Technology Available for Licensing

Large Format Corrugated Quantum Well Infrared Photodetector (C-QWIP) Camera Element

Inventor

Dr. K. K. Choi

US Army Research Laboratory

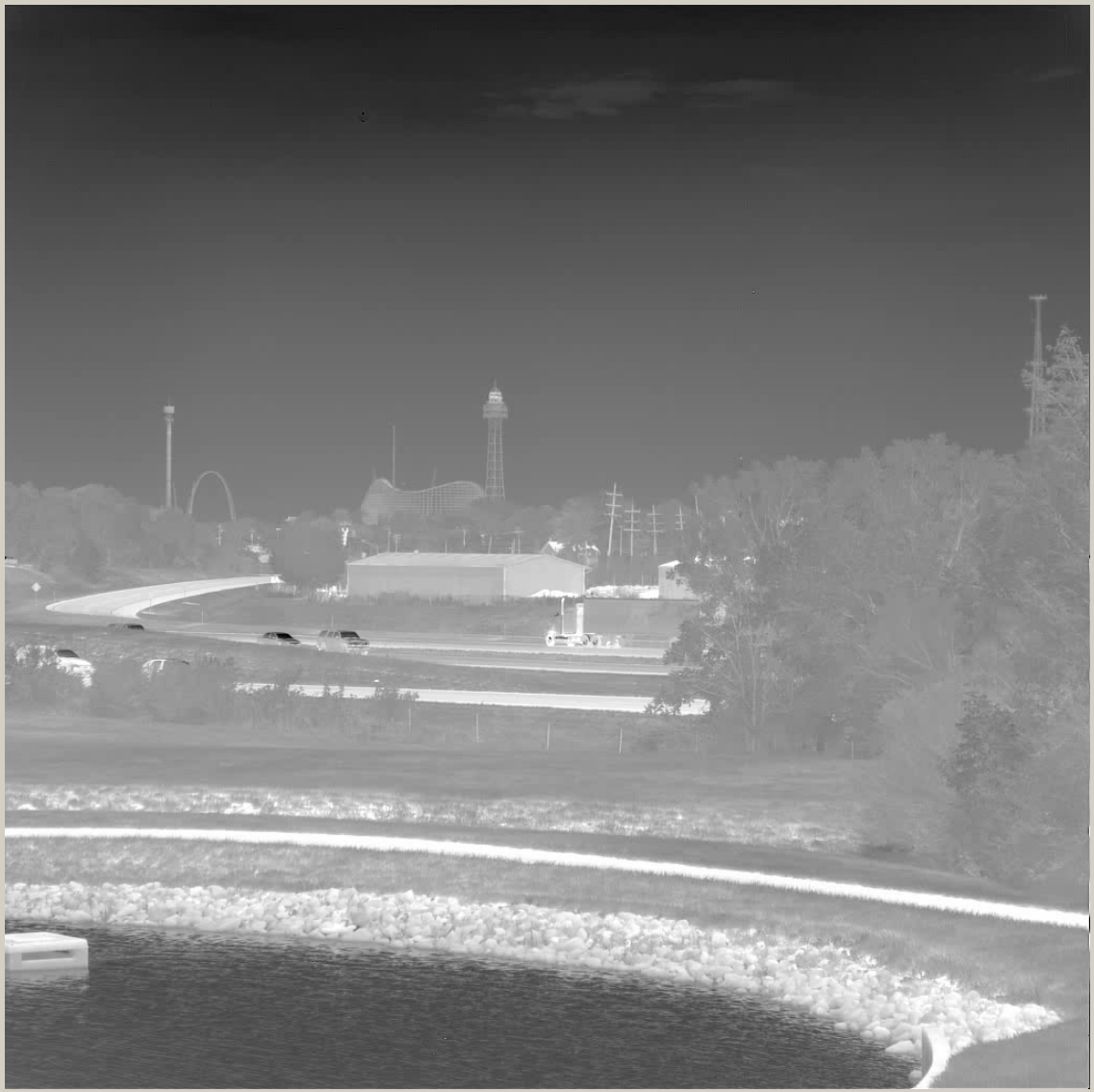
1024 x 1024 C-QWIP FPA

~12"

In collaboration with L-3 CE.

First demonstration of a 1K x 1K tactical long wavelength FPA!

NEΔT = 22 mK



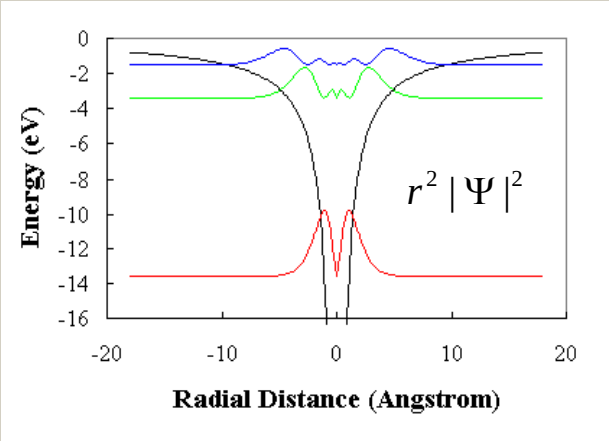
Double Click Mouse on Above Photo to Initiate Film Clip

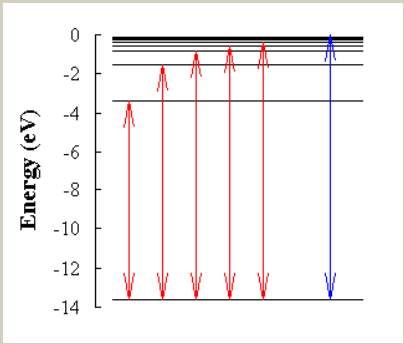
Indoor Image Using C-QWIP Focal Array

Double Click Mouse on Above Photo to Initiate Film Clip

Conventional QWIP Technology: Material Design at the Nano-Scale

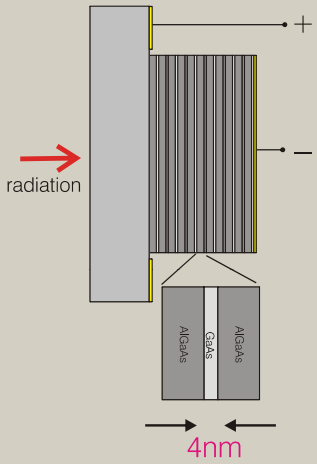
Natural atoms: large energy level separation
⇒ Ultra-violet absorption

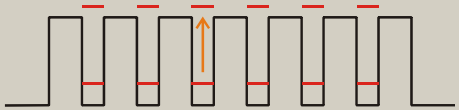


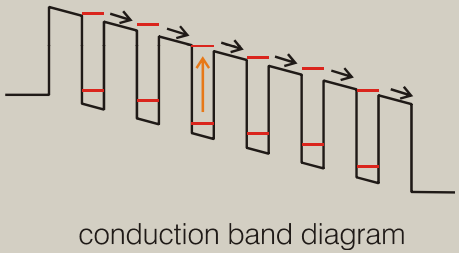


Hydrogen atom: potential well width = 0.5 nm, energy spacing = 13.6 eV, λ = 0.1 μm

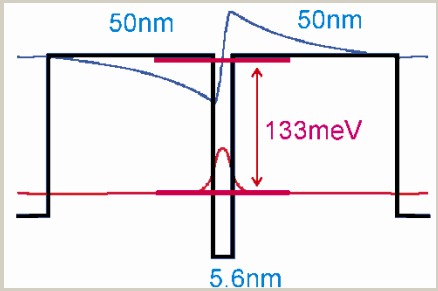
Artificial atoms: adjustable energy separation
⇒ infrared absorption







Bethea and Choi et al. Pat # 4894526, (1990).



InGaAs/AlGaAs: potential well width = 5.6 nm, energy spacing = 133 meV, λ = 9.3 μm

Current Commercial QWIP Performance

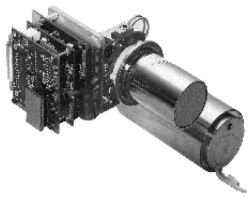
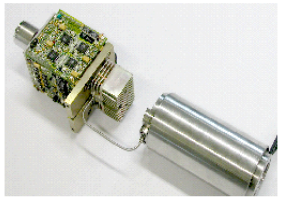
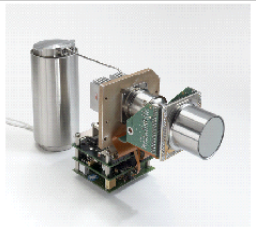
Product Line from AIM Germany Based on QWIP Technology
This is a Representative Listing of Specifications for QWIP Based Products

FLIR, US

ThermoVision 3000
Portable Long-Range (> 10 km) Infrared Surveillance System

AIM Germany

Thales Optronique (France)

IDCAs Quantum Well Infrared Photoconductors 2D Focal Plane Arrays Subframe capability			
FORMAT	**256 x 256 (0.066 MP)**	**384 x 288 (0.11 MP)**	**640 x 512 (0.33 MP)**
Spectral wavelength range / µm	7.6 – 9.3	7.6 – 9.3	7.6 – 9.3
Pixel Size [μm^2]	37 x 37	22 x 22	22 x 22
Pixel pitch / µm x µm	40 x 40	24 x 24	24 x 24
Array Size [mm x mm]			
Fill factor	85 %	85 %	85 %
Quantum efficiency η	> 5 %	> 5 %	> 5 %
NETD [mK] @ 300K	< 14 mK @ τ_i = 20 ms	< 25 mK @ τ_i = 20 ms	< 25 mK @ τ_i = 20 ms
F-number (standard)	2.0	2.0	2.0
Frame Rate / Hz	50, option 100	50, option 100	30, option 100
Signal Outputs Readout mode	2 rolling frame snap shot (option)	2 rolling frame snap shot (option)	2 rolling frame snap shot (option)
Output video rate / MHz	< 16		
AD-Converter	14 bit, 16 MHz	14 bit, < 18 MHz	14 bit, < 18 MHz
Dynamic range	> 12 bit	> 12 bit	> 12 bit
Cryo-Cooler	1W,SL-100	1W,SL-100	1W,SL-100
Power consumption (incl. Cooler)	< 70 W, regulated < 50 W	< 70 W, regulated < 50 W	< 70 W, regulated < 50 W

Current QWIP Camera Applications

QWIP infrared imagers are also deployed in:

BILL Anti-Tank missile system (Sweden),

Forward Observer System (Norway),

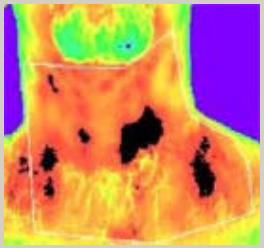
Anti-oil pollution monitoring (Dutch Coast Guard),

Maritime patrol and surveillance (Polish Border Guard),

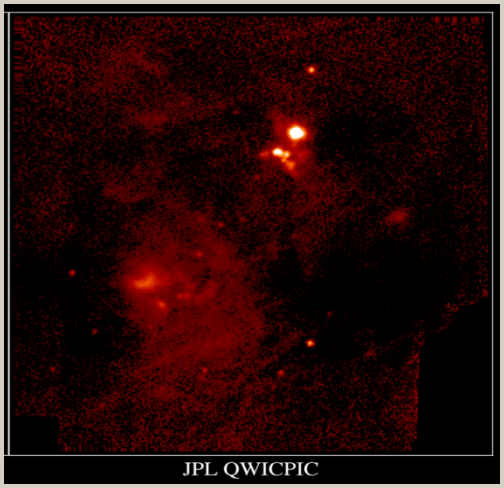
Cancer diagnostics (US and Germany, OmniCorder BioScanIR System),

Infrared astronomy (US, Palmer Hale Telescope)

OmniCorder BioScanIR System - FDA510K



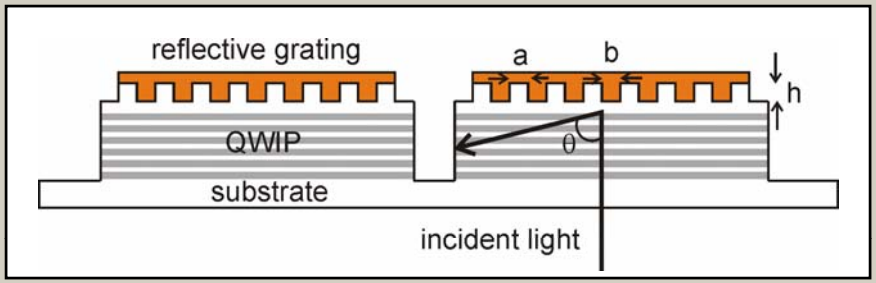
BioScanIR image of diagnosed lymphoma



JPL QWICPIC

Vastly Improved Corrugated-QWIP Design

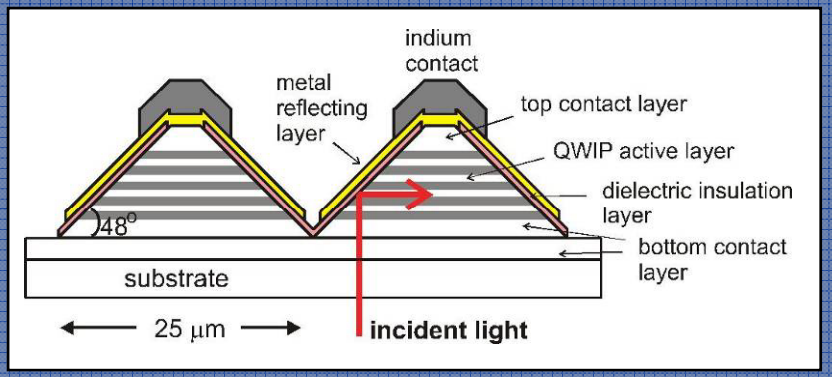
Conventional approach: Light coupling by diffraction



- Low quantum efficiency (5%)
- Narrow band detection (0.7 micron)
- Requires large pixel size that lowers pixel counts (40 X 40 micron size)
- Requires submicron grating features that limit array size
- Expensive and low fabrication yields (months for single wafer, ~10% yield)

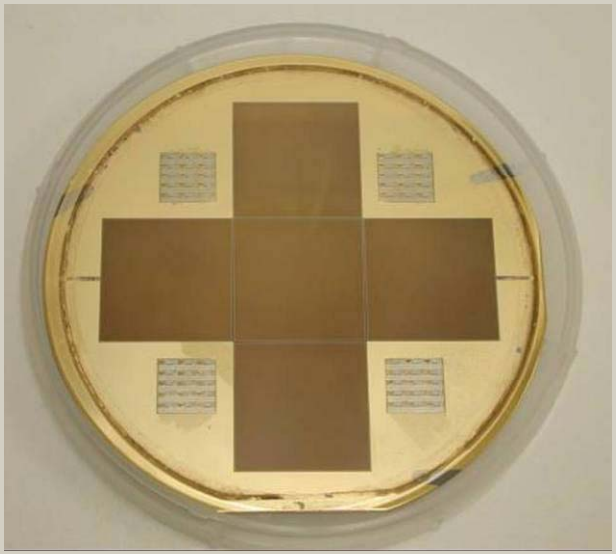
Revolutionary C-QWIP approach: Light coupling by reflection

(Pat # 5485015, 7217926)

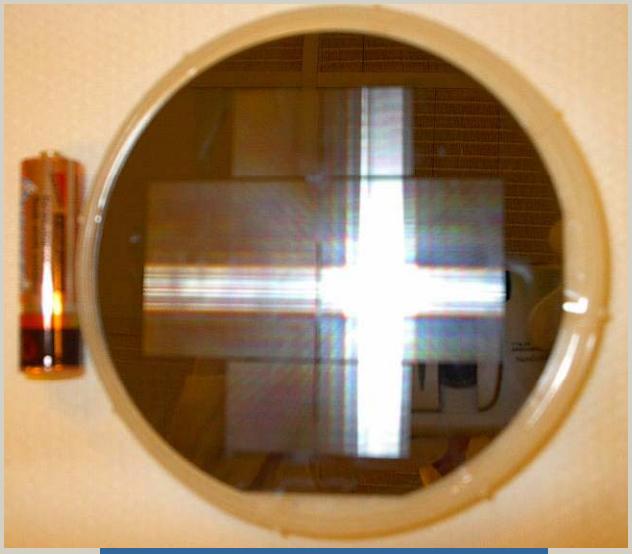


- Large quantum efficiency (35%)
- Broadband detection (4 micron or larger)
- High density, large format (18 X 18 micron size – better resolution)
- Low cost, high fabrication yield (<week for single wafer, 70%)
- Fast manufacturing cycle
- Large volume production (many wafers at one time)

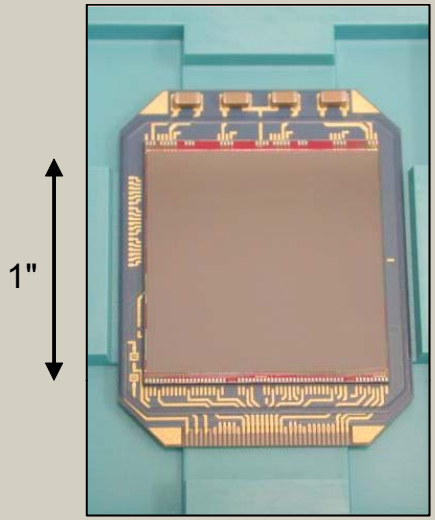
C-QWIP FPAs Produced In-House

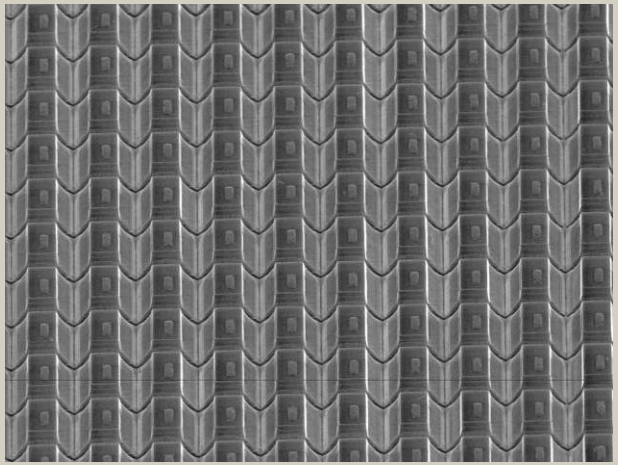


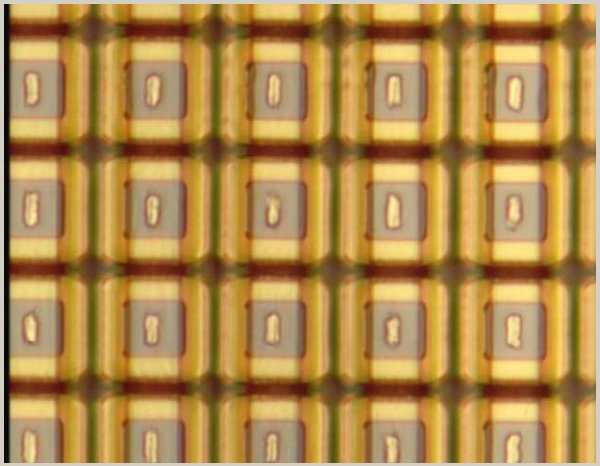
1024 x 1024 on 4" wafer

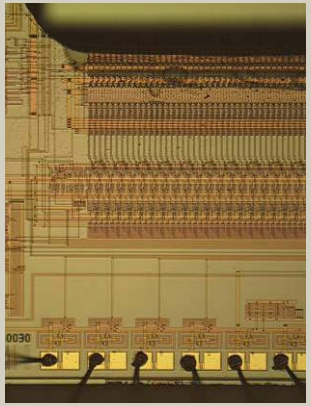


2048 x 2048 on 4" wafer

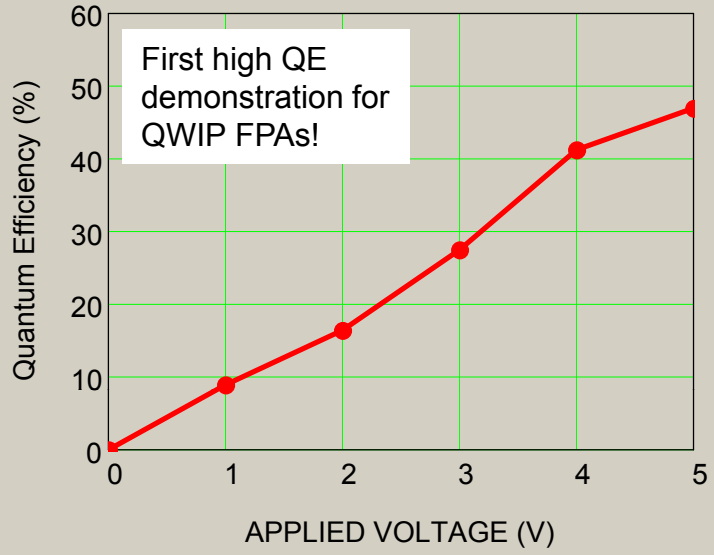


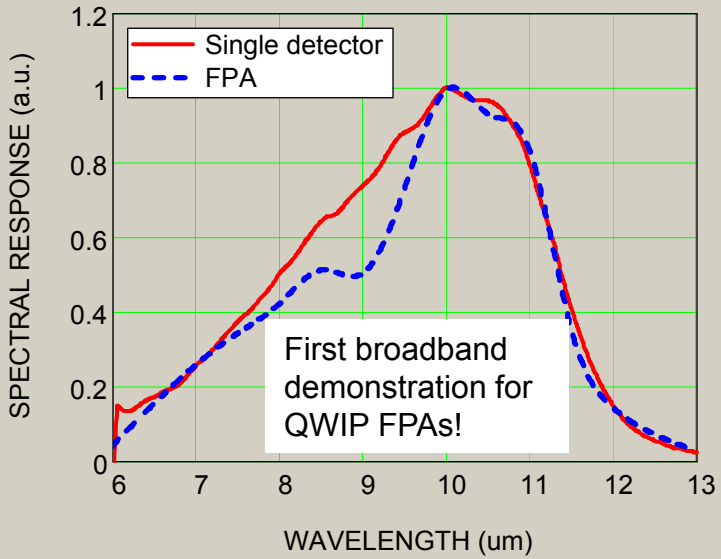






Verification through Experimentation

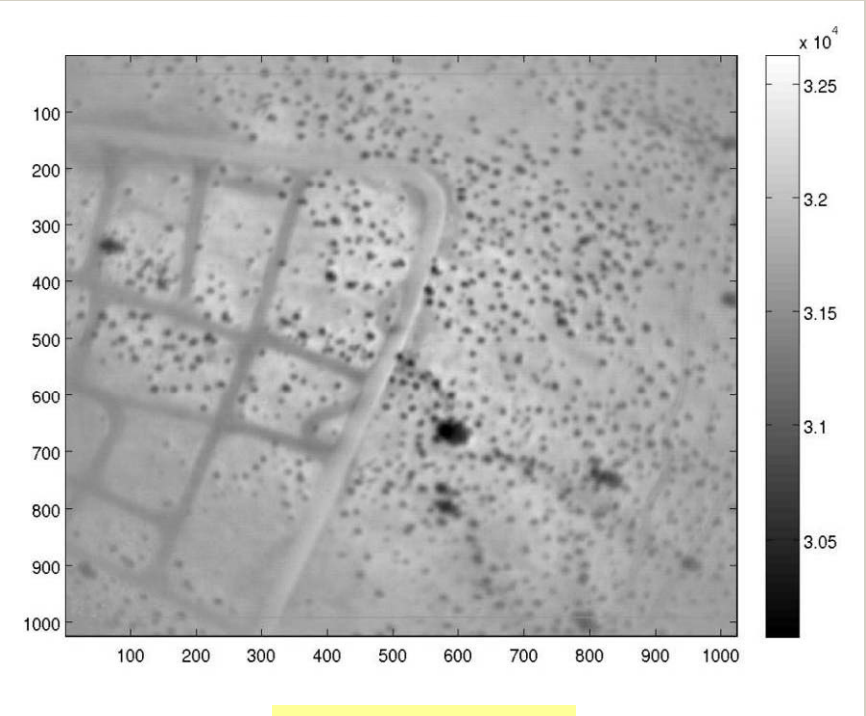




(Warm is dark)

C-QWIP Prototype Applications

- **Army** – developing higher resolution C-QWIP FPAs for large area persistent surveillance and helicopter pilotage
- **Navy** – delivered several cameras for ocean surface characterization
- **Air Force** – integrating cameras into Jet fighters
- **NASA** – delivered cameras for mission to Mars study and environmental monitoring
- **Missile Defense Agency** – several observation programs
- **Commercial Customers**



A desert fly-by

NASA used C-QWIP FPAs to hunt for caves in Arizona and New Mexico in the preparation for Mission to Mars and to perform environmental monitoring in Thailand.

Summary

Corrugated Quantum Well Infrared Photo-detector Arrays (C-QWIP FPAs) When Compared to Currently Available Conventional QWIP Technology Have:

- **Much Higher Quantum Efficiency**
- **Greater Broadband Detection**
- **Higher Speed Operation**
- **Higher Resolution**
- **Much More Affordable**

World's first highly sensitive and highly affordable long wavelength infrared technology for the Army, the DOD, and the scientific community at large.

Business Arrangements Sought

Licensing of Intellectual Property

- Partially exclusivity available for specific fields of use
- Initial licensing fee
- Annual royalty payments

Cooperative Research & Development Agreement with the Army Research Laboratory can enable:

- ARL custom fabricate C-QWIP chips for specific application
- Licensee have access to facility while chip fabrication is being made to gain knowledge and know-how of fabrication
- Consulting support while C-QWIP being made at client's facility
- Reasonable Cost to Client

Opportunity for the Right Company

Best fit for this technology is a company already in the business

- Know the market
- Have a market base
- Can do needed hardware/software integration

Can be very competitive with existing technology

- Tremendous savings in chip manufacturing time
- Fantastic improvement in product yields from 10% to over 70%
- Significant improvement in performance :
  - ✓ Formats increased from 0.3 MP to 4 MP.
  - ✓ Improvement of temperature sensitivity by factor of 2 or more.
  - ✓ Shutter speeds increased by 2 to 4 times.

Premium markets currently demand $200K per camera unit, with cost savings realized from manufacturing can compete and make significant profit for supplimenting start up costs.

Easier to mass produce, therefore great potential to open large new markets.

Highlights of Opportunities and Markets

Technical Highlights and Advantages

•High temperature sensitivity translates into fast shutter speeds and more frames per minute

•No light source required so ideal for surveillance and robotic applications

•Can enhance vision through smoke, fog, clouds, etc.

•Large format, high speed and high resolution pictures taken in real time.

•Much easier and faster chip fabrication with very low part rejection rate translates into a product that is much more easily mass produced, potentially opening larger commercial markets.

Potential Markets and /or Commercial Application

•Military

•Medical

•Security and Surveillance

•Search and Rescue for sea and land

•Scientific equipment such as astronomy telescopes

•Firefighting including "see-through-smoke", hot spot detection, etc

•Visual assist for cars, airplanes, boats and trains for fog, snow, rain, night-time and cloud like environments.

•Artificial vision for robots

•Quality control inspection devices for electronics, food packaging, etc.

•Monitoring of chemical processing equipment and plants

•Equipment maintenance and diagnostics

Points of Contact

Interested and/or have questions?

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