OCAST

2018 OARS Projects

List of Projects

Solution-processable halides for radiation detection

PI: Dr. Bayrammurad Saparov, University of Oklahoma, Norman

Industry Partner: Amethyst Research Inc., Ardmore

OCAST Project: AR18-008

Research Area: Material Science

This project aims to develop an exciting class of new materials for radiation detection applications, which range from medical imaging and astrophysics to national security. The preliminary studies indicate the new class of hybrid organic-inorganic lead halide materials perform better than some of the current state-of-the-art materials used for radiation detection. In this project, we aim to develop these and derivative materials, which have even higher promise based on their crystal and electronic structures, and test them in working radiation detector devices. We anticipate that upon the successful completion, the high resolution radiation detectors developed under the project will result in establishment of a new brand of radiation detectors developed, produced and marketed from Oklahoma.

Data model and algorithms for data-driven team building with quantifiable exaptation potential

PI: Dave King, Exaptive Inc., Oklahoma City **OCAST Project:** AR18-009 **Research Area:** Computer Systems & Software Applications

Good ideas are getting harder to find. The growing number of researchers in the US are failing to produce value that outpaces what their employers are spending to innovate. 'Innovation manager' is a job title that's popping up all over the place, but how does a manager create innovative teams?

Exaptive is building a data model on top of which predictive technology can be utilized to forecast data-driven teams that will outperform teams handpicked by traditional means. An analogy would be a weather model. Predictive technology is put on a weather model to forecast storms. Predictive technology can be put onto the Exaptive data model to predict which teams will be more innovative.

Exaptive has a team in place to test this hypothesis: the exaptation potential of a team correlates to improved performance in a variety of scenarios, including ideation and execution scenarios. We have an expert data modeler and data scientist, applied mathematician, cultural anthropologist, machine learning computer scientist, software architect, and software user experience designer ready to test this hypothesis in four test environments with real world early adopters.

We need grant funding to hire two data scientists and two full-stack developers to ensure the research opportunities in the four test environments don't get overshadowed by client needs. If we can assign two data scientists and two full-stack developers to collect and analyze the data and build a data model based on the research, we can bring a strong, technically-sound, evidence-based product to market within six months of completing the research.

Development of a fluid turbulator for use in fired heaters to reduce fouling

PI: Dr. Erwin Platvoet, XRG Technologies LLC, Tulsa **OCAST Project:** AR18-015 **Research Area:** Oil & Gas Equipment & Machinery

XRG Technologies LLC is developing a mechanical insert that will be used in refineries and petrochemical facilities to reduce something called fouling in fired heater coils. Fouling in a fired heater reduces the heater output, lowers the overall efficiency, damages the equipment, requires the heater to be shut down for cleaning, and costs the operating facility a lot of money. You can relate a coil to a human artery. Instead of carrying blood, the coil transports a petroleum product like crude oil through a heater to be heated to a desired temperature. The fouling (or coking) is like plaque in an artery. Instead of plaque, it is crude oil that is decomposing and adhering to the inner walls of the heater coil. This prevents heat transfer to the rest of the crude oil inside the tube and impedes the refinery production. Our device will reduce the propensity of the crude oil to foul or "coke" inside of the heater coil. This is done by creating a swirl flow that will lower the film temperature, sweep the film back into the bulk of the crude oil, increasing and evening the heat transfer throughout the system. The device will allow the heater to run longer before being shut down for cleaning. This will save operating facilities significant amounts of money.

Translation of a diagnostic test for Lupus flare prediction from bench to clinic

PI: Dr. Eldon Jupe, Progentec Diagnostics, Inc., Oklahoma City **OCAST Project:** AR18-019 **Research Area:** Diagnostic & Therapeutic Biotechnology

Systemic lupus erythematosus (SLE), also known simply as lupus, is an autoimmune disease characterized by episodic flares that cause organ damage and poor quality of life for patients. Lupus affects a significant proportion of the US population, often with onset during young adulthood. The Lupus Foundation of America estimates the number of possible lupus patients to be as high as 1.5M in the US alone with 16,000 new cases reported each year with more than 90% of affected patients being women between the ages of 15 and 45. Lupus affects a wide range of organs and systems, including the skin, musculoskeletal system, kidneys, central nervous system, heart, and lungs. Lupus patients, on average, suffer from 2 disease flares annually and the primary treatment is steroid drugs, which are toxic and can cause organ damage with repeated use. There could be a major improvement in lupus clinical management if a diagnostic test were available to inform the practice of proactive, precision medicine in lupus patients.

Progentec's product, the Lupus Flare Prediction Index (LFPI), is a diagnostic test for assessing a patient's risk of a lupus disease flare. The test measures levels of inflammatory and regulatory mediators and uses weightings for these factors in an algorithm to calculate a single risk score. This score provides an assessment of whether the patient's physiological state is likely to promote (positive) or suppress (negative) a flare. The goals of the proposed project are to complete the final set of milestones necessary to commercialize this test thereby making it eventually available for use to the broad population of clinicians and patients who would benefit from such a test.

Natural gas-water mixture as an alternate fracturing fluid to enhance oil

PI: Dr. Khalid Hossain, Amethyst Research, Inc., Ardmore **OCAST Project:** AR18-022 **Research Area:** Energy Resources/Petroleum

Traditional fracking has substantially increased gas production, however, failed to increase recovery rate (mostly below 20%) while created overuse and contamination of fresh water supply. An optimized natural gas-based fracturing fluid developed under this project will enhance recovery significantly ensuring 100 more years of domestic gas supply from shale.

As such, a less aqueous fracturing fluid will enhance oil/gas recovery, reduce the amount of re-injection of water, and thus reduce the probability of seismic activity and limit water contamination. These changes will have both a significant public benefit and economic impact.

A novel method for enhancing artificial lift performance

PI: Dr. Machhad Fahs, University of Oklahoma, Norman **OCAST Project:** AR18-023 **Research Area:** Energy Resources/Petroleum

The proposed research aims at evaluating the limits of applicability for a recently patented process that can increase oil production in some wells. This proposed research which will be conducted over a period of 12 months will help us identify the potential oil fields that would benefit from this technology. We will use this information to market licensing the technology after putting a dollar value on it. An evaluation will also be performed for the potential of a startup company that would be based in Oklahoma and can develop this technology further for commercialization.

The new process was initial discovered by accident and then further investigated for reproducibility and scope. It includes combining two methods that are currently used in oil production in order to reduce the required energy for lifting emulsions in the production tubing, emulsions being a mixture of water droplets inside the crude oil which have a very thick texture and are difficult to mobilize.

Novel nitrite embedded packaging to increase value of dark-cutting beef

PI: Dr. Ranjith Ramanathan, Oklahoma State University, Stillwater **OCAST Project:** AR18-025 **Research Area:** Food Science

Beef purchasing decisions are influenced by color more than any other quality factor because consumers use discoloration as an indicator of freshness and wholesomeness. Consumers' associate bright red color of steak with freshness and wholesomeness. Any deviation from the bright red color during beef processing leads to discounted price. Dark cutting beef is a condition in which beef will not have the characteristic bright red color. Although mechanism of dark cutting beef is not clear, it will widely accepted that pre-harvest stress leads to depletion of glycogen reserves prior to slaughter, and is often described as meat that fails to brighten after the cut surface has been exposed to oxygen. Dark cutting beef is one of the most prominent meat quality issues worldwide.

The National Beef Quality Audit reported that the US Beef industry lost approximately $165 - $170 million dollars in 2000 due to dark cutting carcasses. More specifically, this loss results from discounted price in beef carcasses. In Canada, it has been estimated that approximately $11 million loss per year to beef producers. Our laboratory has developed a post-harvest processing technology (crude prototype technology; Intellectual property in-processing) that convert dark cutting beef to normal appearance beef by novel nitrite-embedded packaging film. The overall goal of this Oklahoma Applied Research Support is to standardize the conditions for optimum packaging time and enhancement solution to improve color. More specifically our objectives are: 1) To optimize the conditions such as packaging time and antimicrobial application to improve the surface color of dark cutting beef, 2) To assess the effects of standardized storage time on cooked color and sensory properties/eating qualities of dark cutting beef. We believe that developing novel strategies will minimize the losses resulting from discounting of carcass value due to dark cutting issues.

Novel compact separators for fine separation of water and oil

PI: Dr. Ram Mohan, University of Tulsa, Tulsa **OCAST Project:** AR18-026 **Research Area:** Energy Resources/Petroleum

Over the past 25 years the petroleum industry has been keen on developing compact multiphase separators that are smaller in size, less expensive and have smaller footprint, as alternatives to conventional gravity separators. Overall objective of the current proposal is the development of novel compact separators integrating TU's patent pending filter technology with the Liquid–Liquid Cylindrical Cyclone (LLCC©) technology. The proposed filter media, which is an ultra-lightweight and highly selective filter can be configured either as oil-friendly or water-friendly, enabling a wide range of practical applications for fine separation of oil and water.

The project objectives are met through laboratory testing of the compact separator design prototypes at University of Tulsa, mechanistic modeling for design and scale-up, and development of design criteria for field units. The experimental program consists of design, fabrication and testing of laboratory prototype compact separators for batch (Year 1) and in-line (Year 2) configurations.

Oil and gas (O&G) industry plays a critical role in Oklahoma economy. Crude oil production in Oklahoma has been steadily increasing the past decade from 172,000 barrels/day (BPD) in 2007 to 454,000 BPD in 2017 (https://www.eia.gov). According to the latest OK Chamber of Commerce Research Foundation report, in 2015, household earnings ($15.6 billion) from the O&G sector total 13.2% of total state earnings. Also, the oil and gas industry is the single largest source of tax revenue in the state, paying total direct state taxes of $2.0 billion in FY2015, or 22% of all state taxes in the period and producing 17% of state GDP.

According to a recent estimate (https://www.owrb.ok.gov), Oklahoma is the 3rd largest water producing state in US with 9 Million BPD average. There is too much produced water compared to limited underground injection capacity for disposal (www.owrb.ok.gov). This water must be cleaned before reinjecting into the reservoir or further processing. It can be done effectively at lower cost using the proposed compact separators, which can be easily manufactured in Oklahoma helping its economy. The proposed fine separators will be efficient, low cost, easy to construct, and convenient to install. They will be more affordable for the small producers of Oklahoma. Meeting proof-of-concept objectives would lead to development of a commercial unit allowing for economic impacts within a 2-3 year timeframe.

Turboelectric unmanned aircraft sensor system for oil and gas pipeline

PI: Dr. Kurt Rouser, Oklahoma State University, Stillwater
OCAST Project: AR18-028
Industry Partner: Trinity Services and Consulting, LLC, Enid
Research Area: Unmanned Aircraft Systems

Considering that the US energy infrastructure includes over 2.5 million miles of transmission, gathering and distribution pipeline, there is a critical need to develop economical means to inspect and monitor these vast, aging systems against sabotage and failure. Legacy inline non-destructive evaluation and pipeline flow sensors are inadequate for detecting small leaks that cause billions of dollars in lost revenue and environmental damage. Existing aerial inspection methods using hazardous low-altitude manned aircraft are starting to be replaced by unmanned aircraft with advanced sensors, but the cost-per-mile is relatively high. A system-level approach is required to develop sensors, platforms and power for low-cost inspection and monitoring methods to ensure pipeline integrity and to protect new and existing pipeline systems against potential theft and/or sabotage.

The goal of this project is to develop and evaluate a hybrid gas-electric unmanned aircraft and advanced sensor system to economically inspect and monitor oil and gas pipelines for integrity and safety. The hybrid power system will utilize a combustion engine and electrical generator to convert hydrocarbon fuel into electricity, taking advantage of the higher energy density of hydrocarbon fuels (75 times denser than lithium batteries) for increased range and endurance and reduced operating cost. The versatile design of this proposed hybrid turboelectric system can operate on both fixed-wing and rotary-wing aircraft, avoiding challenges expected with a hybrid power system, such as weight, complexity, vibration and the need for engine cooling.

This project will characterize the performance of the hybrid gas-electric system in a wind tunnel at various flight speeds and throttle settings and will then integrate the hybrid power system and an advanced sensor suite into small unmanned aircraft to determine feasibility of the system for oil and gas pipeline inspection. Prototype aircraft and sensor systems will be evaluated for range and endurance at an unmanned aircraft flight station. Field testing for an operational evaluation will be coordinated with an oil and gas pipeline inspection customer. It is anticipated that range and endurance will be over 10 times greater than that of existing battery-powered unmanned aircraft sensor systems, reducing operating costs associated with inspection and monitoring by reducing the number of aircraft excursions.

Downhole separator design for pumping systems in horizontal wells

PI: Dr. Eduardo Pereyra, University of Tulsa, Tulsa **OCAST Project:** AR18-033 **Research Area:** Energy Resources/Petroleum

Recent advancements in horizontal well drilling and fracking resulted in a significant increase in oil and gas production that contributed to energy independence in the United States. In early stages of production, horizontal wells used gas in the well to drag the liquid to the surface. With time, the gas declines, reducing its capability to bring the liquid to the surface. Consequently, liquid accumulates at the bottom of the well, potentially causing a reduction in productivity. Successful production in these wells requires liquid removal known as deliquification. As the available reservoir energy further decreases with time, various pumping methods such as sucker rod, progressive cavity (PCP) or electrical submersible (ESP) pumps are required. These methods add energy to the system, but their performances strongly depend on the success of the downhole separation of gas and liquids. The main objective of this project is developing a new downhole separator for pumping systems in horizontal wells.

There is a need for new technology that facilitates the exploitation of existing horizontal wells after the utilization of any artificial lift method. Pumping systems can be utilized only if a proper gas-liquid separator is used. The design of this separator must be different from all previous downhole separators, which were optimized for mostly conventional vertical wells. Thus, this proposed project is necessary to optimize the performance of this separator for conditions in horizontal wells.

The proposed technology will also promote the development and manufacture of new, more efficient and less expensive pumps. There are approximately 41 manufacturers in Oklahoma and several related downhole tool manufacturers which can also build downhole separators based on the specifications given by the proposed program. This technology would have an immediate impact on these manufacturers and the additional supporting industries. It would not only help retain current employees; it has the potential to produce a new product with such a wide reach that manufacturers could add a substantial number of new jobs. Two companies specifically in Oklahoma have projected between them they would add 250-600 jobs in the next 3-5 years with an average wage of $49,500. Impact to the state from the additional gas production plus the new jobs created in the manufacturing sector would also be significant.

Commercialization of a novel single-use bioreactor

PI: Dr. Joshua Ramsey, Oklahoma State University, Stillwater **OCAST Project:** AR18-035 **Research Area:** Bioprocessing/Biomedical Engineering

Our research creates innovative high-quality solution to streamline biopharmaceutical manufacturing. A multi-chamber single-use bioreactor allows biopharmaceutical manufacturers to save fixed costs, variable costs, production space, and reduce risk of microbial contamination and complete loss of product. Mammalian cells are the dominant platform to produce biopharmaceutical drugs. Cell cultures start as just a few milliliters and take weeks to divide and grow to reach thousands of liters at the production scale. Cells are grown in a vessel called a bioreactor. A traditional single-use bioreactor is designed as a single compartment bag with a maximum turndown ratio (i.e., the ratio of the maximum and minimum capacity) of 5:1. This volume limitation for cell cultivation inside a single bioreactor necessitates the use of multiple bioreactors with different working volumes throughout the scale up. This process is tedious and expensive with a high risk of microbial contamination, which is a complete loss. We developed patent pending technology to solve this problem. A multi-chamber single-use bioreactor, allows this scale up process to be completed in a single container and enables our customers to eliminate independent, traditional bioreactor units and save at least $200,000 in fixed costs. This includes costs associated with the purchase, qualification, and cGMP footprint of the equipment.

Moreover, the simplified process can save customers variable costs of $100,000 each year of bags, and up to $100,000 by reducing labor requirements. Finally, eliminating the need to open the bioreactor bags to transfer the culture from one intermediate bag to another reduces the risk of microbial contamination ($1.2 million in COGS is the estimated loss due to microbial contamination of a 1000 L process). We successfully developed and tested a two-chamber bioreactor which can operate from 2 L to 50 L. Further research work is required to take our invention to the next level of development and commercialization. Development and testing of a larger volume prototype is essential to prove the concept at the industrial scale. Establishing a manufacturing process for bioreactor bags is important to prove the feasibility of manufacturing at low price and high quality. By the end of the 2 year project we will have a tested, industrial scale two-chamber bioreactor and a validated manufacturing process for multi-chamber bioreactors.

New steel connections for seismic retrofit and strengthening of bridges and buildings

PI: Dr. Mohamed Soliman, Oklahoma State University, Stillwater
OCAST Project: AR18-037

Industry Partner: W&W/AFCO Steel, Oklahoma City
Research Area: Advanced Construction Technology

This project focuses on investigating the behavior of steel connections that are both bolted and welded, with the bolts and the welds sharing loads. Steel building connections have traditionally relied on either bolts or welds to efficiently and effectively transfer forces from member to member. Accordingly, steel construction connections are either bolted or they are welded. However, for many applications in existing structures it becomes apparent that strengthening can only be accomplished by welding pre-existing bolted connections. Additionally, even in new construction and most especially in large structures, fit-up problems during erection may create the need to combine welds with bolted connections. Unfortunately, neither research nor the historical findings provide sufficient guidance for how these combination bolted/welded connections should be treated.

This proposed research is in partnership with W&W | AFCO Steel, a national leader in steel building industry based in Oklahoma, and the American Institute of Steel Construction (AISC). The AISC is the leader in structural-steel-related technical and market-building activities, including: specification and code development, research, education, technical assistance, quality certification, standardization, market development, and advocacy. W&W | AFCO Steel Co. will provide the fabricated samples to be tested at the Bert Cooper Engineering Laboratory at OSU. Additionally, W&W/AFCO Steel Co. will provide technical expertise and support to help ensure the overall success of the research program. The ultimate goal of the research team is to provide design guidance for realistic configurations of connections employing bolts and welds that may exist in steel buildings and bridges, and to provide the structural engineering community the necessary tools for design.

Aeration process controls to reduce energy costs in wastewater treatment plants

PI: Dr. David Lampert, Oklahoma State University, Stillwater **OCAST Project:** AR18-042 **Research Area:** Environmental Technologies

Wastewater treatment plants (WWTPs) use large quantities of energy for treatment. The majority of WWTPs are owned by municipalities who are responsible for ensuring compliance with environmental agencies and operation of the facilities. In many cases, the owners of the WWTPs are also responsible from providing electricity to the community. Since the operators of the WWTPs are primarily motivated by compliance with water quality regulations and do not pay directly for their electricity, they have little incentive to reduce their consumption. WWTPs often drastically oversupply oxygen in their aeration processes. The problem of excess energy consumption in these facilities is particularly pervasive in rural areas where operational budgets are limited. The long-term goal of the proposed project is to develop a simple, cost-effective approach decrease energy costs in WWTPs using new process control and design technology. The proposed technologies has potential commercial viability through the sales of a monthly licensing agreement to ensure compliance and reduce WWTP energy costs.

Intra-operative 3D scanning system for minimally invasive surgery

PI: Dr. Hakki Refai, Optecks LLC, Tulsa **OCAST Project:** AR18-045 **Research Area:** Optics & Photonics

The proposed project has the primary goal of developing the prototype of an integrated 3D optical scanning system capable of intra-operative measurement and detection during minimally invasive surgical procedures. Surgeons perform laparoscopic and robotic surgery by threading instruments through small holes instead of making large incisions, minimizing tissue trauma, reducing recovery times, shortening hospital stays and simplifying patient care. Current systems, however, lack the ability to make accurate intra-operative measurements, requiring surgeons to use approximate techniques that can reduce the rate of surgical success and limiting the range of applications for an otherwise highly beneficial surgical technique.

The proposed project develops a 3D optical scanner with new designs and configurations capable of miniaturization to sizes suitable for integration with laparoscopic and robotic surgical instruments, producing 3D models and measurement of the surgical space in real time with millimeter accuracy, and providing the image data and control data to support a range of augmented and autonomous functionality beyond that currently available in the surgical theater.

The developed prototype will consist of a miniaturized 3D scanner located at the end of the surgical instrument, controlled externally by the surgeon, which captures high resolution images of the illuminated tissue in a single shot and transmits image data to sophisticated software designed as part of the project. The software employs algorithms that transform the data into 3D representations of the surgical space with millimeter accuracy, allowing the surgeon to make accurate measurements of critical features such as the size and shape of a hernia.

The proposed system can potentially employ multiple scanners to increase accuracy and monitor large surgical spaces such as inside the abdomen. The proposed system can easily add software modules that utilize the 3D model data to provide advanced functionality, including detecting abnormalities (e.g. colon polyps) earlier and with less error during endoscopy, add images of current health to the patient’s medical records for later use, provide alarms to warn the surgeon when surgical instruments approach to closely to critical tissues and organs, provide surgical simulators with real-life cases for training new surgeons or new procedures, and input data to control systems for semi-autonomous and autonomous surgical procedures.

Low-NOx and low-noise burner final development

PI: Dr. Yul Shaffer, GasTech Engineering LLC, Sapulpa **OCAST Project:** AR18-050 **Research Area:** Energy Resources/Petroleum

The increasing necessity to reduce combustion emissions places more demands upon process plant, heater, and burner suppliers to install equipment and burners with ever decreasing levels oxides of nitrogen (NOx) production. To meet current requirements, suppliers must use forced draft burners and elaborate control systems. Such burners consume electrical power thus further increasing the overall demand for energy and emissions related to electrical power generation. GasTech expects future emissions requirements to be more restrictive and increasingly specific.

Further, society expects reduced environmental impact not only with respect to air emissions, but also to noise levels. Forced draft burners, now used to reduce NOx emissions, combine the noise of the burner with that of the combustion air blower. This project focuses on advanced development of an existing innovative, natural draft burner design that intimates lower than current and anticipated future mandated NOx production while operating at reduced noise levels. The project will collect data from an existing prototype burner; via empirical methods, modify the prototype burner to reduce the NOx output and noise level of the burner; retest the modified burner to establish the lowest achievable NOx and noise output; develop a computational fluid dynamics (CFD) model that matches the performance of the modified prototype, low-NOx, low-noise burner; using the CFD model, determine modifications that will further reduce the burner's NOx and noise production; implement the CFD indicated modifications to the prototype burner; retest the prototype burner to confirm the desired NOx and noise reduction.

Upon confirmation of repeatable, stable, low-NOx, low-noise performance, GasTech Engineering commercialization efforts will commence. This project provides the possibility for significant impact for GasTech and the State of Oklahoma by reducing a NOx production rate of over 36,000 metric tons per year; reducing a projected NOx production rate increase of over 700 metric tons per year; increasing the sale of low-NOx, low-noise burners by over $12,000,000 per year; increasing the sale of process equipment using low-NOx, low-noise burners by over $75,000,000 per year. GasTech hopes to drive Oklahoma to the lead in reducing carbon production on the world stage.

Deployable CIGS solar cells for "SmallSat" Deep Space Missions

PI: Dr. Ian Sellers, University of Oklahoma, Norman
OCAST Project: AR18-052
Industry Partner: Amethyst Research, Inc, Ardmore
Research Area: Optics & Photonics

Recently, there has been lots of interest in missions into deeper space, to planets where the environment is particularly hostile. Indeed, NASA has launched several recent missions to the outer reaches of our solar system including small satellite voyages to Jupiter, Mars, and Saturn. Typically in deep space power generation relies on nuclear systems, however, the significant improvement of solar cells has enabled these systems to be viable for outer space. Now, they are considered the best option for longer term missions; since, only solar illumination is required to continue operating, assuming they do not degrade in their environment. Testament to the potential of solar cells in deep space was the use of solar cells on the recent BioSentinel mission, a small Cube Satellite which was sent to understand the effects of the space environment on yeast production. This has been an important first test to determine the effects of deep space on biological systems. For missions to Jupiter, for example, the temperature, low light illumination, and radiation effects can be particularly hostile, conditions that will require technologies that can withstand these environments.

Current solar cell technologies cannot withstand these conditions without considerable encapsulation, which increases the size, weight, and cost of the solar cells. This limits the maximum size that can be considered, reducing the total power generation. Here, we propose to investigate a new solar cell system (CIGS: Copper Indium GaAs di-Selenide) that is commercially available on flexible substrates. The flexible nature allows it to be folded up and then deployed while in deep space, which increases the total power that can be generated. In addition, in the laboratory this material has also been shown to withstand much higher radiation doses than conventional solar cells that are currently used in space. Therefore, this program aims to develop and test such CIGS systems for power applications in deep space; therefore designing, solar cells that become the unique technology used by NASA and commercial space companies when venturing further from the Sun.

Optimization of flow and disbursement for a green fire suppression agent

PI: Ross Faith, SpectrumFX Inc., Tulsa
OCAST Project: AR18-056
Partner: Oklahoma State University, Stillwater
Research Area: Other Materials

This OARS project presents the unique opportunity to provide an alternative to Halon that is more effective against a wider spectrum of fires, without having the negative environmental and health effects of Halon. In 1987, the Montreal Protocol phased out production of Halon because the gas is harmful to humans and the environment. Specifically, Halon damages the ozone layer and is harmful to the respiratory, cardiovascular, and central nervous systems when inhaled. The fire safety industry has developed several alternative agents, but none of the alternatives are as effective as Halon, requiring much higher volumes of product to match Halon's utility, which is both more expensive and heavier.

This trade-off is especially significant for the Air Force, as fire-suppression systems on USAF aircraft must be effective, lightweight, and cost-effective. They should also be, like Halon, non-corrosive. The Air Force and private industry need a next-generation, non-toxic, EPA-approved alternative to Halon that is as effective and lightweight, but also at least as economical as Halon.

Firebane® has already proven it meets many of the requirements to replace Halon. Firebane® is a composition of sugar alcohol and water, which has superior heat absorption compared to water alone. It has passed EPA environmental standards to replace Halon as a flooding and streaming agent, meaning it is both non-toxic and non-ozone depleting. Furthermore, it is rated to extinguish Class A and B fires, just as Halon is. Firebane® has the additional benefit of being able to extinguish Class D fires, such as lithium battery and titanium fires, which Halon cannot do. To make matters worse, Halon reacts violently in these situations.

To enable replacement of Halon in aircraft applications, Firebane® will need a more efficient delivery mechanism than either flooding or streaming can provide. Furthermore, a timely/efficient delivery mechanism would ideally not involve total bay flooding, which involves sending large volumes of water over valuable cargo and aircraft. The key performance benefit that Halon has over Firebane® right now is that Halon, as a gas, can disperse around a wider area than a liquid agent that streams or floods from an extinguisher – it can cover areas between cargo units or those that are out of reach by a single stream of liquid.

The UNIVERSITY of OKLAHOMA

Infrared detectors with narrow tunable linewidths

PI: Dr. Michael Santos, University of Oklahoma, Norman
OCAST Project: AR18-063
Industry Partner: Amethyst Research, Inc., Ardmore
Research Area: Semiconductors

We propose to develop an infrared detector that has unprecedented low noise and a spectral response that is narrow and tunable. The detector consists of a thin absorbing layer inserted into an optical cavity between two mirrors – all in an integrated device formed in III-V semiconductor materials. Amethyst will be responsible for the design of the layer structure. The University of Oklahoma will grow the layer structures using molecular beam epitaxy and characterize their materials properties. Amethyst will fabricate the layer structures into infrared detectors and characterize their device properties. Data from the materials and device characterizations will be used to optimize the design of the layer structure, the procedures for epitaxial growth, the fabrication process, and the device geometry.

The detector's narrow spectral response and low noise will make it ideal for detection of laser sources and narrow absorption lines of gases. Because the lines for different gases can overlap with each other, an ability to tune the detector's wavelength range is advantageous. We will develop two methods to tune the detector: first by varying its operating temperature and then by tilting it with respect to the direction of incident light. This project will include optimizing the detector design for various gases, and fabricating and testing the detectors to ensure that their performance meets the requirements for low-cost sensor systems. The goal of the proposed research is a proof-of-concept demonstration of an infrared detector for gas detection with performance specifications that exceed currently available technology.

eSWIR

PI: Dr. Jiayi Shao, Amethyst Research Inc., Ardmore **OCAST Project:** AR18-069 **Research Area:** Optics & Photonics

This program seeks to create a novel, high-performance infrared imaging capability via research and development of a process for optical detector material synthesis. This program focuses on optimization of the detector material synthesis process to create the highest quality infrared detector within the extended shortwave infrared wavelength optical detection band. Initial detector optimization will be carried out in collaboration with The University of Oklahoma which has a high-quality research facility for infrared materials synthesis. Once the infrared material has been optimized at The University of Oklahoma, the material synthesis technology will be transferred to Amethyst Research's production-grade infrared materials synthesis laboratory. The program aims to provide a very important world-first infrared imaging band capability to the infrared imaging market with benefits to many current customers/users. Additionally, the program aims to open the infrared detector market to new users by lowering imager costs significantly.

A new class of miniaturized lightweight highly efficient solid state cryogenic cooler

PI: Dr. S. Ali Shojaee, Amethyst Research Inc., Ardmore **OCAST Project:** AR18-070 **Research Area:** Semiconductors

This proposal plans to combine recent advances in permanent magnets with a new semiconductor design to develop solid-state coolers for cryogenic applications. The solid-state coolers currently available are not capable of reaching low temperatures and if successful, the proposed solid-state coolers will be the first. Unlike mechanical coolers, solid-state coolers do not depend on parts with vibration, limited lifetime, and high-power consumption and can provide cooling with lower power consumption and higher efficiency.

The UNIVERSITY of OKLAHOMA

Development of intelligent protection systems for mitigating dynamic disturbances in remote distribution feeders with microgrids

PI: Dr. Paul Moses, University of Oklahoma, Norman **OCAST Project:** AR18-073 **Research Area:** Electrical Power Systems

Electrical power systems in Oklahoma are growing more complex with the infusion of volatile renewable energy sources such as wind and solar power. As a result, the network is experiencing more frequent and severe electrical disturbances or transients which may threaten crucial Oklahoma industries with costly outages and downtime. Furthermore, remote area rural communities and industries such as oil fields may operate as microgrids which have very limited electrical support from the utility and can operate in an islanded fashion with distributed energy resources. Such conditions are becoming common in Oklahoma and highly vulnerable to power transients. This project is aimed at developing intelligent protection systems with better situational awareness which will help alleviate particular transients and increase the reliability of the power supply. New techniques for monitoring the health of critical assets such as power transformers and rotating machines are proposed which are aimed to detect a problem well before a failure occurs.

Acoustic metastructures for next generation aircraft liners

PI: Dr. James Manimala, Oklahoma State University, Stillwater
OCAST Project: AR18-078
Research Area: Aerospace Structures & Acoustics, Metamaterials

Acoustic metastructures trace their conceptual origins to acoustic metamaterials that display unique mechanical wave manipulation capabilities. Metamaterials, are man-made structural materials that evince unusual dynamic properties pertaining to electromagnetics or acoustics that are not readily realizable in natural materials. In light of recent proof-of-concept achieved for a metastructural approach to significantly enhance acoustic performance in liners especially for lightweight, compact, broadband, low-frequency applications, for which there are currently no practical solutions, OSU and Spirit AeroSystems, Inc. propose to conduct R&D to commercialize this technology to develop new acoustic liners for next-generation commercial aircraft. Airborne noise with a dominant low-frequency content can have detrimental effects in many applications, a primary concern being in commercial aviation. Conventional approaches using acoustic liners, foams or claddings become impractical for low-frequency spectra or ultra-compact spaces such as those encountered in modern jet engines.

With global noise regulations becoming more and more stringent, and acoustic performance that can be extracted from conventional approaches tending to plateau, new approaches such as the metastructural approach that could take advantage of the latest developments in hybrid manufacturing materials and processes are bound to prove feasible. Based on prior research, an acoustic metastructural solution combining innovative core geometries such as 3D folded and phased cores with potentially incorporating acoustically nonrigid elements with advanced aerospace materials and fabrication processes is proposed to be developed. The following objectives are identified for this R&D and commercialization program: (i) Investigate candidate metastructural configurations to ascertain the best options to realize technical and commercial aims, (ii) Achieve technology demonstration using aerospace-grade prototypes under simulated operational environment conditions, (iii) Develop modeling and design optimization tools as well as custom automation and tooling for fabrication to create aircraft liner products based on this technology, and (iv) Accelerate the technology transition and commercialization process for this technology to meet the projected needs of the commercial aviation market. A multi-phase, three-year, accelerated development program is proposed to successfully commercialize this technology.