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Standard Form 901 (11-18)
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Small Business Innovation Research(SBIR) Program - Proposal Cover Sheet

Disclaimer

Knowingly and willfully making any false, fictitious, or fraudulent statements or representations may be a felony under the Federal Criminal False Statement Act (18 USC Sec 1001), punishable by a fine of up to $10,000, up to five years in prison, or both.

SBIR Direct to Phase II Proposal

Proposal Number:	**F2D-15326**
Proposal Title:	**Affordable Electrical Accumulator Unit**

Agency Information

Agency Name:	**USAF**
Command:	**AFMC**
Topic Number:	**AF244-D011**

Firm Information

Firm Name:	**Bryka Skystocks LLC**
Address:	**549 Cedar Street , Newington, CT 06111-1814**
Website:	**brykagp.com**
UEI:	**RB4XFCMC9KZ7**
DUNS:	**967264990**
CAGE:	**6afx5**
SBA SBC Identification Number:	**002227699**

Firm Certificate

OFFEROR CERTIFIES THAT:

1. It has no more than 500 employees, including the employees of its affiliates.	**YES**
2. Number of employees including all affiliates (average for preceding 12 months)	**3**
3. The business concern meets the ownership and control requirements set forth in 13 C.F.R. Section 121.702.	**YES**
4. Verify that your firm has registered in the SBAS Company Registry at www.sbir.gov by providing the SBC Control ID# and uploading the registration confirmation PDF:	**SBC_002227699**

Supporting Documentation:

- SBC_002227699.pdf

5. It has more than 50% owned by a single Venture Capital Owned Company (VCOC), hedge fund, or private equity firm	**NO**
6. It has more than 50% owned by multiple business concerns that are VOCs, hedge funds, or private equity firms?	**NO**
7. The birth certificates, naturalization papers, or passports show that any individuals it relies upon to meet the eligibility requirements are U.S. citizens or permanent resident aliens in the United States.	**YES**
8. Is 50% or more of your firm owned or managed by a corporate entity?	**NO**
9. Is your firm affiliated as set forth in 13 CFR Section 121.103?	**NO**
10. It has met the performance benchmarks as listed by the SBA on their website as eligible to participate	**YES**
11. Firms PI, CO, or owner, a faculty member or student of an institution of higher education	**NO**
12. The offeror qualifies as a: [ ] Socially and economically disadvantaged SBC [**X**] Women-owned SBC [ ] HUBZone-owned SBC [ ] Veteran-owned SBC [ ] Service Disabled Veteran-owned SBC [ ] None Listed	
13. Race of the offeror: [ ] American Indian or Alaska Native [ ] Native Hawaiian or Other Pacific Islander [**X**] Asian [ ] White [ ] Black or African American [ ] Do not wish to Provide	
14. Ethnicity of the offeror:	**NON-HISPANIC**
15. It is a corporation that has some unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have not been exhausted or have not lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability:	**FALSE**
16. Firm been convicted of a fraud-related crime involving SBIR and/or STTR funds or found civilly liable for a fraud-related violation involving federal funds:	**NO**
17. Firms Principal Investigator (PI) or Corporate Official (CO), or owner been convicted of a fraud-related crime involving SBIR and/or STTR funds or found civilly liable for a fraud-related violation involving federal funds:	**NO**

Signature:

Printed Name	**Signature**	**Title**	**Business Name**	**Date**
Suresh Mirchandani	Suresh Mirchandani	COO	Bryka Skystocks LLC	06/13/2022

Audit Information

Summary:

Has your Firm ever had a DCAA review?**NO**

VOL I - Proposal Summary

Summary:

Proposed Base Duration (in months): **24**

Technical Abstract:

Skystocks presents an advanced Gallium Oxide (Ga_2O_3)-based Electrical Accumulator Unit (EAU) designed to revolutionize power stability, emergency responsiveness, and fault management within Aircraft Component Power (ACP) systems. With its unique properties, Ga_2O_3 offers unparalleled efficiency in high-stress, mission-critical environments, providing the U.S. Air Force with a next-generation solution for stable, resilient, and autonomous power management in modern aircraft.

The Ga_2O_3 EAU is engineered to deliver over 90% power conversion efficiency, stabilizing power during electrical transients and enabling reliable bidirectional energy flow across ACP systems. A key feature is its rapid emergency backup, which activates within milliseconds to support critical systems in the event of power disruptions, ensuring seamless operation under adverse conditions. The EAU integrates a cutting-edge Fault Management System (FMS), employing machine learning (3D Convolutional Neural Networks and Reinforcement Learning) to autonomously detect, isolate, and correct power anomalies, thereby enhancing system resilience and extending operational longevity. Designed with aviation's stringent weight and volume constraints in mind, the compact Ga_2O_3 EAU achieves high-density power management without adding significant load to aircraft systems. It includes Maximum Power Point Tracking (MPPT) technology to dynamically optimize power distribution across fluctuating demands, minimizing energy wastage and enhancing efficiency even during peak operational phases. The unit's modular architecture allows for seamless scalability, supporting diverse platforms from unmanned aerial vehicles (UAVs) to advanced tactical aircraft and commercial fleets. Through rigorous functional, environmental, and durability testing, this project aims to validate the EAU's performance in simulated and real-world conditions, encompassing rapid cycling, thermal extremes, and vibration tolerance. By meeting and exceeding aviation safety standards, the Ga_2O_3 EAU positions itself as a breakthrough solution for both defense and commercial aviation, enabling safer, more efficient, and sustainable operations. With its high efficiency, autonomous fault resilience, and immediate backup response, the Ga_2O_3-based EAU is set to become an essential power management component for next-generation aircraft, elevating mission readiness and operational reliability to new heights.

Anticipated Benefits/Potential Commercial Applications of the Research or Development:

DoD Applications

1. Tactical Fighter Jets and UAVs
2. Surveillance and Reconnaissance Aircraft
3. Electronic Warfare (EW) Systems
4. Transport and Refueling Aircraft
5. Future Vertical Lift (FVL) Aircraft

Non-DoD Applications

1. Commercial Aviation (Airliners and Cargo Aircraft)
2. Urban Air Mobility (UAM) and Electric Aircraft
3. Space Systems and Satellites
4. High-Speed Rail and Public Transit
5. Renewable Energy Storage and Grid Stabilization
6. Industrial Power Systems

Attention:

Addition:

Enter the page numbers separated by a space of the pages in the proposal that are considered proprietary:

List a maximum of 8 Key Words or phrases, separated by commas, that describe the Project:

Ga_2O_3-based EAU, power stabilization, emergency backup, fault management, high-efficiency power conversion, autonomous fault detection,

VOL I - Proposal Certification

Summary:

1. At a minimum, at least half (50%) of the research and/or analytical work in Phase II will be carried out by your small business as defined by [13 C.F.R Section 701-705](). The numbers for this certification question are derived from **YES**

the budget template. To update these numbers, review and revise your budget data. If the minimum percentage of work requirements are not met, a letter of explanation or written approval from the funding agreement officer must be uploaded.	
Firm POW	**100%**
Subcontractor POW	**0%**
2. Is primary employment of the principal investigator with your firm as defined by 13 C.F.R Section 701-705?	**YES**
3. During the performance of the contract, the research/research and development will be performed in the United States.	**YES**
4. During the performance of the contract, the research/research and development will be performed at the offerors facilities by the offerors employees except as otherwise indicated in the technical proposal.	**YES**
5. Do you plan to use Federal facilities, laboratories, or equipment?	**NO**
6. The offeror understands and shall comply with export control regulations.	**YES**
7. There will be ITAR/EAR data in this work and/or deliverables.	**NO**
8. Has a proposal for essentially equivalent work been submitted to other US government agencies or DoD components?	**NO**
9. Has a contract been awarded for any of the proposals listed above?	**NO**
10. Firm will notify the Federal agency immediately if all or a portion of the work authorized and funded under this proposal is subsequently funded by another Federal agency.	**YES**
11. Are you submitting assertions in accordance with DFARS 252.227-7017 Identification and assertions use, release, or disclosure restriction?	**NO**
12. Are you proposing research that utilizes human/animal subjects or a recombinant DNA as described in DoDI 3216.01, 32 C.F.R. Section 219, and National Institutes of Health Guidelines for Research Involving Recombinant DNA of the solicitation:	**NO**
13. In accordance with Federal Acquisition Regulation 4.2105, at the time of proposal submission, the required certification template, "Contractor Certification Regarding Provision of Prohibited Video Surveillance and Telecommunications Services and Equipment" will be completed, signed by an authorized company official, and included in Volume V: Supporting Documents of this proposal. NOTE: Failure to complete and submit the required certifications as a part of the proposal submission process may be cause for rejection of the proposal submission without evaluation.	**YES**
14. Are teaming partners or subcontractors proposed?	**NO**
15. Are you proposing to use foreign nationals as defined in 22 CFR 120.16 for work under the proposed effort?	**NO**
16. What percentage of the principal investigators total time will be on the project?	**25%**
17. Is the principal investigator socially/economically disadvantaged?	**NO**
18. Does your firm allow for the release of its contact information to Economic Development Organizations?	**YES**

VOL I - Contact Information

Principal Investigator

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Corporate Official

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Authorized Contract Negotiator

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Email:	**aviationsales@brykagp.com**
Address:	**549 Cedar Street , Newington, CT 06111 - 1814**

1.0 Identification and Significance of the Problem or Opportunity:

Concept of Operation (CONOPS):

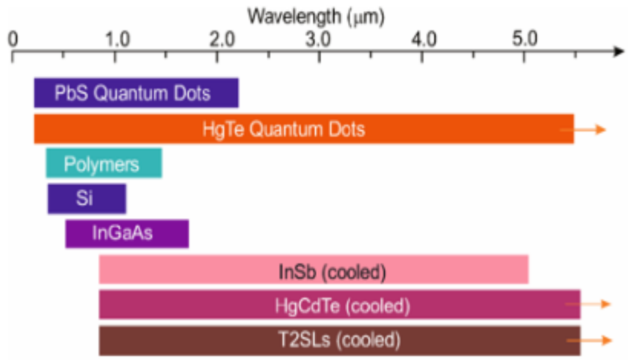


Figure 1 Sensor materials used for detection

The concept of operation (CONOPS) for the U.S. Air Force's proposed HgTe CQD-based MWIR FPA technology involves deploying low-cost, distributed FPA arrays to enhance infrared imaging sensitivity and target tracking capabilities across defense and reconnaissance platforms. These arrays would integrate seamlessly with existing MWIR imaging and targeting systems on platforms such as the MQ-9 Reaper and SBIRS satellites**,** using the scalable, solution-processed HgTe CQD detectors to provide cost-effective, wide-area thermal imaging. The distributed FPA arrays are designed to increase the detection aperture, synchronizing multiple FPA panels across diverse locations to improve spatial coherence and signal fidelity. By focusing on target coherence and multi-array synchronization, this system will enable accurate real-time tracking of low-signature or fast-moving targets, crucial for surveillance and missile defense applications. Operating as a sparse array configuration**,** these HgTe CQD FPAs are optimized for minimal power consumption, utilizing lightweight thermoelectric cooling systems to maintain target sensitivity without requiring heavy cryogenic infrastructure. This low-power, distributed design will enhance the Air Force's capability to monitor large areas and perform high-fidelity imaging in contested environments, all while minimizing system costs and logistical requirements.

Current State of the Art:

The U.S. Air Force and Department of Defense rely on advanced MWIR Focal Plane Array (FPA) systems that integrate cryogenically-cooled, epitaxial semiconductor materials for high-sensitivity infrared detection. These state-of-the-art systems use HgCdTe (mercury cadmium telluride) and InSb (indium antimonide) detectors, which offer exceptional performance in the mid-wave infrared (MWIR) range (3-5 µm), essential for applications in surveillance, missile defense, and target track ing. Cryogenic cooling, often using Stirling or Joule-Thomson cryocoolers, is necessary to maintain low noise levels and high sensitivity, as these materials generate significant thermal noise at higher temperatures. Critical systems include space-based infrared (SBIR) sensors, such as those used in the Space-Based Infrared System (SBIRS) and Overhead Persistent Infrared (OPIR) satellites, as well as airborne platforms like the MQ-9 Reaper and RC-135 Rivet Joint. These sensors provide high-resolution MWIR imaging and tracking capabilities across a wide field of view, supporting real-time threat detection and monitoring. However, the reliance on expensive substrates, epitaxial growth processes, and cryogenic cooling increases overall system costs and complexity, limiting the scalability of such systems for broader or more compact platforms. While these FPAs deliver robust performance for missile detection and tracking, ongoing research into HgTe CQD and PbSe-based detectors aims to develop more scalable, lower-cost alternatives that could operate effectively at higher temperatures, reducing the need for cryogenic cooling and enabling deployment in expendable or smaller defense platforms.

Limitations of the current state of the Art:

High Cost: Current MWIR FPAs use epitaxial compound semiconductor materials that require cryogenic cooling to reduce noise, which increases costs. Major cost factors include high-quality substrates, complex material deposition, fabrication, die-level hybridization, and the cryocooler.

Low Operating Temperature Requirement: To achieve the desired noise performance, these FPAs operate at cryogenic temperatures, often requiring cooling below 77 K. This cooling setup not only adds to the cost but also increases system size and weight, limiting deployment on low-cost or expendable platforms.

Limited Material Stability and Process Maturity: Emerging alternatives like PbSe-based photoconductors and mercury chalcogenide CQDs (HgTe and HgSe) require significant development in areas such as material stability and process optimization, particularly for small-pixel fabrication and understanding carrier dynamics.

Noise and Dark Current Challenges: For both PbSe and CQD-based detectors, managing 1/f noise and achieving low dark current levels are significant challenges. These factors impact the detector's sensitivity and are crucial for achieving a NEP target below 100 fW/Hz^1/2**.**

Complexity in ROIC Integration: Integration with ROIC (Readout Integrated Circuit) at the wafer scale, especially for photoconductors, requires specialized designs to maintain performance at small pixel scales. This ROIC adaptation for photoconductor architectures adds design and manufacturing complexity.
Reliance on Cryogenic Cooling for CQDs: While mercury chalcogenide CQDs operate at slightly higher temperatures than traditional epitaxial materials, they still require some level of cryocooling to manage dark current and noise, which complicates design and increases overall system costs.

Proposed Technology:

Bryka Skystocks LLC., which has 20 years with a robust background in sensor and quantum dot technology development for defense applications, proposes a cost-effective, high-sensitivity thermal imaging solution based on HgTe Colloidal Quantum Dot (CQD) Focal Plane Array (FPA) technology for mid-wave infrared (MWIR) detection. This HgTe CQD FPA technology is engineered to provide reliable MWIR imaging capabilities that are scalable, lightweight, and optimized for low-cost production, addressing critical requirements for advanced infrared detection in U.S. Air Force applications.

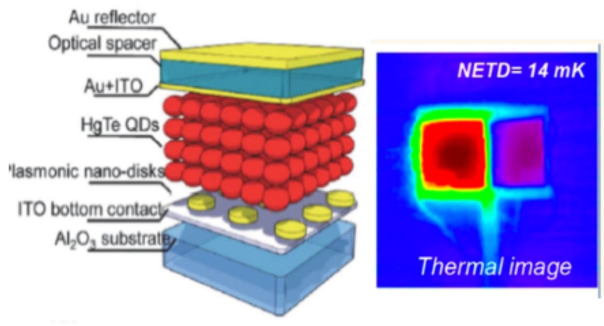


Figure 2 Bryka Skystocks proposed solution

HgTe CQD-Based FPA Panels: Bryka Skystocks LLC's HgTe CQD FPAs use a scalable thin-film deposition method to produce arrays with high efficiency in the MWIR band (3-5 µm), suitable for thermal imaging, tracking, and target acquisition. This approach offers an ideal solution for enhanced sensitivity and wide-area thermal imaging without cryogenic cooling.
Mid-Wave Infrared Compatibility: Optimized for the 3-5 µm MWIR range, the HgTe CQD-based FPA panels enable high-resolution thermal detection, supporting broad-area target tracking and situational awareness across various defense and surveillance applications. The optimized MWIR sensitivity facilitates effective performance in low-light and high-contrast scenarios, improving target discrimination.
Solution-Based Processing for Cost Reduction: Using cost-efficient solution processing for HgTe CQDs, Bryka Inc. has developed FPA panels that balance performance with low production costs, allowing for broad deployment across multiple platforms without significantly increasing budget constraints.
Thermoelectric Cooling for Low Power Consumption: These CQD panels operate at higher temperatures (around 200 K) with optional thermoelectric cooling, eliminating the need for bulky cryogenic systems. This provides efficient thermal imaging at lower power, enabling use on small, battery-operated, and lightweight platforms.
Distributed Focal Plane Array System: The proposed solution adopts a distributed architecture, with multiple FPA panels deployed across various platforms, allowing for synchronized, large-area MWIR coverage.
Independent Front-Ends: Each FPA panel operates independently but synchronizes data to ensure coherence, enabling high-resolution thermal imaging and real-time tracking across wide operational regions. This setup supports platform orientation and deployment location adaptability, enhancing versatility across defense missions.
Digital Signal Processing and Synchronization: Each FPA panel includes digital processing components to enhance signal clarity and coherence across the array. This is crucial for applications requiring precise target detection and tracking.

Distributed Phased-Array Front-Ends:
The proposed solution employs a distributed phased-array architecture, where multiple phased-array front-ends are positioned across a wide area. Each front end operates independently but synchronized, forming a highly sensitive, scalable radar system.
Independent Front-Ends: Each front-end includes 64-channel transmit-receive (TR) modules and 64-channel signal processors. These components work together to process incoming radar signals, perform beamforming, and synchronize with other panels in the array.
Modular and Adaptable Layout: These distributed front-ends allow for adaptive deployment. Panels can be positioned at various locations, allowing the system to cover different geographical areas depending on mission requirements. This flexibility helps create a wide-area radar system to detect missile threats across vast regions.
Digital Processing: Each front-end features high-speed digital signal processors (DSPs) that handle real-time radar data processing. This includes tasks such as down-conversion, filtering, and beamforming. The system uses coherent

processing, ensuring that the radar signals collected from multiple panels are synchronized and combined to produce a unified radar picture.

Synchronized Wide-Area Thermal Imaging: A key feature of the HgTe CQD-based FPA system is its synchronized wide-area imaging capability, allowing for real-time, coherent thermal data capture across multiple platforms. This approach ensures rapid thermal scanning of large areas, supporting responsive situational awareness.

Accurate Data Synchronization: The system achieves synchronization across multiple FPAs, maintaining data coherence and precision. This is essential for aligning thermal images from different viewpoints, ensuring consistent, accurate detection of low-signature and fast-moving targets.

Wide-Field Scanning: The FPA panels perform efficient wide-field scanning, enabling coverage over large areas with minimal latency. This rapid scanning capability is critical for real-time threat detection, particularly in high-mobility defense scenarios.

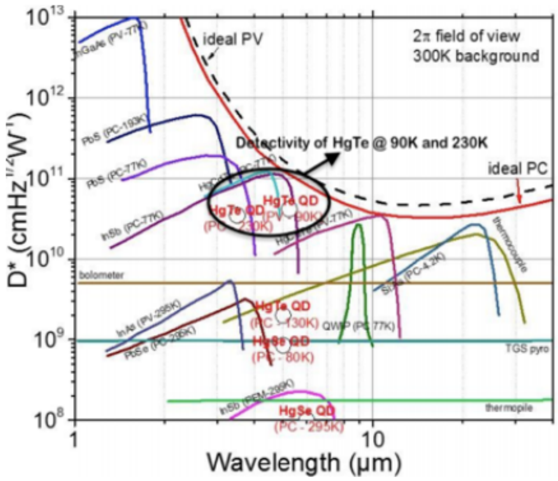


Figure 3: Specific detectivity of various QD Detectors

System Scalability and Modular Design: The proposed HgTe CQD FPAs are modular and scalable, supporting seamless expansion by integrating additional panels to broaden MWIR coverage. This scalability allows for mission-specific deployment adjustments, ensuring adaptability for various Air Force applications. Commercial CQD processing technology reduces per-unit costs, making the system viable for large-scale deployment without compromising performance.

Integration with Air Force Systems: Bryka Skystocks LLC's HgTe CQD FPAs are designed for easy integration with existing Air Force EO/IR systems, providing a cost-effective means of enhancing thermal detection capabilities across surveillance and target acquisition networks. This compatibility with Air Force platforms allows for expanded sensor capabilities to support various applications within the Air Force's layered defense infrastructure, from survey to missile warning.

Cost Efficiency: By leveraging solution-processed HgTe CQDs, Bryka Skystocks LLC. Achieves significant cost reductions, making this FPA technology suitable for broad deployment across multiple platforms. The scalable and modular nature of the design enables flexible expansion, allowing for wide-area thermal imaging coverage at a fraction of the cost of traditional MWIR systems.

Unique Position: Bryka Skystocks LLC. Brings specialized expertise in advanced infrared sensor development, drawing from successful projects with the U.S. Department of Defense and other government agencies. Recently, Bryka Skystocks LLC. has advanced HgTe Colloidal Quantum Dot (CQD) technology in collaboration with the U.S. Air Force on high-sensitivity, mid-wave infrared (MWIR) focal plane arrays (FPAs). This technology development included creating solution-processed HgTe CQDs with optimized quantum efficiency across the 3-5 µm range, tailored for high-sensitivity MWIR imaging. The FPA panels are specifically engineered for stable, high-resolution thermal imaging without cryogenic cooling. They are suitable for demanding applications like airborne and satellite surveillance, target acquisition, and threat detection in defense environments. Bryka Skystocks LLC. Leverages its experience in material science, sensor design, and system integration to refine HgTe CQD-based FPAs for wide-area MWIR coverage, combining modularity and scalability with efficient power management. By drawing on this expertise, Bryka Inc. is well-positioned to deliver cost-effective, advanced MWIR FPA solutions that address the U.S. Air Force's requirements for low-cost, high-performance thermal imaging across various mission-critical applications.

<u>Overview of the 3-Phase Program and Key Outcomes:</u>

In Phase 1**,** Bryka Skystocks LLC, will create a comprehensive reference model for the proposed HgTe Colloidal Quantum Dot (CQD) Focal Plane Array (FPA) technology aimed at mid-wave infrared (MWIR) detection, specifically designed for operation at temperatures above 200 K. This initial phase will survey current MWIR technologies to evaluate the scalability and suitability of HgTe and PbSe CQDs for low-C-SWaP (Cost, Size, Weight, and Power) applications. Key performance metrics such as Noise Equivalent Power (NEP)**,** dark current**,** and quantum efficiency (EQE) will be defined, and a testbed will be constructed to assess multi-array coherence and stability. In Phase 2**,** Bryka Skystocks LLC. will design a complete distributed FPA system, integrating independently operable CQD arrays with thermoelectric cooling to achieve high-resolution imaging and efficient thermal stability without relying on cryogenic systems. Rigorous testing will validate NEP, dark current, and system stability**.** Phase 3 will expand the technology for broader deployment, aiming to reach target pixel operability (>98%) and meet scalability requirements for real-world applications. This phase will confirm coherence, signal processing, and MWIR imaging performance across the 3-5 µm range, demonstrating the system's robustness for surveillance, reconnaissance, and threat detection applications, aligned with Air Force mission requirements.

2.0 Technical objective:

Technical Objective 1: Develop and Simulate a Comprehensive Reference Model for HgTe CQD FPA Technology:
We will develop and simulate a comprehensive reference model for the proposed HgTe CQD-based Focal Plane Array (FPA) technology**,** tailored for mid-wave infrared (MWIR) detection across the 3-5 µm spectrum. The simulation will optimize the FPA to meet essential Air Force requirements for sensitivity, dark current, and noise reduction in surveillance and target acquisition applications. This model will ensure that the HgTe CQD-based FPA maintains high Noise Equivalent Power (NEP) and dark current performance while providing stable, high-resolution imaging across the MWIR range, supporting reliable detection and tracking in diverse operational conditions.
Risk: Data Insufficiency on Current Technologies-Without a thorough understanding of existing MWIR FPA technologies, the reference model may need more critical details, leading to design inefficiencies.
Mitigation: Conduct an exhaustive survey of existing HgTe CQD and alternative FPA technologies to establish benchmarks for cost, scalability, NEP, dark current, and EQE. Bryka will use data from similar solution-processed materials to predict and validate critical metrics, ensuring the model reflects feasible performance standards.

Technical Objective 2: Establish Multi-Array Synchronization and Coherence Requirements:
We will design and simulate the performance of multi-array synchronization and coherence algorithms across distributed HgTe CQD-based Focal Plane Array (FPA) panels. This simulation will validate real-time coherence, signal combining, and synchronization across arrays, ensuring minimal discrepancies in data capture and maximizing imaging clarity. By establishing and testing dynamic coherence controls, we aim to ensure that the FPA system achieves optimal data alignment, high thermal imaging, and target tracking accuracy, even in multi-platform deployments across varying operational environments.
Risk: **Complexity in Synchronizing Distributed Arrays** – Ensuring precise coherence across multiple FPA panels may be challenging, potentially affecting imaging clarity and multi-array operability.
Mitigation: Develop a testbed for validating multi-array synchronization and implement software-based dynamic coherence controls to maintain consistent image quality. Bryka will simulate different deployment configurations to optimize synchronization, minimizing potential issues during real-world operation.

Technical Objective 3: Define Dark Current and NEP Standards for the Target Operating Temperature (200 K or Higher):
This objective will focus on testing and validating the HgTe CQD-based Focal Plane Array (FPA) system to maintain target dark current and Noise Equivalent Power (NEP) standards at 200 K or higher operating temperatures. Simulations will ensure that the FPA system sustains high performance and low noise levels across distributed arrays, leveraging adaptive signal processing and robust thermal stabilization methods. By defining precise dark current and NEP thresholds, the system will be optimized for sensitivity and noise control in real-world surveillance and target acquisition applications, supporting consistent imaging clarity and reliability at elevated temperatures.

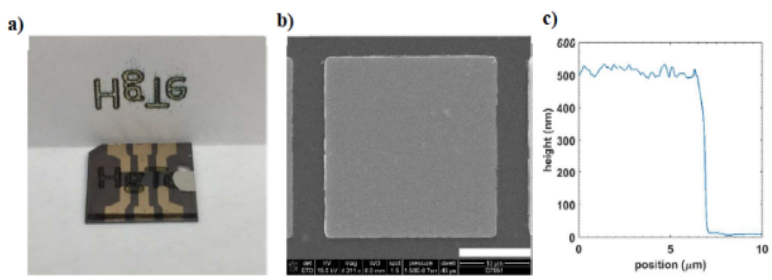


Figure 4 Ag2Te/ HgTe thin film prepared on ITO/Sapphire substrate

Technical Objective 4: Evaluate Suitability of Pixel-Less Array Fabrication for Cost Reduction:
Risk: **High Dark Current at Elevated Temperatures** – Operating at 200 K could result in elevated dark current, impacting sensitivity and noise levels in the FPA.
Mitigation: Integrate thermoelectric cooling within the FPA design for stable operation at or above 200 K, reducing dark current without cryogenic systems. Surface passivation and optimized CQD synthesis will be applied to reduce trap states, helping meet the desired NEP and dark current levels.

Technical Objective 5 : Seamless Integration with CMOS-Compatible Readout Integrated Circuits (ROIC):

Risk: **Material and Compatibility Issues**: Integrating HgTe CQDs with CMOS technology can be challenging due to differences in material properties and processing conditions.

Mitigation: Bryka Skystocks LLC will apply hybrid bonding techniques that allow the CQD layer and ROIC to be manufactured and bonded at lower temperatures, preserving CMOS compatibility. The team will also develop CMOS-compatible encapsulants and coatings to protect the CQDs without interfering with signal transmission, ensuring efficient integration and performance consistency.

Technical Objective 6: Radiation Hardness for Space Applications:

Risk: **Sensitivity to Radiation**: HgTe CQDs can be sensitive to radiation, a significant risk for long-term use in space environments where radiation exposure is high.

Mitigation: Bryka Skystocks LLC will explore radiation-resistant coatings or materials, such as oxide passivation layers, to shield the CQDs from radiation. Testing the CQD arrays in simulated radiation environments will help assess resilience, while material improvements can focus on creating a stable structure less prone to radiation-induced defects.

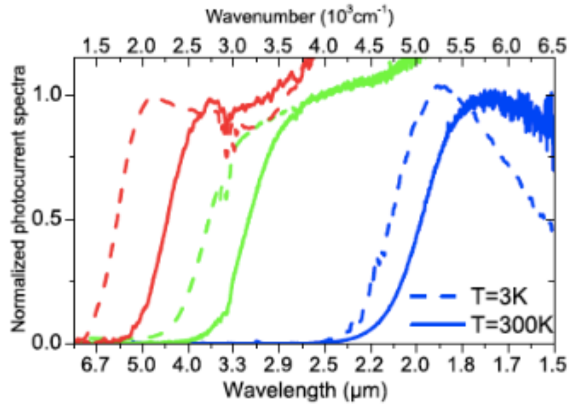


Figure 5 Normalized photocurrent spectra for three different sizes of HgTe nanoparticle@T=3K (dashed line) and at room temperature (solid line). Particle size 5nm (blue), 8nm and 12nm(red)

3.0 Statement of Work:

Task 1: Design of HgTe CQD Film for MWIR Detection:

Subtask: Synthesize HgTe Quantum Dots (QDs):

- **Define Target QD Size**:

Based on MWIR wavelength sensitivity, target a quantum dot size of 8-12 nm**,** which optimally tunes the bandgap to the 3-5 µm range.
This size selection allows enhanced infrared absorption while controlling carrier recombination rates to achieve the desired sensitivity.

- **Synthesize QDs Using Solution-Phase Chemical Techniques**:

Prepare a solution-phase synthesis using precursors such as HgCl2 (mercury chloride) and NaHTe (sodium hydrogen telluride**)** as sources of Hg and Te, respectively.
The reaction will occur in a coordinating solvent such as oleylamine at a controlled temperature of 80-100°C**.** This solvent provides stabilization during growth, preventing QD aggregation and maintaining size uniformity.
Monitor the reaction using UV-Vis spectroscopy to observe shifts in absorbance, confirm QD size, and narrow the bandgap to align with MWIR requirements.
Once the QDs reach the target size (confirmed through absorbance peaks in the desired MWIR range), the reaction is quenched by rapidly lowering the temperature, which stops growth and preserves the desired size distribution.

- **Purify Quantum Dots**:

Purify the synthesized QDs by repeated centrifugation and washing with nonpolar solvents, such as hexane, to remove excess ligands and unreacted precursors.
After purification, disperse the QDs in a solvent suitable for deposition, such as toluene**,** to ensure uniform film formation.

Subtask 2: Prepare Substrate and Deposition Parameters:

- **Select Substrate**:

Choose a CMOS-compatible substrate like silicon or glass with a deposited SiO2 layer (thickness 50 nm) to enhance compatibility with readout integrated circuits (ROICs) and improve device integration.

- **Clean the Substrate**:

Clean the substrate using a standard Piranha solution (3:1 mixture of H2SO4 and H2O2) to remove organic contaminants. Rinse thoroughly with deionized water and dry with nitrogen.
Conduct a final plasma treatment (e.g.**,** oxygen plasma for 5 minutes**)** to enhance surface energy and promote adhesion of the QD film.

- **Define Deposition Parameters**:

Use spin-coating as the deposition method to ensure uniform film thickness. Set initial parameters for spin-coating at 3000 rpm for 30 seconds to create a uniform 1 µm thick layer of HgTe CQDs on the substrate.

Multiple layers of QDs may be required to achieve the desired thickness and sensitivity. Repeat the spin-coating process to build up to the final thickness (targeting 1-2 μm).

Subtask 3: Ligand Exchange for Enhanced Conductivity:

- **Prepare Ligand Exchange Solution**:

Prepare a ligand exchange solution using 1,2-ethanedithiol (EDT) in acetonitrile. Replace the long insulating ligands on the QDs with short conductive ones, improving charge transport across the film.

- **Perform Ligand Exchange on Film**:

After each spin-coated layer, apply the EDT solution to the film for 1-2 minutes**,** allowing it to infiltrate and replace the original ligands.

Rinse the film with acetonitrile to remove unreacted EDT and ensure the film is not damaged.

This exchange process improves carrier mobility and reduces resistance, optimizing the QD film for MWIR detection.

Subtask 4: Annealing the Film for Enhanced Stability:

- **Set Annealing Temperature and Time**:

Place the substrate with the HgTe CQD film in a controlled inert gas atmosphere (e.g., nitrogen) to prevent oxidation during annealing.

Anneal the film at 150°C for 30 minutes to remove any remaining solvent residues and enhance bonding between QDs, stabilizing the film.

- **Monitor Film Quality Post-Annealing**:

Scanning electron microscopy (SEM) inspects the surface morphology of the annealed film, ensuring uniformity and minimal cracking.

Check the thickness post-annealing to confirm it aligns with the target (1-2 μm), as the annealing process may cause minor shrinkage.

Subtask 5: Characterize and Test HgTe CQD Film Performance:

- **Conduct Absorption Spectroscopy**:

Use an infrared (IR) spectrometer to measure the absorption spectrum of the film across the 3-5 μm range, confirming that the QD bandgap aligns with MWIR detection needs.

- **Measure Dark Current and Quantum Efficiency**:

Measure dark current at the operational temperature of 200 K, aiming for a dark current value of approximately 5 x 10^-9 A**.**

Measure quantum efficiency (QE) across the MWIR range, targeting at least 0.6 to ensure sufficient photoresponse for high-sensitivity applications.

- **Evaluate Noise Equivalent Power (NEP)**:

Using a calibrated infrared source, measure the film's Noise Equivalent Power (NEP) at 200 K, with the target NEP set at 100 fW/Hz1/2 for effective MWIR detection.

Task 2: Integrate HgTe CQDs with Black Silicon and Gold Reflector Structure:

Subtask 1: Prepare the Black Silicon Substrate:

- **Create Black Silicon Layer**:

Begin with a silicon wafer (typically p-type or n-type) as the base substrate. Reactive-ion etching (RIE) with SF6 and O2 plasma gases creates a black silicon layer on the wafer. This process forms nano-scale surface structures that trap light, reducing reflectance and enhancing photon absorption.

To achieve the desired nano-texturing, set the RIE parameters to 200 W power, 20 mTorr pressure, and a processing time of 10 minutes.

- **Characterize Black Silicon Properties**:

Measure the black silicon layer's reflectance using a UV-Vis-NIR spectrometer to confirm it is below 1% in the MWIR range (3-5 μm). Ensure uniformity across the surface to maintain consistent absorption characteristics.

Subtask 2: Deposit a Gold Reflector Layer:

- **Apply Adhesion Layer**:

Using electron beam evaporation, deposit a 5 nm titanium layer on the black silicon. This layer enhances adhesion between the black silicon and gold layers without affecting optical performance.

- **Deposit Gold Layer**:

Thermal evaporation deposits a 100 nm thick gold layer on the titanium adhesion layer. The gold layer acts as a back reflector, ensuring that any unabsorbed light in the MWIR range is reflected into the HgTe CQD layer for additional absorption.

Confirm layer thickness and uniformity using scanning electron microscopy (SEM) and measure the reflectivity to ensure optimal reflection in the MWIR band.

Subtask 3: Spin-Coat HgTe CQD Film on Black Silicon with Gold Reflector:

- **Prepare HgTe CQD Solution for Spin Coating**:

Disperse the synthesized HgTe CQDs in a solvent (e.g., to luene) to form a stable colloidal solution suitable for spin-coating. Ensure a particle concentration that allows for a uniform 1-2 µm thick film.

- **Spin-Coat HgTe CQD Film**:

Spin-coat the HgTe CQD solution onto the black silicon with the gold reflector structure at 3000 rpm for 30 seconds to achieve a uniform 1 µm film thickness. Repeat the process to build up to a final thickness of 1-2 µm for enhanced MWIR sensitivity.

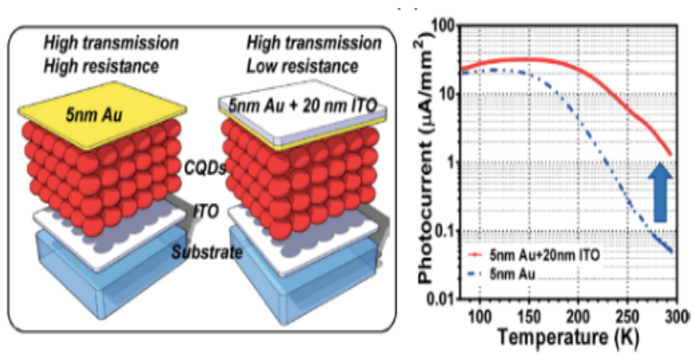


Figure 6: Illustration of top Au and Au+ITO contact and temperature dependent photocurrent density

- **Perform Ligand Exchange**:

After each layer deposition, a ligand exchange with 1,2-ethanedithiol (EDT) replaces insulating ligands with conductive ones, improving charge transport through the CQD layer.

Subtask 4: Anneal the Composite Structure:

- **Conduct Inert Gas Annealing**:

Place the composite structure in a nitrogen atmosphere for 30 minutes to anneal at 150°C. This process improves adhesion between layers and removes any remaining solvent, enhancing film stability and conductivity.

- **Inspect Film Quality Post-Annealing**:

Use SEM to check the film surface for uniformity and potential defects. Confirm that the HgTe CQD layer adheres well to the black silicon with the gold reflector and shows no signs of cracking.

Task 3: Simulation of a Complete HgTe CQD Photodetector:

Subtask 1: Define Photodetector Structure and Material Properties:

- **Set Device Layer Structure**:

Define the layered structure of the photodetector, including:
HgTe CQD layer (1 µm thick).
SiO2 passivation layer (50 nm thick).
Gold reflector (100 nm thick).
Silicon or glass should be used as the primary substrate for compatibility with CMOS integration.

- **Input Material Properties**:

For the HgTe CQD layer, set:
Absorption coefficient: 10^4 cm^-1, tuned to 3-5 µm MWIR range.
Electron mobility: 10 cm^2/V·s.
Dielectric constant: 12.
Set properties for other materials:
SiO2 dielectric constant of 3.9.
Gold layer reflectivity tuned for 3-5 µm wavelengths.
Enter these values into the simulation tool to model the interactions within the photodetector.

Subtask 2: Perform Optical Simulation:

- **Configure Optical Simulation for Absorption and Reflection**:

Use COMSOL Multiphysics' Wave Optics module to set up an optical simulation across the MWIR wavelength range of 3-5 µm.
Model light enters the photodetector structure at normal incidence and passes through the HgTe CQD layer, with reflections from the gold reflector layer.

- **Analyze Absorption Efficiency**:

Set the simulation to measure absorption efficiency across the 3-5 µm range. The goal is to achieve absorption of over 90% of incident light within this range, which maximizes the quantum efficiency of the device.
Generate an absorption map of the HgTe CQD layer to observe how light is absorbed and where enhancement is needed.

- **Validate and Adjust Parameters**:

Based on the absorption results, adjust the thickness of the CQD or reflector layer if absorption falls below target levels. By maximizing absorbed light ensures that the configuration achieves maximum photon-to-electron conversion.

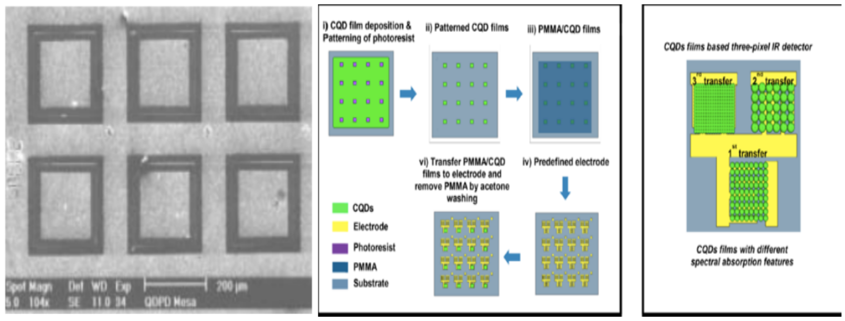


Figure 7: Quantum dot IR Detector, PMMA assisted method for multipixel photodetector array and schematic configuration of fabricated multipixel photodetector

<u>Subtask 3: Simulate Electrical Behavior and Carrier Dynamics:</u>

- **Configure Electronic Simulation for Charge Transport**:

Using Sentaurus TCAD**,** the electronic simulation is set up to model carrier transport within the HgTe CQD layer. Input electron mobility of 10 cm^2/V·s and hole mobility of 5 cm^2/V·s to reflect realistic transport dynamics in the CQD material.
The photodetector's operating bias should be set to 0.5 V to facilitate charge separation and movement within the CQD layer.

- **Analyze Dark Current and Carrier Recombination**:

Simulate to observe dark current levels across the photodetector, targeting a value below 5 x 10^-9 A at 200 K.
Model carrier recombination within the CQD layer to identify areas with high recombination rates, which can reduce sensitivity. Adjust material properties, such as doping levels or layer thickness, to minimize recombination and dark current.

- **Measure Quantum Efficiency (QE) and NEP**:

Simulate the photodetector's response to incident photons across the 3-5 µm range, calculating quantum efficiency (QE) at each wavelength. Aim for a QE of 0.6 to ensure effective photon-to-electron conversion.
Calculate the Noise Equivalent Power (NEP**)** at 200 K, targeting a 100 fW/Hz^1/2 value to achieve high sensitivity for MWIR applications.

<u>Subtask 4: Perform Thermal Simulation for Temperature Stability:</u>

- **Configure Thermal Simulation for 200 K Operation**:

In COMSOL Multiphysics, the Heat Transfer module simulates the photodetector's thermal behavior when operating at 200 K with thermoelectric cooling.
Set heat generation parameters based on dark current and biasing, considering power dissipation within the CQD layer and other components.

- **Analyze Temperature Distribution**:

Simulate to measure the temperature distribution across the photodetector, ensuring that all layers remain stable around 200 K.
If temperature hotspots are observed, adjust cooling parameters or introduce additional thermal management layers to stabilize the system.

- **Validate Stability Against Thermal Fluctuations**:

Check that the thermal stability is maintained within ±2 K of the target operating temperature to prevent performance degradation. Confirm that dark current and NEP remain stable under these thermal conditions.

<u>Subtask 5: Summarize and Validate Simulation Results:</u>

- **Compile Performance Metrics**:

Summarize the simulation results, explicitly noting:
Absorption efficiency: Target >90% across 3-5 µm.
Dark current: Below 5 x 10^-9 A at 200 K.

Quantum efficiency (QE): 0.6 or higher.
Noise Equivalent Power (NEP): 100 fW/Hz^1/2.

- **Validate Against Design Requirements**:

Compare the achieved values with the design requirements. If performance metrics fall short, adjust layer thickness, material properties, or cooling configurations and re-run simulations.
Document final validated values as benchmarks for experimental design and fabrication stages.

- **Report Findings for Design Optimization**:

Generate a report detailing simulation outcomes, adjustments, and final design parameters. This report will guide the physical construction of the HgTe CQD photodetector.

Task 4: Simulation of a Complete HgTe CQD Photodetector for MWIR Detection:
Subtask 1: Define Device Structure and Material Properties:

- **Layered Device Structure Setup**:

Define a multi-layered structure in the simulation model that includes:
HgTe CQD active layer (1 µm thickness),
SiO2 passivation layer (50 nm thickness), and
Gold reflector (100 nm thickness).
Use a silicon substrate with a 50 nm SiO2 layer chosen for compatibility with CMOS integration.

- **Material Properties Assignment**:

Input the following critical properties for each layer:
HgTe CQD Layer: Absorption coefficient of 10^4 cm^-1 tuned to the 3-5 µm MWIR range, electron mobility of **10 cm^2/V·s**, dielectric constant of 12.
Gold Reflector: Set reflectivity properties for 3-5 µm wavelengths.
Ensure each property is realistic and tuned for the MWIR range, essential for the photodetector's sensitivity and absorption performance.

Subtask 2: Perform Optical Simulation

- **Set Up Optical Absorption Simulation**:

In the COMSOL Multiphysics' Wave Optics module, configure an optical simulation that models incident light at 3-5 µm wavelengths entering the HgTe CQD layer and reflecting off the gold reflector.
Define simulation boundaries to capture photon interactions across the entire detector structure.

- **Run Absorption Analysis**:

Run the simulation, focusing on absorption efficiency. Aim for absorption levels above 90% within the 3-5 µm range.
Generate an absorption map of the HgTe CQD layer, showing photon distribution and identifying areas with optimal absorption.

- **Parameter Adjustment and Re-simulation**:

If absorption efficiency is below target, adjust the thickness of the CQD layer (within a range of 1-2 µm) or the reflector layer and re-run the simulation. The goal is to optimize photon interaction to maximize quantum efficiency.

Subtask 3: Simulate Electrical Properties and Charge Transport:

- **Setup for Charge Transport Simulation**:

In Sentaurus TCAD**,** configure the electronic simulation model to evaluate charge transport through the HgTe CQD layer. Use properties like electron mobility of 10 cm2/V ·s and hole mobility of 5 cm2/V ·s to reflect realistic carrier dynamics.
Apply a bias voltage of 0.5 V across the photodetector to drive charge separation and facilitate carrier movement.

- **Dark Current and Recombination Analysis**:

Simulate to observe dark current behavior, targeting a stable level of 5 x 10^-9 A at 200 K.
Model carrier recombination processes within the CQD layer, identifying areas of high recombination and minimizing them by adjusting layer properties (e.g., doping or thickness).

- **Quantum Efficiency (QE) and NEP Calculation**:

To calculate quantum efficiency (QE), simulate the photodetector's response to incident photons across the 3-5 µm range. Aim for QE values of at least **0.6** for effective photon-to-electron conversion.
Calculate the Noise Equivalent Power (NEP) at 200 K, with a target of 100 fW/Hz^1/2**,** ensuring that the photodetector has high sensitivity for MWIR applications.

Subtask 4: Perform Thermal Stability Simulation:

- **Set Up Thermal Simulation for 200 K Operation**:

Using the Heat Transfer Module in COMSOL Multiphysics, a thermal simulation was set up to model temperature stability when operating at 200 K with thermoelectric cooling.
Define the heat generation parameters based on dark current and bias power, as these factors influence the thermal profile across the detector.

- **Analyze Temperature Distribution**:

Run the simulation and monitor the temperature distribution across the layers. The target is maintaining stable operation at 200 K with minimal thermal gradients.
If temperature fluctuations exceed ±2 K, adjust cooling settings or layer thicknesses to stabilize the thermal profile.

- **Validate Performance Stability**:

Confirm that dark current, QE, and NEP metrics remain stable under simulated thermal conditions. Verify that the design meets target performance values without degradation due to temperature instability.

<u>Subtask 5: Compile and Validate Simulation Results:</u>

- **Document Key Performance Metrics**:

Record the final results for each performance metric, ensuring they meet the design targets:
Absorption efficiency: >90% within 3-5 µm range.
Dark current: Approximately 5 x 10^-9 A at 200 K.
Quantum Efficiency (QE)**:** At least 0.6.
Noise Equivalent Power (NEP)**:** 100 fW/Hz^1/2.

- **Evaluate Results Against Design Requirements**:

Compare each achieved value with the design targets. If any metric falls short, adjust material properties, layer thickness, or bias settings, and re-run simulations as needed.
Ensure that results align with MWIR application requirements for high-sensitivity, low-noise detection.

- **Finalize Report on Simulation Findings**:

Prepare a comprehensive report summarizing simulation outcomes, adjustments, and validated parameters. Include detailed results for absorption efficiency, dark current, QE, and NEP to guide future experimental validation and fabrication.

<u>Task 5: Implementation of CMOS-Compatible ROIC for HgTe CQD-Based MWIR Photodetector:</u>
<u>Subtask 1: Define ROIC Design Requirements and Specifications:</u>

- **Establish Key Performance Metrics**:

Set target specifications based on photodetector requirements:
Input capacitance: Match with the HgTe CQD pixel capacitance to ensure minimal signal degradation.
Dark current noise floor: Design for compatibility with the photodetector's dark current of approximately 5 x 10^-9 A**.**

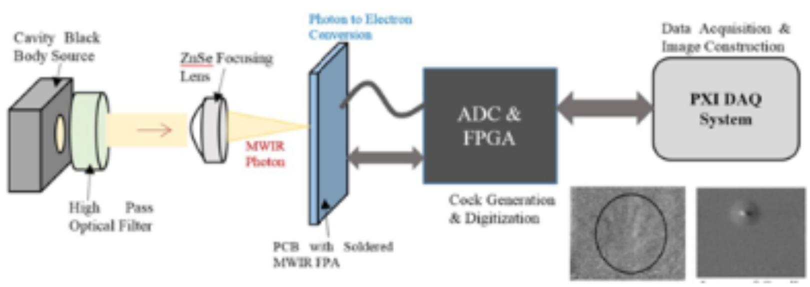


Figure 8: MWIR test set up block diagram.

Noise Equivalent Power (NEP):
Ensure the ROIC maintains signal integri ty compatible with the photodetector's 100 fW/Hz^1/2 NEP target**.**

- **Define Architecture and Power Requirements**:

Choose a low-noise trans-impedance amplifier (TIA) architecture, as it offers high sensitivity and minimal noise in MWIR applications.
Set the ROIC's operating voltage at 3.3 V**,** which is standard in CMOS processes and ensures compatibility with other integrated circuit components.
Outline an adaptive power management circuit to minimize power usage without sacrificing sensitivity, which is crucial for operation at 200 K.

<u>Subtask 2: Design Signal Amplification and Noise Control Circuits:</u>

- **Design Transimpedance Amplifier (TIA) for Low-Noise Amplification**:

Configure the TIA with a **gain of 1 MΩ** to amplify weak photocurrent signals from the HgTe CQD photodetector without excessive noise.
Set the TIA bandwidth in the MWIR range using a feedback resistor and capacitor combination, ensuring signal fidelity across the 3-5 µm wavelength range.

- **Implement Dark Current Management Circuitry**:

Design an auto-zeroing circuit to cancel out the dark current component from the output signal, improving overall signal clarity.
Integrate a low-pass filter with a cutoff frequency around 10 Hz to smooth out any remaining noise spikes due to dark current fluctuations, aligning with the photodetector's target dark current performance.

- **Add Low-Noise Bias Control Circuitry**:

Implement a bias control circuit with a precision voltage regulator to maintain stable bias across each pixel and reduce noise from power supply variations.
Include a temperature-compensation feature to adjust bias levels as the ROIC operates at 200 K, ensuring signal stability across the FPA.

Subtask 3: Design Real-Time Signal Synchronization for Multi-Array Coherence:

- **Develop Synchronization Clock Network**:

Design a distributed clocking network that provides a synchronization signal to each pixel in the array, ensuring coherence between panels in multi-array configurations.
Set the clock frequency at 10 MHz for optimal timing resolution, with an inter-pixel delay tolerance within 0.1 ns to maintain signal coherence.

- **Integrate Sample-and-Hold Circuitry for Signal Integrity**:

Implement sample-and-hold circuits in each pixel, capturing the signal immediately after amplification and holding it for analog-to-digital conversion. This approach prevents signal degradation in real-time imaging applications.
The sampling time should be 100 ns**,** ensuring minimal signal loss and enabling real-time imaging coherence across distributed arrays.

Subtask 4: Simulate the ROIC Performance and Validate Design:

- **Run Noise and Signal Integrity Simulations**:

Use Cadence Virtuoso to simulate noise levels within the ROIC circuitry. Confirm that the dark current noise floor is well within the tolerance of the photodetector's dark current (targeting a noise floor of 1 x 10^-10 A).
Simulate the TIA's performance with input currents in the 1-10 nA range and verify that the amplification maintains signal clarity across this range.

- **Validate Thermal Performance at 200 K**:

The ROIC at 200 K will be simulated to ensure biasing and signal amplification stability. The bias control circuits will be tested for thermal shifts, and the temperature compensation circuit will be adjusted as needed.

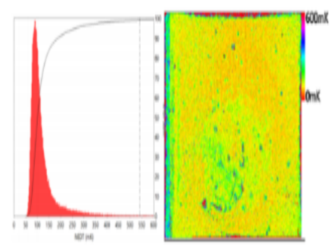


Figure 9: Histogram of NEDT of FPA

- **Test Synchronization and Coherence**:

Simulate the clocking network and sample-and-hold circuitry to ensure that the timing across pixels remains within the 0.1 ns coherence threshold**,** essential for multi-array configurations.
Confirm that each sample-and-hold circuit functions effectively across the entire array, allowing real-time signal alignment.

Subtask 5: Prepare for Fabrication and Prototype Testing:

- **Finalize ROIC Layout and Submit for Fabrication**:

Complete the ROIC layout in Cadence Virtuoso**,** ensuring it meets size constraints for integration with the HgTe CQD photodetector.
Perform a design rule check (DRC) to confirm the layout adheres to CMOS fabrication requirements and submit the design for fabrication.

- **Plan for Prototype Testing**:

Develop a testing plan for the ROIC, including setup for noise, gain, synchronization, and thermal stability testing.
Outline metrics to validate the ROIC's compatibility with the photodetector's dark current, NEP, and synchronization requirements in the prototype testing phase.

Task 6: Fabrication of Solution-Processed HgTe Quantum Dots on a CMOS-Compatible Substrate:

Subtask 1: Prepare CMOS-Compatible Substrate:

- **Select Substrate Material**:

Choose a silicon substrate with a 50 nm SiO2 layer for CMOS compatibility. This ensures structural stability and an appropriate surface for CQD adhesion.

- **Clean the Substrate**:

To remove organic contaminants, perform a Piranha etch (a 3:1 mixture of H_2SO_4 and H_2O_2) for 10 minutes. Rinse thoroughly with deionized water.
Dry the substrate with nitrogen and perform a 5-minute oxygen plasma treatment to increase surface energy and promote the adhesion of the HgTe CQD layer.

- **Inspect Substrate**:

An optical microscope inspects the substrate surface for cleanliness and confirms uniform SiO_2 coating, as imperfections may affect CQD layer deposition.

Subtask 2: Synthesize and Purify HgTe Quantum Dots:

- **Synthesis of HgTe CQDs**:

In a solution-phase reaction, $HgCl_2$ (mercury chloride) and NaHTe (sodium hydrogen telluride) are precursors to form HgTe QDs. For controlled growth, the reaction should be carried out in oleylamine as a coordinating solvent at 80-100°C. Monitor QD size using UV-Vis spectroscopy, targeting an average QD size of 8-12 nm to align with MWIR detection requirements in the 3-5 µm range.

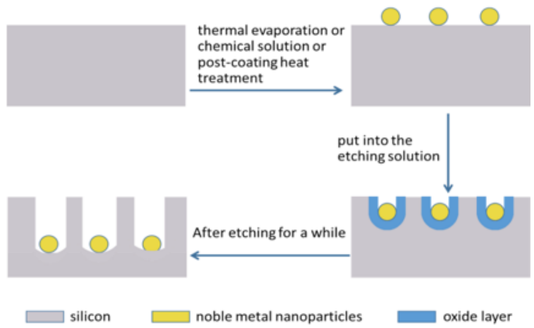


Figure 10: The fabrication principle of black silicon using metal-assisted chemical

- **Purification of QDs**:

Purify the QDs by centrifugation and washing with hexane to remove unreacted precursors and excess ligands.
Redisperse the purified QDs in toluene, achieving a stable colloidal solution suitable for spin-coating. Confirm the particle concentration, which should yield a uniform 1-2 µm film on the substrate.

Subtask 3: Spin-Coat HgTe CQD Layer onto Substrate:

- **Spin-Coating Preparation**:

Place the cleaned CMOS-compatible substrate on the spin-coating platform. Dispense a sufficient volume of the HgTe CQD solution (prepared in Step 2) onto the center of the substrate.

- **Perform Spin-Coating**:

Set the spin-coater to 3000 rpm for 30 seconds, targeting a 1 µm thick layer in a single coat. Repeat the spin-coating process to build up to a 1-2 µm total thickness.
After each coating, allow the solvent to evaporate naturally before applying additional layers. This will ensure uniformity and prevent defects.

- **Inspect Layer Thickness**:

After each coating step, a profilometer ver ifies the thickness, ensuring the final layer meets the desired thickness range. If the thickness deviates from the target values, adjust the spin speed or solution concentration.

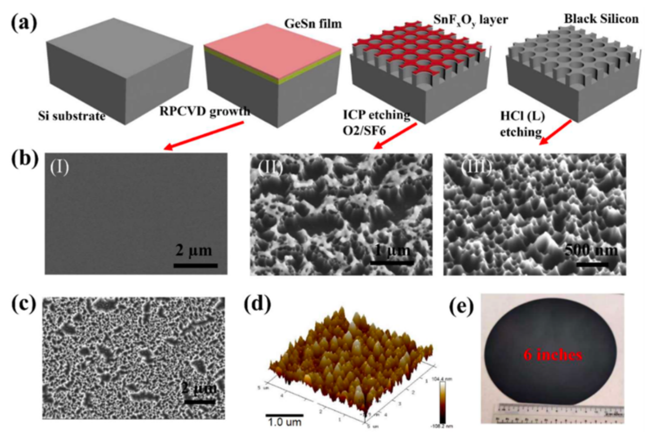


Figure 11 a) The schematic fabrication proceess steps from Si substrate preparatio to GeSn growth, ICP-RIE etching,and clewanin for SnOxFy removal

Subtask 4: Perform Ligand Exchange for Improved Charge Transport:

- **Prepare Ligand Exchange Solution**:

For ligand exchange, a solution of 1,2-ethanedithiol (EDT) in acetonitrile was used. This step replaces the long insulating ligands with short conductive ones, enhancing the charge transport properties of the HgTe CQD film.

- **Apply Ligand Exchange Solution**:

Drop-cast the EDT solution onto the CQD layer and let it sit for 1-2 minutes to allow full ligand exchange. This will facilitate charge movement across the C QD layer.
Rinse the film with acetonitrile to remove unreacted EDT and prevent film degradation.

- **Confirm Ligand Exchange**:

Use Fourier Transform Infrared (FTIR) spectroscopy to confirm the ligand exchange by observing the characteristic bond signatures of EDT. This step verifies that the conductive ligands are successfully integrated into the CQD layer.

Subtask 5: Anneal the CQD Layer for Stability and Adhesion:

- **Set Annealing Conditions**:

To prevent oxidation, place the substrate with the CQD layer in a nitrogen-filled oven**.** Set the temperature to 150°C and anneal for 30 minutes**.**

This annealing process removes residual solvents, stabilizes the CQD film, and improves adhesion to the substrate.

- **Inspect Film Quality Post-Annealing**:

After annealing, scanning electron microscopy (SEM**)** is used to inspect the surface morphology. Verify uniformity and ensure no cracks or delamination occurred during the annealing process.

Confirm the thickness of the final CQD layer using a profilometer, ensuring that it remains within the 1-2 µm target range.

Subtask 6: Characterize the Optical and Electrical Performance of the CQD Layer:

- **Optical Absorption Test**:

Measure the absorption spectrum of the HgTe CQD film across the 3-5 µm range using an FTIR spectrometer. Aim for an absorption efficiency of over 90% to meet MWIR sensitivity requirements**.**

- **Measure Dark Current and Quantum Efficiency (QE)**:

Measure dark current at the operational temperature of 200 K. The target value should be approximately 5 x 10^-9 A to ensure low noise.

Calculate quantum efficiency (QE) across the MWIR spectrum, targeting a QE of 0.6 or higher to ensure effective photon-to-electron conversion.

- **Noise Equivalent Power (NEP) Evaluation**:

Evaluate the Noise Equivalent Power (NEP) using a calibrated infrared source, aiming for a target NEP of 100 fW/Hz^1/2. This metric confirms the film's sensitivity and noise performance for MWIR applications.

Milestone Chart:

#	Milestone	Tasks	M1	M2	M3	M4	M5	M6
1	Kickoff (KO)	• Project review and kickoff meeting with stakeholders						
2	Design and Fabrication of HgTe CQD Film for MWIR Detection	• Design of HgTe CQD Film with MWIR alignment • Fabricate solution-processed HgTe CQD film on CMOS-compatible substrate						
3	Integration of Black Silicon and Gold Reflector Structure	• Integrate HgTe CQD film with black silicon and gold reflector structure						
4	Simulation of Complete HgTe CQD Photodetector	• Optical and Electrical Simulation of HgTe CQD Photodetector • Thermal Stability Simulation						
5	Implementation of CMOS-Compatible ROIC	• Design and simulate CMOS-compatible ROIC with low-noise amplification and real-time synchronization						
6	Validation and Prototyping of Complete Detector	• Integrate and prototype MWIR photodetector with HgTe CQD film, ROIC, and thermoelectric cooling						
7	Performance Testing and Optimization	• Conduct performance testing to measure QE, NEP, and dark current stability at 200 K						
8	Final Report Submission	• Submit comprehensive report detailing design methodologies, simulation results, fabrication processes, and performance outcomes						

4.0 Related Work:

Bryka Skystocks LLC, has harnessed its expertise in HgTe Colloidal Quantum Dot (CQD) technology to create advanced MWIR sensing solutions, forming a solid foundation for the proposed Air Force FPA system. Leveraging previous developments in high-sensitivity CQD-based detectors, Bryka Skystocks LLC will integrate multi-array synchronization and real-time coherence for distributed FPAs, targeting precise alignment across arrays. Their experience in scalable, solution-processed CQD imaging systems, optimized for low dark current and stable NEP at 200 K, aligns with Air Force requirements. This expertise ensures that Bryka's HgTe CQD FPA technology will deliver reliable, high-resolution imaging in distributed, low-power configurations for surveillance and target acquisition.

5.0 Relationship with Future Research or Research and Development:

Anticipated Results of the Proposed Approach:

Completing Phase I**,** Bryka Inc. will deliver a detailed system model for the HgTe CQD-based FPA technology, laying the groundwork for a scalable, low-cost MWIR detection system**.** This model will guide the development of synchronized, multi-array FPA panels optimized for high-sensitivity thermal imaging at elevated temperatures (around 200 K). Emphasis will be placed on refining critical performance metrics, including dark current (targeting 5 x 10^-9 A), Noise Equivalent Power (NEP) (100 fW/Hz^1/2), and quantum efficiency across the MWIR band (3-5 µm). This Phase I model will include simulation and validation of coherence and signal synchronization across arrays, ensuring reliable data alignment for distributed imaging. These achievements will establish proof of concept for a multi-array, real-time MWIR imaging architecture that enhances Air Force capabilities in surveillance, reconnaissance, and advanced target tracking over vast areas.

Significance of the Phase I Effort:

The Phase I effort is essential in establishing the technical foundation for a scalable, low-cost HgTe CQD-based FPA system tailored for MWIR detection. This phase will concentrate on developing a comprehensive system model for synchronized, distributed FPA panels designed to provide high-sensitivity, real-time thermal imaging, and target tracking over large operational areas. Key technical goals include optimizing parameters such as dark current (targeted at 5 x 10^-9 A), Noise Equivalent Power (NEP) (100 fW/Hz^1/2), and phase coherence, ensuring the system meets stringent Air Force standards for MWIR detection.

Phase I will also simulate and validate multi-array synchronization and coherence techniques, ensuring seamless operation across distributed FPA panels. These advancements are vital for enhancing imaging sensitivity and tracking accuracy, particularly for detecting low-contrast or fast-moving targets. The outcomes of Phase I will confirm the feasibility of a low-cost, multi-array MWIR detection system, laying the groundwork for integration into more considerable defense and reconnaissance infrastructures and opening opportunities for further application in areas like environmental monitoring and industrial inspection.

6.0 Commercialization Strategy:

6.1 First Planned Product to Incorporate Technology:

The primary application of Bryka Inc.'s HgTe CQD-based FPA technology is in Air Force MWIR imaging systems, enhancing real-time surveillance and reconnaissance capabilities over large operational areas. The distributed, synchronized FPA panels will significantly improve target tracking and detection, especially for low-signature and high-speed objects, by providing real-time coherence and high sensitivity in the 3-5 µm MWIR range. The system's scalability and low-cost design ensure efficient deployment across various defense platforms.

Commercial Applications: Beyond defense, the HgTe CQD-based FPA technology holds promise in multiple civilian sectors:

Industrial Inspection: High-sensitivity MWIR imaging can aid equipment monitoring and detecting heat-related issues before failure.

Environmental Monitoring: MWIR sensitivity allows for real-time tracking of pollution, wildfires, and other environmental hazards.

Space Exploration: Adapted FPAs can enhance imaging for space missions, aiding in thermal data collection and object tracking in space.

Automotive Safety: High-resolution MWIR imaging could support advanced driver-assistance systems (ADAS), improving night vision and obstacle detection.

6.2 Customers and Market Size:

Market	Need the Technology Will Address	Principals Operating in this Market	Value/Size/Trend

Defense Surveillance Systems	Enhanced real-time detection and tracking for low-signature and fast-moving targets in MWIR range (3-5 µm)	Northrop Grumman, Lockheed Martin, U.S. Air Force	Global infrared imaging market expected to reach $15.5B by 2028
Industrial Inspection	Improved heat anomaly detection in equipment, enabling predictive maintenance	FLIR Systems, Bosch, Honeywell	Infrared inspection market projected to grow at 6.3% CAGR
Space Exploration	High-sensitivity thermal imaging and tracking for space missions, including satellite monitoring	NASA, SpaceX, Boeing	Space sensor market expected to reach $12B by 2030
Automotive Safety	Enhanced night vision and obstacle detection for advanced driver-assistance systems (ADAS)	Tesla, Ford, Mobileye	ADAS market projected to grow to $131.7B by 2027
Environmental Monitoring	Real-time tracking of environmental hazards such as wildfires, pollution, and temperature changes	Thermo Fisher Scientific, Agilent, PerkinElmer	Environmental monitoring market expected to reach $3.5B by 2025

6.3 Money to Bring Technology to Market:

Activity	Milestone	Anticipated Expenditure	Funding Source	Deliverable/Timeframe
Phase I SBIR Project	Develop proof-of-concept for HgTe CQD-based FPA technology	$250,000	SBIR Phase I	Final report and system model/Jan-2024
Phase II SBIR Project	Prototype demonstration of distributed HgTe CQD-based FPA system	$2,750,000	SBIR Phase II	Prototype system, Phase II Report/Feb-2025
Phase III Commercialization	Full-scale production and commercial deployment of MWIR imaging system	$4,000,000	Internal funds, investors, or defense contracts	Production plan, market deployment/Dec-2027

6.4 Marketing Expertise:

Bryka Skystocks LLC. has extensive expertise in developing and commercializing HgTe CQD-based FPA technologies and over a decade of experience in infrared imaging and sensor solutions for defense applications. Bryka has successfully delivered advanced thermal imaging and sensing systems to agencies such as the U.S. Air Force and DARPA, showcasing its ability to meet stringent military standards for performance and reliability. This expertise has positioned Bryka as a trusted high-sensitivity, cost-effective infrared detection system provider.

Our strategy will center on forming partnerships with industry leaders like Northrop Grumman and Lockheed Martin to promote the distributed HgTe CQD FPA for defense and surveillance applications. In addition, Bryka will target commercial markets, such as environmental monitoring and industrial inspection, emphasizing the technology's scalability and real-time imaging benefits. Through targeted marketing and leveraging established partnerships, Bryka aims to become a leading provider of advanced MWIR imaging solutions for defense and commercial sectors.

6.5 Competition and Technical Advantages:

Bryka Skystocks LLC. faces competition from established defense and thermal imaging companies like FLIR Systems, Raytheon, and Lockheed Martin, which offer high-cost MWIR imaging and detection systems with sophisticated but expensive components. In contrast, Bryka Skystocks LLC's HgTe CQD-based FPA technology provides a cost-effective solution by leveraging scalable, solution-processed quantum dot materials and CMOS-compatible integration, achieving MWIR sensitivity without costly cryogenic cooling. This approach allows Bryka Skystocks LLC's FPA system to deliver high-resolution thermal imaging and synchronized multi-array capabilities with scalability and real-time coherence across panels. The modular, low-cost design offers a competitive advantage for defense applications like surveillance and reconnaissance and commercial applications in environmental monitoring and industrial inspection, positioning Bryka Skystocks LLC as a provider of accessible and high-performance MWIR imaging solutions.

7.0 Key Personnel:

7.1 Mr. Suresh Mirchandani - Principal Investigator:

Mr. Suresh Mirchandani, Principal Investigator at Bryka Skystocks LLC., leads the development of HgTe CQD-based Focal Plane Array (FPA) technology for cost-effective MWIR detection in defense and commercial applications, leveraging over 20 years of experience in advanced imaging and electrical engineering. With a B.S. in Electronics Engineering, Mr. Mirchandani's expertise in signal processing and system integration positions him ideally to guide this project. His career has focused on designing, simulating, and implementing multi-array systems, specializing in real-time coherence and high-sensitivity detection-critical features of the proposed FPA technology.

Under Mr. Mirchandani's direction, the FPA project has undergone rigorous modeling and simulation using advanced tools like MATLAB, COMSOL, ANSYS, and Cadence. His extensive knowledge of synchronized multi-array architectures ensures that the HgTe CQD FPA system achieves superior imaging sensitivity and accurate signal alignment, vital for military applications like surveillance and commercial uses in environmental monitoring and industrial inspection. With a record of delivering scalable, high-performance solutions, Mr. Mirchandani's role in refining the FPA design is crucial to successfully deploying this low-cost, state-of-the-art imaging technology for diverse applications. His leadership in simulation and integration solidifies Bryka's FPA system as a leading-edge solution for defense and commercial markets.

7.2 Dr. Alan Mantooth -Wide-Bandgap Semiconductor and Power Converters Expert

Dr. Alan Mantooth a distinguished expert in semiconductor modeling and power electronics, holds a B.S. and M.S. in Electrical Engineering from the University of Arkansas (1985 and 1986) and a Ph.D. from Georgia Tech (1990). He began his career at Analogy, a semiconductor modeling startup in Oregon, where he specialized in creating modeling tools for advanced semiconductor devices. In 1998, Dr. Mantooth joined the University of Arkansas as an Electrical Engineering professor, now a Distinguished Professor. His research encompasses analog and mixed-signal IC design, CAD, device modeling, and power electronics.

Dr. Mantooth co-founded the National Center for Reliable Electric Power Transmission (NCREPT) in 2005 and serves as its Executive Director. He also directs two centers of excellence: GRAPES (a center focused on grid-connected advanced power systems) and SEEDS (a center focused on cybersecurity in energy systems), both funded by the U.S. Department of Energy. In 2015, he launched the Power Optimization for Electro-Thermal Systems (POETS) Engineering Research Center, focusing on high-power density systems for transportation applications.

Dr. Mantooth holds the 21st Century Research Leadership Chair in Engineering and has served as the Immediate past President of the IEEE Power Electronics Society (2019–20) and Editor-in-Chief of the IEEE Open Journal of Power Electronics. An IEEE Fellow, he is also a Tau Beta Pi and Beta Kappa Nu member and a licensed Professional Engineer in Arkansas.

7.3 Dr. Nima Gallaecian – Focal Plane Array Design Engineer:

Dr. Nima Gallaecian, the Focal Plane Array Design Engineer at Bryka Inc., brings over 20 years of expertise in imaging systems and MWIR technologies. He is a critical asset in developing the HgTe CQD-based FPA technology**.** Dr. Gallaecian earned his B.S. in Electrical Engineering and completed his M.S. and Ph.D. in Electrical Engineering from the University of Maryland-College Park, where his research focused on advanced sensor technologies. His extensive background in mid-wave infrared imaging, CQD-based sensors, and real-time coherence solutions directly supports this project, particularly optimizing FPA panel design for low-light sensitivity and distributed array coherence. Dr. Gallaecian's expertise in sensor arrays, non-linear imaging systems, and reconfigurable imaging technologies aligns with the project's focus on achieving high NEP stability, dark current control, and pixel uniformity across multi-array configurations. His previous work at FormFactor, Inc., where he developed precision technologies for probe arrays, underscores his innovative approach to high-performance systems. With a strong record of advancing reconfigurable imaging arrays, Dr. Gallaecian's leadership will ensure Bryka's HgTe CQD-based FPAs meet stringent Air Force standards for real-time imaging and high-sensitivity detection across defense and commercial applications, including environmental monitoring and industrial inspection.

7.4 Dr. Swaroop Darbha – Integration Expert:

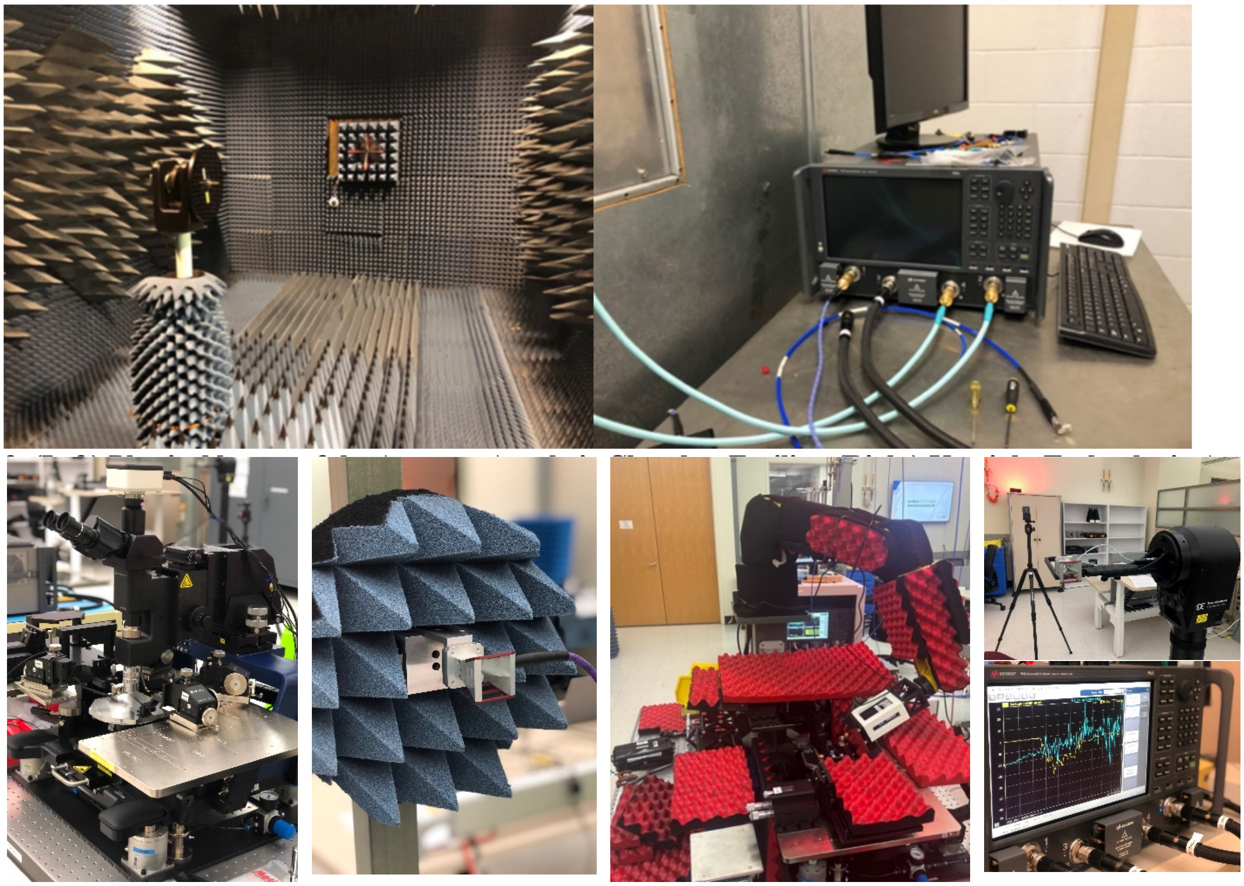
Dr. Swaroop Darbha, a prominent figure in Mechanical Engineering, holds an M.S. and Ph.D. from the University of California, Berkeley (1992 and 1994). Known for his expertise in systems integration, Dr. Darbha's career is marked by significant contributions to control systems and multi-agent communication technologies, making him a valuable

asset in the development of Bryka Inc.'s HgTe CQD-based FPA technology**.** His work optimizes distributed system performance, crucial for synchronizing multi-array panels in the proposed MWIR imaging system.
Dr. Darbha's experience includes being the keynote speaker at the 2018 IEEE COMSNETS Conference, where he discussed the "Benefits of V2V Communications for Automatically Controlled Vehicles." He also presented at the American Control Conference in 2013 and 2015 on "Combinatorial Optimization Methods for Routing Unmanned Vehicles," emphasizing system communication and coordination—essential elements for real-time, distributed sensor applications. His deep understanding of complex system integration and his work on synchronization across distributed units will ensure that the HgTe CQD-based FPA technology achieves precise, real-time data coherence across multi-array configurations, supporting defense, surveillance, and environmental monitoring applications.

8.0 Foreign Citizens:
N.A

9.0 Facilities/Equipment:
Bryka Skystocks LLC., headquartered in Connecticut, operates an advanced facility that supports the complete development, fabrication, and testing cycle of the proposed HgTe CQD-based FPA technology**.** The facility has cutting-edge equipment and technology to ensure precision and high performance at every project phase.

- **Fabrication Capabilities**: Bryka's facility includes precision CNC machining and solution-based CQD deposition systems essential for HgTe CQD layer fabrication. These systems provide consistent material quality and enable homogeneous properties across batches, crucial for maintaining sensitivity and performance in MWIR FPA production.
- **Imaging and Sensor Laboratory**: The facility includes a specialized MWIR Imaging Laboratory, equipped with spectrometers and temperature-controlled chambers to test FPA sensitivity and signal stability across the 3-5 µm wavelength range. The lab supports real-time analysis of key performance metrics, such as NEP and dark current, which are vital for optimizing FPA arrays.
- **Design Software**: Bryka utilizes industry-standard design and simulation tools like COMSOL Multiphysics for material and thermal simulation, MATLAB for coherence algorithms, and Cadence Virtuoso for precise FPA circuitry design, ensuring minimal signal loss and optimized imaging performance across distributed arrays.



10.0 Subcontractors/Consultants:

N.A

11.0 Prior, Current or Pending Support of Similar Proposals or Awards:

- Bryka SkyStocks LLC. has been awarded a **Space Force SBIR** Contract for topic SF24B-T008-Self-Regulating Heaters for Satellites.
- Bryka SkyStocks LLC. has been awarded **Navy STTR** Contract **N6833524C0092** for topic N23B-T030-Secure Mid-wave Free-space Mid-wave Infrared Optical Communication Using Chaotic Laser Mode.
- Bryka SkyStocks LLC. has been awarded **Space Force Contract FA9453-23-P-A043** for topic SF224-0012-Customer Functions Virtualization over Satellite Terminals.
- Bryka SkyStocks LLC. has been awarded **Air Force SBIR** Phase I Contract **FA9451-23-P-A008** for topic AF222-0006-Planar Antenna array for L-Band and S-Band 'PALS.'

DSIP Defense SBIR/STTR Innovation Portal
Cost Volume

SBIR Direct to Phase II Proposal

Proposal Number	F2D-15326
Topic Number	AF244-D011
Proposal Title	Affordable Electrical Accumulator Unit
Date Submitted	11/06/2024 11:58:59 AM

Firm Information

Firm Name	Bryka Skystocks LLC
Mail Address	549 Cedar Street , Newington, Connecticut, 06111
Website Address	brykagp.com
UEI	RB4XFCMC9KZ7
Duns	967264990
Cage	6afx5

Total Dollar Amount for this Proposal	$1,398,866.67
Base Year	$839,686.95
Year 2	$559,179.72
Technical and Business Assistance(TABA)- Base	$0.00
TABA- Year 2	$0.00

Base Year Summary

Total Direct Labor (TDL)	$522,007.20
Total Direct Material Costs (TDM)	$184,800.00
Total Direct Supplies Costs (TDS)	$0.00
Total Direct Equipment Costs (TDE)	$0.00
Total Direct Travel Costs (TDT)	$0.00
Total Other Direct Costs (TODC)	$0.00
G&A (rate 10%) x Base (TDL+TDM+TOH)	$70,680.72
Total Firm Costs	$777,487.92
Subcontractor Costs	
Total Subcontractor Costs (TSC)	$0.00
Cost Sharing	-$0.00
Profit Rate (8%)	$62,199.03
Total Estimated Cost	$839,686.95
TABA	$0.00

Year 2 Summary

Total Direct Labor (TDL)	$347,490.00
Total Direct Material Costs (TDM)	$123,200.00

Total Direct Supplies Costs (TDS)	$0.00
Total Direct Equipment Costs (TDE)	$0.00
Total Direct Travel Costs (TDT)	$0.00
Total Other Direct Costs (TODC)	$0.00
G&A (rate 10%) x Base (TDL+TDM+TOH)	$47,069.00
Total Firm Costs	$517,759.00
Subcontractor Costs	
Total Subcontractor Costs (TSC)	$0.00
Cost Sharing	-$0.00
Profit Rate (8%)	$41,420.72
Total Estimated Cost	$559,179.72
TABA	$0.00

Base Year

Direct Labor Costs

Category / Individual-TR	**Rate/Hour**	**Estimated Hours**	**Fringe Rate (%)**	**Fringe Cost**	**Cost**
Chief Executive/ Principal Investigator (Suresh Mirchandani)	$110.00	570	30	$18810.00	$81,510.00
Electrical Engineer/ Power Electronics Expert (Dr. Uttam Singisetti)	$100.00	595	30	$17850.00	$77,350.00
Materials Engineer/ material expert (Dr. Alex Usenko)	$90.00	660	30	$17820.00	$77,220.00
Electrical Engineer/ Battery expert (Dr. Rodney lafollete)	$80.00	725	30	$17400.00	$75,400.00
Electronics Engineer/ Integration Expert (Dr. Lloyd Linder)	$80.00	723	30	$17352.00	$75,192.00

Subtotal Direct Labor (DL)	$386,672.00
Labor Overhead (rate 35%) x (DL)	$135,335.20
Total Direct Labor (TDL)	**$522,007.20**

Direct Material Costs

Gallium Oxide	$168,000.00
Subtotal Direct Material Costs (DM)	$168,000.00
Material Overhead (rate 10%) x DM	$16,800.00
Total Direct Material Costs (TDM)	**$184,800.00**

G&A (rate 10%) x Base (TDL+TDM+TOH)	$70,680.72
Cost Sharing	-$0.00
Profit Rate (8%)	$62,199.03

Total Estimated Cost	$839,686.95
TABA	$0.00

Year 2

Direct Labor Costs

Category / Individual-TR	Rate/Hour	Estimated Hours	Fringe Rate (%)	Fringe Cost	Cost
Chief Executive/ Principal Investigator (Suresh Mirchandani)	$110.00	380	30	$12540.00	$54,340.00
Electronics Engineer/ Material expert (Alex Usenko)	$100.00	400	30	$12000.00	$52,000.00
Electronics Engineer/ Power Electronics Expert (Dr. Uttam Singisetti)	$90.00	420	30	$11340.00	$49,140.00
Electronics Engineer/ Battery expert (Dr. Rodney lafollete)	$80.00	490	30	$11760.00	$50,960.00
Electronics Engineer/ Integration expert (Dr. Lloyd Linder)	$80.00	490	30	$11760.00	$50,960.00

Subtotal Direct Labor (DL)	$257,400.00
Labor Overhead (rate 35%) x (DL)	$90,090.00
Total Direct Labor (TDL)	**$347,490.00**

Direct Material Costs

Gallium oxide	$112,000.00
Subtotal Direct Material Costs (DM)	$112,000.00
Material Overhead (rate 10%) x DM	$11,200.00
Total Direct Material Costs (TDM)	**$123,200.00**

G&A (rate 10%) x Base (TDL+TDM+TOH)	$47,069.00
Cost Sharing	-$0.00
Profit Rate (8%)	$41,420.72
Total Estimated Cost	$559,179.72
TABA	$0.00

Explanatory Material Relating to the Cost Volume

The Official From the Firm that is responsible for the cost breakdown

Name: Suresh Mirchandani
Phone: (732) 851-9034
Phone: aviationsales@brykagp.com
Title: Proposal Owner

If the Defence Contracting Audit Agency has performed a review of your projects within the past 12 months, please provide: No

Select the Type of Payment Desired: Partial payments

Cost Volume Details

Direct Labor

Base

Category	Description	Education	Yrs Experience	Hours	Rate	Fringe Rate	Total
Chief Executive	Principal Investigator	Bachelor's Degree	20	570	$110.00	30	$81,510.00
Electrical Engineer	Power Electronics Expert	PhD	10	595	$100.00	30	$77,350.00
Materials Engineer	material expert	PhD	15	660	$90.00	30	$77,220.00
Electrical Engineer	Battery expert	PhD	10	725	$80.00	30	$75,400.00
Electronics Engineer	Integration Expert	PhD	10	723	$80.00	30	$75,192.00

Are the labor rates detailed below fully loaded? **YES**

Please explain any costs that apply.
Fringe Benefits includes Federal Unemployment Tax Allowance, State Unemployment Tax, Workmen's Compensation Insurance, Employee Benefits such as Health and welfare including life, accident and health

Provide any additional information and cost support data related to the nature of the direct labor detailed above.
Principal Investigators, and Other Engineers will be compensated at Industry-standard rates. https://www.bls.gov/oes/current/oes_ct.htm#19-0000

Direct Labor Cost ($): $386,672.00

Year2

Category	Description	Education	Yrs Experience	Hours	Rate	Fringe Rate	Total
Chief Executive	Principal Investigator	Bachelor's Degree	20	380	$110.00	30	$54,340.00
Electronics Engineer	Material expert	PhD	15	400	$100.00	30	$52,000.00
Electronics Engineer	Power Electronics Expert	PhD	10	420	$90.00	30	$49,140.00

Electronics Engineer	Battery expert	PhD	10	490	$80.00	30	$50,960.00
Electronics Engineer	Integration expert	PhD	10	490	$80.00	30	$50,960.00

Are the labor rates detailed below fully loaded? **YES**

Please explain any costs that apply.
Fringe Benefits includes Federal Unemployment Tax Allowance, State Unemployment Tax, Workmen's Compensation Insurance, Employee Benefits such as Health and welfare including life, accident and health

Provide any additional information and cost support data related to the nature of the direct labor detailed above.
Principal Investigators, and Other Engineers will be compensated at Industry-standard rates. https://www.bls.gov/oes/current/oes_ct.htm#19-0000

Direct Labor Cost ($): $257,400.00

Sum of all Direct Labor Costs is($): $644,072.00

Overhead

Base

Labor Cost Overhead Rate (%) **35**

Apply Overhead to Direct Materials Cost? **YES**

Material Cost Overhead Rate (%) **10**

Overhead Comments:

Overhead Cost ($): **$152,135.20**

Year2

Labor Cost Overhead Rate (%) **35**

Apply Overhead to Direct Materials Cost? **YES**

Material Cost Overhead Rate (%) **10**

Overhead Comments:

Overhead Cost ($):	**$101,290.00**
Sum of all Overhead Costs is ($):	**$253,425.20**

General and Administration Cost

Base

G&A Rate (%):	**10**
Apply G&A Rate to Overhead Costs?	**YES**
Apply G&A Rate to Direct Labor Costs?	**YES**
Apply G&A Rate to Direct Material Costs?	**YES**
Please specify the different cost sources below from which your company's General and Administrative costs are calculated.	
G&A Cost ($):	**$70,680.72**

Year2

G&A Rate (%):	**10**
Apply G&A Rate to Overhead Costs?	**YES**
Apply G&A Rate to Direct Labor Costs?	**YES**
Apply G&A Rate to Direct Material Costs?	**YES**
Please specify the different cost sources below from which your company's General and Administrative costs are calculated.	
G&A Cost ($):	**$47,069.00**
Sum of all G&A Costs is ($):	**$117,749.72**

ODC-Materials

Base

Description: Gallium Oxide

Vendor: Classic Wafer

Quantity: 10

Total Cost($): $168,000.00

Consumable? yes

Competitively Sourced? yes

Exclusive for this Contract? yes

Supporting Comments:
For this project

Year2

Description: Gallium oxide

Vendor: Classic wafer

Quantity: 10

Total Cost($): $112,000.00

Consumable? yes

Competitively Sourced? yes

Exclusive for this Contract? yes

Supporting Comments:
For this project

ODC-Summary

Base

Do you have any additional information to provide? **NO**

Year2

Do you have any additional information to provide?

Profit Rate/Cost Sharing

Base

Cost Sharing ($): **-**

Cost Sharing Explanation:

Profit Rate (%): **8**

Profit Explanation:

Total Profit Cost ($): **$103,619.75**

Year2

Cost Sharing ($): **-**

Cost Sharing Explanation:

Profit Rate (%): **8**

Profit Explanation:	
Total Profit Cost ($):	**$103,619.75**
Total Proposed Amount ($):	**$1,398,866.67**

CERTIFICATE OF COMPLETION

THIS CERTIFICATE IS PRESENTED TO

Suresh Mirchandani, Bryka Skystocks LLC

FOR SUCCESSFULLY COMPLETING FRAUD, WASTE AND ABUSE TRAINING AND MEETING ALL REQUIREMENTS SET FORTH BY THE OFFICE OF SMALL BUSINESS PROGRAMS

Nov 06, 2024

COMPLETION DATE

Nov 06, 2025

EXPIRATION DATE