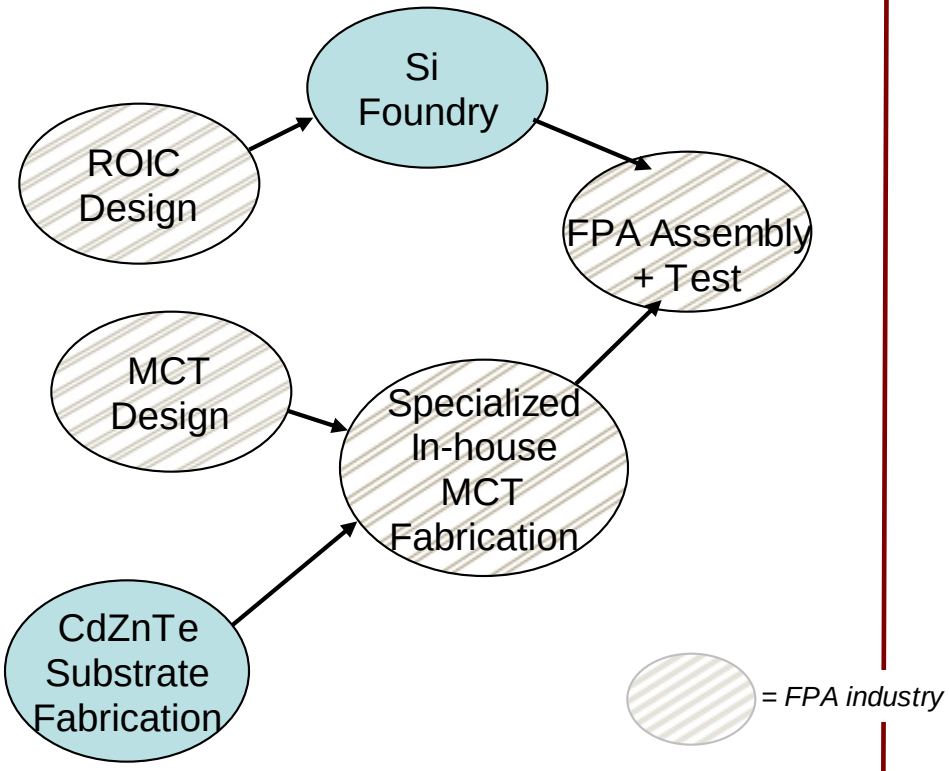
Features making Electro-Optical sensors ideal for these and other warfighting applications include:

- Passive
- Intuitive
- Low Cost
- Day/Night
- Capable in many weather conditions
- Real-time (fast framing)

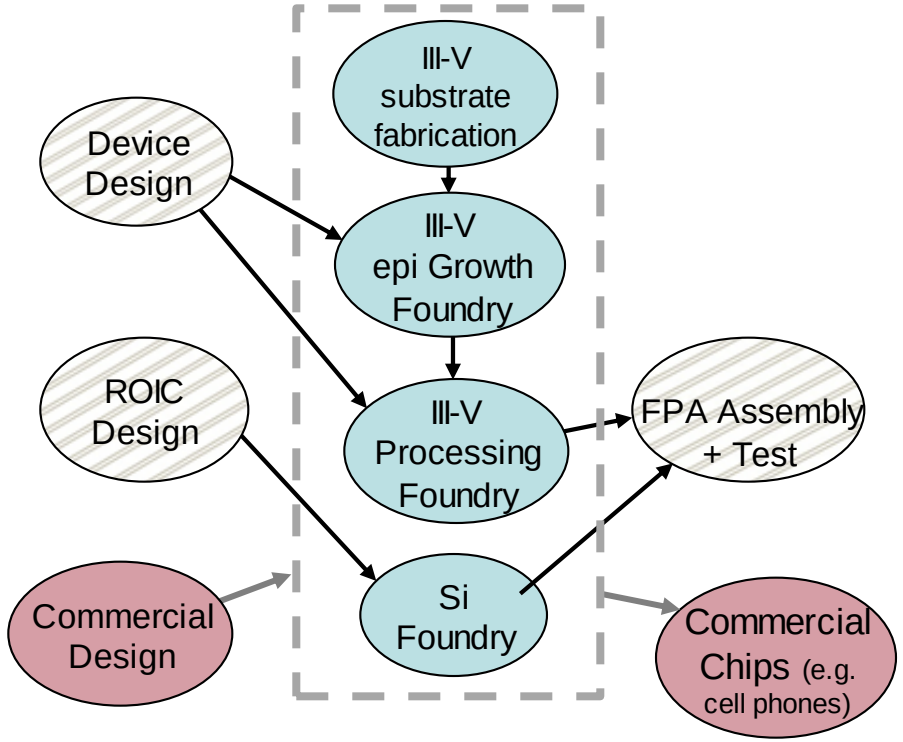
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

The III-V Opportunity

MCT Business Model



Potential III-V Business Model

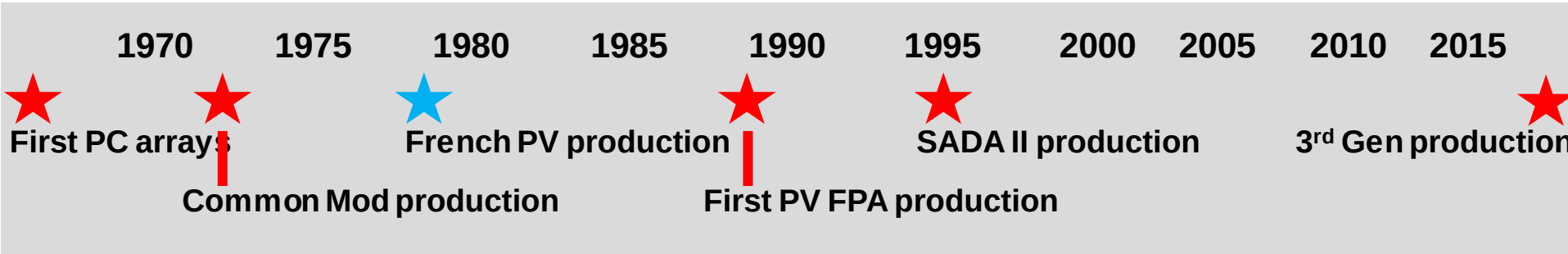


Use of III-V commercial foundries for both growth and processing during production can significantly reduce overhead and cost.

May no longer need to maintain specialized production facilities in the future.

VISTA: Compressing the development timeline at lower cost

Old Technology (HgCdTe): Vertical development at each US contractor. Costly and slow



III-V SLS/nBn: Collaborate effort with multiple contractors, commercial vendors and US Labs
Low cost and very fast

Horizontal integration, collaborate effort has achieved technical parity with HgCdTe in a much shorter time and much less cost

Summary

- VISTA is an OSD funded, Tri-Service managed National Effort led by Army NVESD
- VISTA success has significant impact on future US military systems and investment in this field
- US Night Vision Lab is committed to this new material and will continue to work in improving it
- We welcome collaborations