ARMY STTR 13.A
PROPOSAL SUBMISSION INSTRUCTIONS

The approved FY13.A topics solicited for in the Army's Small Business Technology Transfer (STTR) Program are listed below. Offerors responding to the Army STTR FY13.A Solicitation must follow all the instructions provided in the Department of Defense (DoD) Program Solicitation. Specific Army requirements in addition to or that deviate from the DoD Program Solicitation are provided below and reference the appropriate section of the DoD Solicitation.

The United States Army Research Office (ARO), STTR Program Management Office (PMO), manages the Army's STTR Program. The Army's STTR Program harnesses the collective knowledge and experience of more than 7,000 scientists and engineers, across nine Army organizations, to identify and put forward research or research and development (R/R&D) topics that are consistent with the mission of the organization and the purpose of the STTR program – i.e., to stimulate a partnership of ideas and technologies between innovative small business concerns (SBCs) and research institutions (RI) through Federally-funded R/R&D and address Army Science & Technology Challenge Areas. Information about the Army STTR Program can be found at https://www.armysbir.army.mil/sttr/Default.aspx.

Solicitation, topic, and general questions regarding the STTR Program should be addressed in the DoD portion of this solicitation. For technical questions about specific topics during the Pre-Solicitation period, contact the Topic Authors listed for each topic in the Solicitation. To obtain answers to technical questions during the formal Solicitation period, visit http://www.dodsbir.net/sitis. For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (8:00 am to 5:00 pm EST). Specific questions pertaining to the Army STTR Program should be submitted to:

Dr. Bradley E. Guay
Army STTR Program Manager
usarmy.rtp.aro.mail.sttr-pmo@mail.mil

US Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709
(919) 549-4200
FAX: (919) 549-4310

PHASE I PROPOSAL GUIDELINES

Phase I proposals should address the feasibility of a solution to the topic. Awards will be made on the basis of technical evaluations using the criteria contained in this DoD solicitation (see section 6.0) and availability of Army STTR funds. Army STTR uses only government employees as reviewers. The Army anticipates funding one or two STTR Phase I contracts to small businesses with their partner research institutions for each topic. If no proposals within a given area merit support relative to those in other areas, the Army will not award any contracts for that topic. Phase I contracts are limited to a maximum of $150,000 over a period not to exceed six months.

The DoD SBIR/STTR Proposal Submission system (http://www.dodsbir.net/submission/) provides instruction and a tutorial for preparation and submission of your proposal. Refer to section 5.0 at the front of this solicitation for detailed instructions on Phase I proposal format. You must include a company Commercialization Report as part of each proposal you submit. If you have not updated your commercialization information in the past year, or need to review a copy of your report, visit the DoD SBIR/STTR Proposal Submission site. Please note that improper handling of the Commercialization Report may result in the proposal being substantially delayed and that information provided may have a direct impact on the review of the proposal. Refer to section 5.4.e of the Solicitation instructions for detailed instructions on the Company Commercialization Report.

Proposals addressing the topics will be accepted for consideration if they are received no later than the closing date and hour of this solicitation – **6:00 a.m. E.T, Wednesday, 27 March 2013**. The Army requires your entire proposal to be submitted electronically through the DoD-wide SBIR/STTR Proposal Submission Web site (http://www.dodsbir.net/). A hardcopy is NOT required and will not be accepted. Hand or electronic signature on the proposal is also NOT required. In this Solicitation, Army has established a **20-page limitation** for Technical Volumes submitted in response to its topics. This does not include the Proposal Cover Sheets (pages 1 and 2, added electronically by the DoD submission site), the Cost Volume, or the Company Commercialization Report (CCR). The Technical Volume includes, but is not limited to: table of contents, pages left blank intentionally by you, references and letters of support, appendices, key personnel biographical information, and all attachments. The Army requires that small businesses complete the Cost Volume form on the DoD Submission site versus submitting within the body of the uploaded volume. Since proposals are required to be submitted in Portable Document Format (PDF), it is the responsibility of submitters to ensure any PDF conversion is accurate and does not cause the Technical Volume portion of the proposal to exceed the 20-page limit. **Any pages submitted beyond the 20-page limit, will not be evaluated.** If you experience problems uploading a proposal, call the DoD Help Desk 1-866-724-7457 (8:00 am to 5:00 pm ET).

Companies should plan carefully for research involving animal or human subjects, biological agents, etc (see sections 4.7 - 4.9). The few months available for a Phase I effort may preclude plans including these elements, unless coordinated before a contract is awarded.

If the offeror proposes to use a foreign national(s) – refer to sections 3.5 and 5.4.c in the DoD Solicitation for definitions and reporting requirements. Please ensure no Privacy Act information is included in this submittal.

If a small business concern receives an STTR award they must negotiate a written agreement between the small business and the research institution allocating intellectual property rights and rights to carry out follow-on research, development, or commercialization (section 10).

PHASE II PROPOSAL GUIDELINES

Beginning with the STTR FY13.A cycle, all Phase I awardees may apply for a Phase II award for their topic – i.e., no invitation required. Note, however, Phase II selections are based, in large part, on the success of the Phase I effort, so it is vital for SBCs to discuss the Phase I project results with their Army Technical Point of Contact (TPOC). Each year the Army STTR Program Office will inform SBCs of the annual submission date for Phase II proposals. Phase II submission dates will also be posted on the DoD SBIR/STTR Solicitation web page at http://www.dodsbir.net/solicitation/. The exact date may vary from year-to-year based on Agency funding and contract award execution. The SBC may submit a Phase II proposal for up to three years after the Phase I selection date, but not more than twice. The Army STTR Program cannot accept proposals outside the Phase II submission dates. Proposals received at any time other than the prescribed submission period will not be evaluated.

Phase II proposals will be reviewed for overall merit based upon the criteria in section 8.0 of this solicitation. STTR Phase II proposals have 4 sections: Proposal Cover Sheets, Technical Volume, Cost Volume and Company Commercialization Report. The Technical Volume has a **38-page** limit including, but not limited to: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents (e.g., statements of work and resumes) and all attachments. However, offerors are instructed to NOT leave blank pages, duplicate the electronically generated cover pages or put information normally associated with the Technical Volume in others sections of the proposal submission as THESE WILL COUNT AGAINST THE 38-PAGE LIMIT. ONLY the electronically generated Cover Sheets, Cost Volume and Company Commercialization Report (CCR) is excluded from the 38-page limit. As instructed in section 5.4.e of the DoD Program Solicitation, the CCR is generated by the submission website based on information provided by you through the "Company Commercialization Report" tool. **Army Phase II proposals submitted over 38-pages will be deemed NON-COMPLIANT and will not be evaluated.**

Small businesses submitting a proposal are required to develop and submit a technology transition and commercialization plan describing feasible approaches for transitioning and/or commercializing the developed technology in their Phase II proposal. Army Phase II Cost Volumes must contain a budget for the entire 24 month Phase II period not to exceed the maximum dollar amount of $1,000,000. During contract negotiation, the contracting officer may require a Cost Volume for a base year and an option year. These costs must be submitted using the Cost Volume format (accessible electronically on the DoD submission site), and may be presented side-by-side on a single Cost Volume Sheet. The total proposed amount should be indicated on the Proposal Cover Sheet as the Proposed Cost. Phase II projects will be evaluated after the base year prior to extending funding for the option year.

Phase II proposals should be structured as follows: the first 10-12 months (base effort) should be approximately $500,000; the second 10-12 months of funding should also be approximately $500,000. The entire Phase II effort should not exceed $1,000,000. Contract structure for the Phase II contract is at the discretion of the Army's Contracting Officer after negotiations with the small business.

PUBLIC RELEASE OF AWARD INFORMATION

If your proposal is selected for award, the technical abstract and discussion of anticipated benefits will be publicly released via the Internet. Therefore, do not include proprietary or classified information in these sections. Note also that the DoD website contains data on all past DoD SBIR/STTR Phase I and II awards. This information can be viewed on the DoD SBIR/STTR Awards Search Website at http://www.dodsbir.net/awards.

NOTIFICATION SCHEDULE OF PROPOSAL STATUS AND DEBRIEFS

Once the source selection is complete, the Army STTR Program Manager will send an email to the individual listed as the "Corporate Official" on the Proposal Coversheet with an attached letter of selection or non-selection.

The Army STTR Program Manager will provide debriefings to offerors in accordance with FAR Subpart 15.5. The notification letter referenced above will provide instructions for requesting a proposal debriefing. Small Businesses will receive a notification for each proposal submitted. Please read each notification carefully and note the proposal number and topic number referenced. All communication from the Army STTR Program management will originate from the program specialist's e-mail address.

Army STTR 13.A Topic Index

Army STTR 13.A Topic Descriptions

A13A-T001 TITLE: Electrochemically Assisted Precision Form Grinding

TECHNOLOGY AREAS: Materials/Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.4 of the solicitation.

OBJECTIVE: This topic seeks to develop a new class of machine tools that can produce hypersmooth (less than 1 microinch Ra roughness), burr-free ground surfaces on hard metallic materials such as case hardened steels. This new class of grinding machine shall combine the latest advancements in form grinding techniques with those of electrochemical machining to allow the production of complex precision ground parts with improved accuracy, speed and surface finish while eliminating formation of burrs. The capability to produce a burr free part with hypersmooth surface finish will eliminate the costly post processing operation of removing burrs by hand and subjecting the part to a final superfinishing process which may change the final geometry. In addition, the creation of a hypersmooth surface has been proven to have performance benefits for gears and bearings due to reduced friction and improved oil film thickness. These new grinding machines should have multi axis capability similar to those used to grind complex 3-D surfaces on spiral bevel gears and airfoils for turbomachinery.

DESCRIPTION: Electrochemical grinding is a process that combines both electrochemical and mechanical action to remove hard electrically conductive material. Because of the electrochemical nature of the process, the workpiece material is ground without the production of burrs, with very low heat generation and the potential for hyper smooth surfaces. The electrochemical grinding process typically embodies a grinding wheel which uses an electrically conductive abrasive and bonding agent. The electrolyte is introduced to the work area in the same manner that coolant would be introduced in conventional wet grinding operations. This topic seeks to develop an electrochemically assisted precision form grinding machine with multi axis capability typically required for the production of complex hardened steel parts such as spiral bevel gears and other hard metallic materials such as nickel for turbomachinery airfoils and bladed disks. The achievement of ground surfaces with finishes of less than 1 microinch Ra roughness is one of the key objectives of this effort. The ability to eliminate the formation of burrs on the edges of these components is also highly desired. The integration of the electrochemical features into that of an existing grinding machine is thought to be the primary challenge associated with the successful development of the device. Other challenges include the selection of proper grinding wheel materials and design configurations, electrolyte formulation and delivery system. The potential benefits include a reduction in production costs by elimination of hand removal of burrs and the elimination of a secondary superfinishing process currently performed post grinding. Potential performance benefits will be obtained by the reduced friction of the hypersmooth surfaces which significantly impacts gear efficiency and load capacity and could improve the efficiency of turbine airfoils. The potential applications of the electrochemically assisted precision form grinding machine are numerous and include any type of commercial or military mechanisms which uses gears and airfoils, such as cars, trucks, aircraft, spacecraft, ships, wind turbines and gas turbines.

PHASE I: Phase I effort shall focus on the design, fabrication and demonstration of a bench top scale electrochemically assisted precision form grinding machine. This device shall be simple in configuration and may have only a single axis of movement with a wheel design capable of producing a ½ inch deep, 3 inch long, 20 degree angle v-notch in a block of case hardened alloy steel such as 8620 or 4340. This device shall be utilized to investigate various wheel compositions, electrolyte formulations and the overall integration of the mechanical and electrical aspects of the machine. The objective at the conclusion of Phase I is to produce the simple v-notch slot in a block of hardened steel. The resulting slot should have a hyper smooth surface finish (less than 1 microinch Ra roughness) and be free of burrs and burns due to arching and overheating.

PHASE II: Phase II effort shall consist of further design and analysis of the proposed the electrochemically assisted precision form grinding machine based upon the findings of Phase I effort. The Phase II objective is to scale–up the design and apply it to a multi axis form grinding machine capable of producing complex gears and airfoils with lengths and diameters greater than 12 inches. Physical and mechanical property testing of the gears or airfoils produced by the prototype electrochemically assisted precision form grinding machine shall be conducted. A target initial application shall be selected and a manufacturing plan and benefits analysis performed.

PHASE III DUAL USE APPLICATIONS: The potential commercial and military applications of an electrochemically assisted precision form grinding machine is widespread. The machine could be utilized to produce high performance parts with a significant reduction in cost and time. The achievement of a hypersmooth surface would provide significant increase the durability and power density of propulsion systems for all types of aircraft and ground vehicles. Most, if not all of these types of components are common in both commercial and military application, and thus, the dual use potential is very high.

REFERENCES:

1) Nontraditional manufacturing processes: Volume 19 of Manufacturing engineering and materials processing, CRC Press, 1987, pp. 153–160, ISBN 0-8247-7352-7, http://books.google.com/books?id=xdmNVSio8jUC&pg=PA153

2) Derek Pletcher, Frank Walsh (1990), Industrial electrochemistry, Springer, pp. 464–466, ISBN 0-412-30410-4, http://books.google.com/books?id=E_u9ARrm37oC&pg=PA465

3) Valenti, Michael, "Making the Cut," Mechanical Engineering, American Society of Mechanical Engineers, 2001. http://www.memagazine.org/backissues/membersonly/nov01/features/makcut/makcut.html, accessed 2/23/2010

4) McGeough, J. A. (1988), Advanced methods of machining, Springer, pp. 82, ISBN 0-412-31970-5

5) The Fundamentals of Grinding: http://nd.edu/~manufact/MPEM%20pdf_files/Ch09.pdf

6) http://www.abrasiveengineering.com/semgrind.pdf

KEYWORDS: electrochemical, grinding, gears, airfoils, electrolytes

A13A-T002 TITLE: Solar Blind, Plasmonic Enhanced Ultraviolet Photodectector

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Design, fabricate, and demonstrate a new category of solar blind ultraviolet photodetectors with enhanced sensitivity through the use of a plasmonic electrode or other electrode to funnel and localize ultraviolet energy while rejecting solar radiation.

DESCRIPTION: Ultraviolet photodetectors have numerous applications including the detection of missile plumes and muzzle flash, missile guidance, detection of biological/chemical agents, flame detection, and non-line-of-sight communications. A typical problem with the detection of weak ultraviolet signals is the large amount of background solar radiation which can easily overwhelm the detectors. The strong solar background requires ultraviolet detectors to be combined with additional optics in the form of high performance filters.

In the past decade there has been significant progress in the development of wide bandgap semiconductors for ultraviolet detectors to replace bulky, fragile, and expensive photomultiplier tubes. These high gain, low noise, photomultiplier tubes can have a fairly low responsivity to solar radiation with the proper choice of the photocathode material but they still require optical filtering. The newer wide bandgap semiconductors are also relatively insensitive to the solar background due to their step shaped absorption spectrum but there is always an absorption tail spilling into the solar spectral range which requires filtering. The solid state, low cost, rugged, wide bandgap semiconductors are the ideal choice for ultraviolet detectors but they have not yet achieved the sensitivity of photomultiplier tubes.

Aside from intrinsic semiconductor issues related to carrier lifetime and mobility, the metal electrode on the semiconductor photodectors can seriously degrade the detector responsivity. For example, in metal-semiconductor-metal detectors comprised of back-to-back Schottky diodes, the interdigitated electrodes provide high speed response but also substantially shadow the active region of the device leading to poor responsivity[1]. Electrodes composed of semitransparent metal oxide conducting films can overcome these issues but have low conductivity and are expensive to apply[2].

Recent developments in plasmonic based electrodes have provided substantial improvements in the efficiency of solar cells and photodiodes[2]. It has been demonstrated that metallic films with small apertures can collect and funnel light through the film with near perfect efficiency even when the open area of the screen comprises only 10% of the surface area[3,4]. Since most of the area of the screen is metal, the electrical conductance is very high. In addition to the amazing light collection efficiency of the plasmonic screen, the particular geometry of the screen can filter out specific regions of the electromagnetic spectrum. To date, most of the work on plasmonic electrodes has been carried out in the visible, but recent development in ultraviolet plasmonics indicates the potential for a plasmonic electrode that can substantially increase the sensitivity of ultraviolet photodetectors[5].

The ultimate goal of this project is to fabricate a plasmonic electrode or other approach to electrode design that will significantly increase the responsivity of ultraviolet, semiconductor photodetectors while at the same time provide filtering of the solar spectrum.

PHASE I: In the Phase I effort, a complete design of the plasmonic electrode will be formulated and fabrication procedures developed. Designs should include realistic material parameters that include the dispersive properties of the metal. Simulations should be based on accepted analytical methods or rigorous numerical models. Phase I efforts should include fabrication experiments that demonstrate the feasibility of the approach and benchmarks on the improved responsivity of the ultraviolet photodetector and solar rejection parameters.

PHASE II: In the Phase II effort, an array containing several ultraviolet photodetectors will be fabricated and delivered. The performance of the devices in terms of responsivity as a function of wavelength will be evaluated and compared with the Phase I benchmarks. In addition to the prototype array, a report detailing the design for optimizing the electrodes for various spectral ranges of the ultraviolet will be provided. Two days of on-site training and evaluation of the detector array will be provided along with the final report.

PHASE III DUAL USE APPLICATIONS: The Phase III work will demonstrate the scalability and repeatability of the fabrication process to achieve high yield arrays of ultraviolet photodectors. This new technology will have commercialization opportunities for military relevant applications for the detection of missile plumes and muzzle flash, and missile guidance. The same technology will have applications for flame detection in a variety of environments including munitions storage facilities.

REFERENCES:
1) K. Liu, M. Sakurai, and M. Aono, Sensors 10, 8604 (2010).

2) P.B. Catrysse and S. Fan, Nano Lett. 10, 2944 (2010).

3) C. Genet and W. Ebbesen, Nature 445, 39 (2007).

4) A.I. Fernandez-Dominguez, F.J. Garcia-Vidal, and L. Martin-Moreno, Phys. Rev. B 76, 235430 (2007).

5) Q. Gan, L. Zhou, V. Dierolf, and F. Bartoli, IEEE Photonics Journal 1, (2009).

KEYWORDS: plasmonics, ultraviolet detectors, photodectors, wide bandgap semiconductors

A13A-T003 TITLE: Printed Flexible Power Solutions for Armament Systems

TECHNOLOGY AREAS: Materials/Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.4 of the solicitation.

OBJECTIVE: Develop and demonstrate the use of printed, flexible power solutions to increase the power and help reduce the weight of armaments and unmanned systems, as well as reduce the weight burden on U.S. soldiers by providing power for individual weapons.

DESCRIPTION: Today's advanced gun-fired munitions, unmanned systems, and ballistic fire control systems require energy sources with increased power and energy densities, must operate over a wide temperature range, and withstand prolonged storage -- all in a smaller, more lightweight package. Current power solutions for many of these remote weapon systems cannot support their range, precision guidance, and lethality capabilities, greatly reducing the warfighter's mobility and mission-duration and significantly decreasing their value and effectiveness in the field.

The U.S. Army is seeking to equip its weapons systems with new energy solutions, such as hybrid energy/power systems, that can supplement and reduce its dependence on traditional sources. Considerations should be given to flexible, conformal power solutions, which could improve energy density, power levels, safety and reliability, and extend remote military missions. Current advances in materials and deposition technologies offer the potential to integrate small, independent electrical energy sources such as printed batteries, energy harvesting devices, and photovoltaics (ie: integrating power solutions into guns and armaments, powering prognostics and diagnostics for ammunition logistics, space claim and size reduction). Research is needed to determine if alternative power solutions can be integrated into armaments, thus reducing size, while adding capability to meet the power needs of extended warfighter missions and ammunition logistics. The STTR must consider the manufacturing and survivability issues the flexible, conformal power solutions must endure based on the harsh environments in which today's munitions operate.

PHASE I: Develop and manufacture flexible, conformal power solution prototypes using proven, production-ready processes. The prototypes must be as small and flexible as possible to maximize the weapon systems' capabilities, while also being safe, reliable, producible, and affordable. Produce samples for testing and evaluation.

PHASE II: Integrate candidate prototypes into weapon systems (armaments, ammunition, and weapons). Perform system-level testing to assess the improved energy density, power levels, safety, reliability, and other key characteristics of the prototypes, and to ensure its long-term survivability amid the harsh environmental conditions and explosive forces it may face in theater.

Technology Readiness Level: TRL 6 - System/subsystem model or prototype demonstration in a relevant environment.

PHASE III DUAL USE APPLICATIONS: Produce LRIP quantities of selected systems that meet customer needs. Develop and mature the prototype printing process into a full-scale production process for immediate insertion into the industrial base. Document process and prepare technical data package.

REFERENCES:
1) Gary R. Tucholski, "Thin Printable Electrochemical Cell and Methods of Making the Same," US Patent #8268475 B2, September 18, 2012.

2) Chunhong Lei, Peter Wilson, Constantina Lekakou, "Effect of poly(3,4-ethylenedioxythiophene) (PEDOT) in carbon-based composite electrodes for electrochemical supercapacitors," Journal of Power Sources, v.196 n.18, p.7823-7827, September 2011.

3) L.T. Lee, M.H. Ervin, H. Qiu, B.E. Fuchs, J. Zunino, W.Y. Lee, "Inkjet-Printed Graphene for Flexible Micro-Supercapacitors," Proceedings of the 11th IEEE International Conference on Nanotechnology, p.67-71, August 2011.

4) Alexis Laforgue, "All-textile flexible supercapacitors using electrospun poly(3,4-ethylenedioxythiophene) nanofibers," Journal of Power Sources, v.196 n.1, p.559-564, January 2011.

5) Liangbing Hu, Hui Wu, Fabio La Mantia, Yuan Yang, Yi Cui, "Thin, Flexible Secondary Li-Ion Paper Batteries," ACS Nano, v.4 n.10, p.5843-5848, September 2010.

6) Pritesh Hiraral, Shinji Imaizumi, Husnu Emrah Unalan, Hidetoshi Matsumoto, Mie Minagawa, Markku Rouvala, Akihiko Tanioka, Gehan A.J. Amaratunga, "Nanomaterial-Enhanced All-Solid Flexible Zinc-Carbon Batteries," ACS Nano, v.4 n.5, p.2730-2734, April 2010.

7) T.B. Reddy and D. Linden, eds. Linden's Handbook of Batteries. 4th edition. New York: McGraw-Hill, 2010.

8) Wang Guoping, Zhang Qingtang, Yu Zuolong, Qu MeiZheng, "The effect of different kinds of nano-carbon conductive additives in lithium ion batteries on the resistance and electrochemical behavior of the LiCoO2 composite cathodes," Solid State Ionics, v.179 n.7-8, p.263-268, April 2008.

9) Darren Southee, Gareth I. Hay, Peter S. A. Evans, David J. Harrison, "Lithographically Printed Voltaic Cells - A Feasibility Study," Circuit World, v.33 n.1, p.31-35, 2007.

10) Yong Jung Kim, Yoong Ahm Kim, Teruaki Chino, Hiroaki Suezaki, Morinobu Endo, Mildred S. Dresselhaus, "Chemically Modified Multiwalled Carbon Nanotubes as an Additive for Supercapacitors," Small, v.2 n.3, p.339-345, March 2006.

KEYWORDS: flexible, conformal, power solutions, material printing, photovoltaic, munitions, armaments, logistics

A13A-T004 TITLE: Liquid Crystal-based Sensors for Detection of Airborne Toxic Chemicals for Integration with Unmanned Robotic Systems

TECHNOLOGY AREAS: Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.4 of the solicitation.

OBJECTIVE: Development of rugged light-weight liquid crystal-based chemical sensors for integration with unmanned vehicles.

DESCRIPTION: Unmanned vehicles (UMVs) that allow assessment of threat before entering an unknown environment are becoming an integral part of critical missions to ensure personal safety. These remotely controlled robotic devices are typically equipped with multiple infrared cameras and microphones to provide a real-time audio-visual signal from an otherwise unknown environment. Recent advances in new materials, efficient device design, and improved data transfer and processing capabilities have led to the development of small lightweight throwable robots that can be deployed remotely inside a building to provide situational awareness. Besides audio-visual capabilities, the need for onboard sensors to detect presence of potentially lethal or other important chemical agents has long been recognized. Large UMVs can carry large instruments capable of collecting air samples and performing in-situ spectral analysis, but small, recently developed throwable robots do not have integrated chemical sensors primarily due to the absence of a sensing technology that can provide small, lightweight, low-power sensors that can withstand the mechanical impacts during deployment. Chemical sensors based on existing technologies are either too bulky, require high power to operate or they cannot withstand the mechanical shock during deployment. There exists, therefore, an unmet need for small, low-cost rugged sensor technologies that can be integrated into throwable robots to empower them with the third sense (i.e. smell). A sensor that can be integrated with these UMVs will save lives during critical missions by providing real-time information to the operator about the life-threatening chemical environments before entering. These sensors for toxic chemicals should be lightweight and should allow seamless interfacing with the existing wireless data communication system in UMVs. Development of these new sensor technologies requires the design of advanced materials systems that exhibit large changes in physical properties in response to relevant concentrations of targeted toxic chemicals so as to avoid the need for bulky and complex instruments and minimize device power consumption.

Liquid crystal (LC)-based materials systems have potential to address this unmet need by enabling development of a robust, light-weight, sensitive, low power sensor platform. This innovative technology relies on the use of liquid crystalline materials, supported on chemically functionalized surfaces, that undergoes an ordering transition upon exposure to targeted analytes. Together, the use of LC materials and competitive interactions at the molecular scale form the basis of a sensing technology that provides simplicity and selectivity not offered by existing sensing technologies. The sensors can be interrogated optically (by using polarized light) or electronically (by measuring change in capacitance) to yield an unambiguous and quantifiable dose dependent response. By tailoring the physicochemical properties of the chemically functionalized surfaces, a technology can be developed to distinguish classes of chemical agents (e.g. blister vs. nerve agents) and also compounds within a given class (e.g. GB vs. VX nerve agents). The LC-based sensing technology is capable of detection of various gases of relevance to defense and security (nerve agents) and occupational hygiene (toxic chemicals) applications. Optimization of the physicochemical properties of the surfaces will allow detection in the ppb levels in seconds. The technology is based on materials and processes currently employed in well-established LC display technology and therefore it is amenable to high-throughput manufacturing. The technology can be realized in a variety of formats and packaging for surveillance and monitoring of the chemical environment that will allow easy integration with UMVs such as throwable robots.

PHASE I: In Phase I, the LC-based technology should demonstrate detection of at least 4 different chemicals of different classes within seconds and at 100 ppb limits of detection or less. Possible targets include but are not limited to toxic industrial chemicals, chemical agent simulants, and pesticides.

PHASE II: Phase II should continue sensor chemistry development and optimization, and demonstrate detection of at least 7 different chemicals from different classes within seconds and at less than 100 ppb limits of detection. The sensor technology should be able to distinguish classes of chemical agents as well as compounds within the same class. In addition to a sensitive detection surface with rapid response time and non-responsiveness to common interferents, a sensor for integration with the UMVs must be sufficiently rugged to withstand fluctuations in the environmental conditions including temperature and relative humidity variations. Once the optimal chemistry and LC materials are identified, an electrical detection method should be developed. To demonstrate integration with throwable robots, a prototype sensor sub-system should be designed, fabricated, tested, and demonstrated in a realistic environment mimicking operational conditions.

PHASE III DUAL USE APPLICATIONS: This technology has a broad range of potential civilian and military applications. The sensor platform developed for detection of chemical warfare agents and toxic industrial chemicals for military applications can readily be adapted for detection of a range of toxic chemicals for first responders.

REFERENCES

1) http://www.reconrobotics.com/products/

2) http://www.qinetiq-na.com/products/unmanned-systems/talon/

3) Shah, R.R. and N.L. Abbott, Principles for measurement of chemical exposure based on recognition-driven anchoring transitions in liquid crystals. Science 293(5533): 1296-1299 (2001).

4) Cadwell KD et al., Detection of organophosphorous nerve agents using liquid crystals supported on chemically functionalized surfaces. Sensors and Actuators B 128 91–98 (2007).

KEYWORDS: sensor, liquid crystal, detection

A13A-T005 TITLE: Construction of 3-D Terrain Models from BIG Data Sets

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: To design, analyze, and implement a new class of models and algorithms for constructing high-resolution, multi-resolution, and accurate 3D terrain models from BIG point data sets that can handle noise, uncertainty, and dynamic updates in data.

DESCRIPTION: Terrain analysis is an integral part of the military intelligence preparation of the battlefield, commonly used to support both defensive and offensive operations. It consists of providing various tactical aids for military operations by integrating geospatial data with imagery and other sensor data.

The revolution in sensing and mapping technologies is bringing unprecedented advances in characterization and understanding of earth surface, its dynamics, and its properties. For instance, the second generation airborne LIDAR (Light Detecting and Ranging) can map the earth surface at 10-15 cm resolution, and the future generation LIDARs are expected to generate even higher resolution data. Multiple return and waveform LIDAR systems provide additional discrete or continuous data in vertical direction leading to more detailed vegetation and structures mapping.

However, transforming these massive amounts of heterogeneous and temporal data into useful information for vastly different types of users requires solving several challenging mathematical and algorithmic problems such as:

1. Constructing 3-D models: Scalable algorithms for constructing 3-D terrain models at multiple levels of resolution and that can be updated dynamically as new data arrives are necessary. Although solutions exist for small data sets, these methods are not scalable to large dynamic data sets.

2. De-noising: Before analyzing the terrain data, it needs to be cleaned. This cleaning is necessary because the raw data supplied as a set of three-dimensional points includes a lot of noise because of man-made objects (towers and other structures), non-permanent objects (vehicles), etc. and spurious measurements. Such measurements appear due to multiple reflections and refraction, for example.

3. Uncertainty: There is also uncertainty in data because of measurement errors, energy constraints that lead to aggregate or approximate measurements being sent, and privacy and anonymity concerns that force data to be deliberately perturbed. Mathematical models and algorithms for incorporating uncertainty in terrain modeling and analysis are needed.

4. Multiple platforms: Computations need to be performed on different platforms, ranging from cluster, to desktop and laptop, to smart phones, with very different computational and storage capabilities. Algorithms are needed that work seamlessly on multiple platforms, and obtain optimal trade-offs between computation and communication.

The ultimate goal is a software package and/or library that can construct accurate 3-D terrain models from BIG point data sets in the presence of noise, uncertainty, and dynamic updates in data and that will function efficiently on multiple platforms. Although there have been recent advances in the above individual areas for BIG data implementations on specific hardware (e.g., new indexing techniques for dealing with uncertainty, space-time cube analysis for dealing with dynamic updates, laptop applications able to access the Graphics Processing Unit), there is no single software package that incorporates all of the necessary features. These individual advances are an excellent starting point and enabler for such a package. Also, a transition path to the US Army Corps of Engineers (USACE) already exists. For example, with the aid of "BIG data" experts from academia, the processing time of a USACE terrain analysis project centered in Panama was reduced from days to hours. However, the USACE, DoD, and the terrain analysis community would greatly benefit from a stand-alone package they could implement on their own without having to rely on outside expertise.

PHASE I: This portion of the effort will consist of identifying robust and mathematically consistent computational approaches to construct 3D terrain models from BIG point data sets in the presence of noise, uncertainty, and dynamic updates in data.

PHASE II: Using the results from Phase I, the effort will be to build robust, scalable software and interface for constructing 3-D terrain models from BIG point data sets and implementing the algorithms on multiple platforms Technical and user documentation will be developed at this time.

PHASE III DUAL USE APPLICATIONS: In recent years, the potential of terrain information systems has been greatly enhanced by new terrain mapping technologies such as LIDAR, ground based laser scanning and Real Time Kinematic GPS (RTK-GPS) that are capable of acquiring millions of geo-referenced points within short periods of time (minutes to hours). However, transforming the resulting massive amounts of heterogeneous data to useful information for different types of users and applications is lagging behind. Thus the full potential of new mapping technologies has not been utilized; as noted by the Combat Terrain Information System project management office: "The current terrain analysis, topographic, and reproduction support are slow, labor intensive processes that do not meet the needs of the digital battlefield." Civilian applications abound as well, for example, the use of LIDAR data for North Carolina flood maps has proven non-trivial and has become a time consuming process causing significant delays in the releases of new flood maps. Also, existing Geographic Information Systems (GIS) are unable to handle much less process large data sets containing millions of points. The outcome of this effort would be the development of a suite of software tools that would significantly enhance both military and civilian terrain analysis applications when forced to deal with BIG data sets.

REFERENCES:
1) Andrew Danner, Thomas Moelhave, Ke Yi, Pankaj K. Agarwal, Lars Arge, Helena Mitasova: TerraStream: from elevation data to watershed hierarchies. Proc. ACM-GIS 2007: 28

2) Thomas Moelhave, Pankaj K. Agarwal, Lars Arge, Morten Revsbaek: Scalable algorithms for large high-resolution terrain data. COM.Geo 2010

3) Pankaj K. Agarwal, Lars Arge, Ke Yi: I/O-efficient batched union-find and its applications to terrain analysis. ACM Transactions on Algorithms 7(1): 11 (2010)

4) Lars Arge, Kasper Green Larsen, Thomas Moelhave, Freek van Walderveen: Cleaning massive sonar point clouds. Proc. ACM-GIS 2010: 152-161

5) Alex Beutel, Thomas Moelhave, Pankaj K. Agarwal: Natural neighbor interpolation based grid DEM construction using a GPU. GIS 2010: 172-181

6) A. Danner, Pankaj K. Agarwal, and L. Arge: From point cloud to grid DEM: A scalable approach, in Proc 12th Sympos Spatial Data Handling, 2006.

KEYWORDS: 3-D terrain models, big data, dynamic updates, de-noising, uncertainty, multiple platforms, LIDAR

A13A-T006 TITLE: Solar-blind (Be,Mg)ZnO Photodetectors (260-285 nm wavelengths)

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Develop ZnO based UV photodetectors for the solar-blind detection window of 265-280 nm for various military applications.

DDESCRIPTION: The photoresponse of current solar blind detectors (SBDs) is not sufficient for many applications where UV light needs to be sensed. Solar blind photodetectors are specified to the 265-280 nm region of the ultraviolet spectrum and require greater than several hundred milliamps per watt of photoresponse to replace photomultiplier tubes (PMTs) or other semiconductor based SBDs. ZnO (zinc oxide) and its alloys, e.g. (Be, Mg)ZnO, are sought for application to high responsivity photodetectors. (Be,Mg)ZnO alloys have been reported by some groups for application in this regime [1]. Recent programs on SBDs include silicon carbide based APDs (avalanche photodiodes) and GaN based alloy SBDs which have not met the requirements for replacing PMTs. As a highly efficient photoluminescent material, ZnO holds promise for these requirements based on recent development of BeZnO and MgZnO alloys that include nanowires.

PHASE I: Demonstrate (Be,Mg)ZnO semiconductor alloys of high optical quality with optical bandgap of approximately 280 nm for solar blind detection regime with wavelength cutoff > 100 for solar blind window region. Also, demonstrate doping and contact formation needed for the complete UV photodetector. Absorption data, contact resistance data, and p-doping should be measured and included in reports.

PHASE II: Develop high responsivity solar-blind photodetectors (265-280 nm) for military applications. Performance goals should be those to surpass current SBDs with approximate photoresponse of 200 mA/W. Approaches to be investigated could include standard p-n junction photodetectors or avalanche photodetectors. Solar blind photodetectors should be delivered to ARL for evaluation (after evaluation the photodetector(s) - one or more - may be returned if desired). Also, if photodetectors were developed in bands outside the 265-280 nm window they should be delivered for comparison - one in each cutoff wavelength band - < 265 nm, < 280 nm, < 300 nm, etc. to 385 nm, every 20 nm interval.

PHASE III DUAL USE APPLICATIONS: Military applications include UV non-line of sight (NLOS) optical communications, bio-warfare agent detection, missile detection from plume signatures, and other spectroscopic UV signatures. Dual-use (civilian) applications include biosensing and bio-agent detection, flame detection, determination of engine combustion efficiency, atmospheric ozone studies, and astronomical studies.

REFERENCES:
1) L. Li, J. Lubguban, P. Yu, H. W. White, Y. Ryu; T. Lee, “ZnO p-n junction photodetectors,” CLEO '07. 2007 Conference on Lasers and Electro-Optics, 2007, 331-332.

2.) J. L. Liu, F. X. Xiu, L. J. Mandalapu, Z. Yang, “P-type ZnO by Sb doping for PN-junction photodetectors,” Proceedings of the SPIE - The International Society for Optical Engineering, v 6122, 9 Feb. 2006, p 61220H-1-7

3) H. Shen, M. Wraback, C. R. Gorla, S. Liang, N. Emanetoglu, Y. Liu, Y. Lu, “High-gain, high-speed ZnO MSM ultraviolet photodetectors,” GaN and Related Alloys - 1999. Symposium (Materials Research Society Symposium Proceedings Vol. 595), 2000, p 11.16.1-6.

4) H. Liu, D. Mcintosh, X. Bai, H. Pan, M. Liu, J. Campbell, H. Y. Cha, "4H-SiC PIN recessed-window avalanche photodiode with high quantum efficiency," IEEE Photonics Technology Letters, v20, n18, Sept. 15, 2008, pp. 1551-1553.

5) Y. Ryu, T. Lee, J. Lubguban, H. White, Y. Park, C. J. Youn, "ZnO devices: photodiodes and p-type field-effect transistors", Applied Physics Letters, v 87, n 15, 10 Oct. 2005, p 153504-1-3.

KEYWORDS: Zinc oxide, solar blind, ultraviolet, photodetectors

A13A-T007 TITLE: New Approaches for Ammonia Synthesis

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Develop and demonstrate new methods of ammonia synthesis capable of utilizing atmospheric nitrogen that do not require the sustained high pressures required for the Haber-Bosch process.

DESCRIPTION: Ammonia is one of the most widely produced chemicals with a variety of uses including hydrogen storage for fuel cell applications, refrigeration, and fertilizer. In addition, it is also an intermediate in the production of explosives and gun propellants. In the early 1900’s Haber conducted groundbreaking research on the production of ammonia for which he received the Nobel Prize in 1918. His research was followed by that of Bosch who scaled up the process for industrial use. Using the Haber-Bosch process the production of ammonia is energy intensive due to the high pressures, 150-300 bar, and high temperatures, ~500 C, necessary to cleave the nitrogen-nitrogen triple bond with an iron catalyst. In addition the nitrogen and hydrogen reactants must be purified prior to use to minimize catalyst poisoning. Recent research indicates that solid-state electrochemical synthesis of ammonia using both proton and oxygen ion conducting electrolytes are a promising avenue to bypass the thermodynamic restrictions of the Haber-Bosch process, which limit the reaction equilibrium to 10 to 15% for a single reactor. In addition these electrochemical systems have achieved in excess of 70% hydrogen conversion to ammonia.

PHASE I: Demonstrate feasibility for improved synthesis of ammonia in the absence of the sustained high pressures and temperatures required by the Haber-Bosch process. Process inputs should be limited to ambient air, hydrogen, water, and electricity. Show experimental results resulting in ammonia synthesis that exceed the Haber-Bosch reaction equilibrium of 10 to 15%. Determine the hydrogen utilization and optimize the reaction conditions to maximize ammonia production while minimizing ammonia decomposition. Quantify the required nitrogen and hydrogen purities necessary to allow sustained synthesis without poisoning any catalysts present. Process efficiency should exceed 50% of the Haber-Bosch process in terms of the energy use to produce a given mass.

PHASE II: Based on the initial Phase I results develop a self-contained portable system capable of producing ammonia using only atmospheric nitrogen, water, and electricity. Scale and optimize the process to produce at least 5 kg/hr with an efficiency of at least 75% of the Haber-Bosch process in terms of the energy use to produce a given mass. The system should tolerate impurities of sulfur and carbon monoxide of up to 1%.

PHASE III Dual Use Applications: The technology developed under this program will find dual-use in military and civilian applications. Military systems will enable production of ammonia at distributed locations using only water as an input with the potential to reduce supply chain logistics. Civilian applications will enable energy storage from renewable resources as well as the production of fertilizers and chemical precursors from non-petroleum sources.

REFERENCES:
1) G. Marnellos and M. Stoukides, “Ammonia Synthesis at Atmospheric Pressure”, Science, 282, 2 Oct 1998, pp. 98-100.

2) I. A. Amar, R. Lan, C. T. G. Petit and S Tao, “Solid-State Electrochemical Synthesis of Ammonia”, J. Solid State Electrochem., 15, 2011, pp. 1845-1860.

3) A. Skodra and M. Stoukides, “Electrocatalytic Synthesis of Ammonia from Steam and Nitrogen at Atmospheric Pressure”, Solid State Ionics, 180, 2009 pp. 1332-1336.

KEYWORDS: ammonia, ammonium nitrate, fertilizer, renewable energy

A13A-T008 TITLE: Non-Deteriorating Numerical Simulation of 3D Unsteady Wave Phenomena over Long Times

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: To build a high fidelity framework for the treatment of artificial outer boundaries in 3-D numerical wave propagation (electrodynamic or acoustic) which will extend a variety of specified advantageous properties to arbitrarily long time intervals, and to develop algorithms and computer software that will implement these in military and commercial simulation applications.

DESCRIPTION: High fidelity modeling of wave phenomena, such as in electrodynamics or acoustics, has become increasingly important in the design and virtual prototyping of navigation, detection, tracking, and communications systems, helping simulation become widely recognized as the third major component of scientific discovery and development, co-equal with experimentation and theory. A broad range of interesting phenomena in electromagnetism, acoustics, optics, plasma physics, and other disciplines allow a common (or very similar) mathematical description using unsteady wave propagation theory. Hence, an efficient numerical capability for the simulation of unsteady waves will provide a key component for the development of many vital technologies, including those in target recognition, communications, imaging, material identification/non-destructive evaluation, etc. In spite of substantial progress made over the years in this area, some constraints still remain unresolved. In particular, a continuing substantial challenge is presented by the treatment of artificial outer boundaries that would prevent the non-physical reflections of the outgoing waves back into the computational domain, polluting the fidelity of the simulation near boundaries in the short term and further into the domain over long computational times [1, 2]. One of the main difficulties here is that many popular methods may demonstrate excellent performance in reducing the aforementioned reflections over limited time intervals, yet their performance deteriorates over long computational times. Both perfectly matched layers (PMLs) [3, 4] and artificial boundary conditions (ABCs) [5, 6, 7] are subject to this long-time instability. The reasons for the development of the instability are often not known exactly, and may be different for different methods, as well as for different computational settings. Moreover, the methods themselves (ABCs and PMLs) are typically very problem-dependent. They must be adjusted to individual models, domain shapes, discretizations, computational times, and other specifics, which is done by appropriately choosing their design parameters, such as order, incidence angles, etc., for the ABCs [6, 7], or the absorption profile, the complex frequency shift, etc., for the PMLs [8, 9, 10, 11]. Thus, the overall task of selecting and fine-tuning the boundary treatment can be both daunting and tedious.

Recent developments demonstrate a number of methods that can potentially generate very little reflection off the outer boundary. This makes them an attractive computational tool. For example, even though no theoretical estimates are available for the reflection coefficients of either split-field [8, 9] or unsplit [10, 11] PML in the case of a variable absorption profile, in practice one can identify sufficiently long time intervals over which both layers enable a frequency-independent and angle-independent absorption, and can drive the reflection error to negligible levels. Moreover, the local high order ABCs of [7] are superior to those of [6] in that they can guarantee a given error bound during a predetermined interval of time (although it is still not possible to make the error estimate truly uniform in time).

It is therefore highly desirable to develop a capability for extending the specific useful properties of a particular method from the interval on which it performs well to arbitrarily long time intervals. In doing so, none of the characteristics of the original method should be compromised; instead, its performance should be made uniform in time. If such a capability were to be implemented, it will offer two obvious advantages. On the theoretical side, it will allow one to merely "import" and exploit all the previously obtained estimates for the error, reflection coefficients, etc., that characterize a given method (an ABC or a PML), yet guarantee that those estimates will hold for as long as the computation is run. On the side of practical computing, it will allow one to use existing codes with existing subroutines for the treatment of outer boundaries.

The new methodology will ideally be implemented as a "superstructure" that will leave the existing structure of the code in place and will rather add the capability of making its performance uniform in time. The implementation will also take into account the modern production computations that are typically done on parallel architectures. Note that minimizing modifications and retaining the existing structure of the code is particularly important when working with sophisticated codes, such as [12], that are currently used for 3D computations in any of the previously mentioned application areas. To achieve this objective, it will be necessary to identify the appropriate existing methods and codes as candidates for having their characteristics extended in time, propose and develop a general approach that will facilitate such an extension for any chosen method, and then build and test the corresponding algorithms and computer software. An appropriate team for this type of task will include both small business scientists/developers as well as academic researchers, facilitating transfer of the resulting technology to a variety of uses.

PHASE I: In Phase I, the following shall be accomplished:
a) Survey existing techniques, and select candidate methods for extension that guarantee a sufficiently high accuracy of the boundary treatment over reasonably long intervals of time. ("Guaranteed" either provably and/or experimentally, with convincing validation).
b) Develop a general methodology capable of taking a given candidate method and uniformly extending its desirable properties (such as the level of reflections, stability characteristics, etc.) to arbitrarily long time intervals, regardless of the specific design features of the chosen method.
c) Conduct a comprehensive analysis of the proposed methodology aimed at proving the temporally uniform estimates of the error originating at the artificial outer boundary.
d) Obtain and optimize computational complexity estimates, based on the complexity of the original candidate method and that of the proposed extension procedure.

e) Conduct proof-of-concept 3-D computations to demonstrate the general applicability of the proposed extension approach to any appropriate ABC or PML (candidate method), and the temporally uniform performance of the overall combined methodology.

PHASE II: In Phase II, the following shall be accomplished:
a) The technique designed during Phase I will be implemented in software, to include adding the proposed extension methodology to the chosen production codes (e.g., electromagnetic or acoustic or other) that otherwise rely on the previously identified candidate ABCs or PMLs.
b) The ability to combine the proposed extension methodology with a given code without having to go deep into its structure and introduce any major changes will be demonstrated experimentally.
c) A complete series of 3-D numerical tests will be run, showing the performance of the proposed methodology in a production computational environment.
d) The portability of the designed software to a variety of available architectures/platforms will be investigated and optimized. Special attention will be given to implementation on parallel high performance computing (HPC) clusters.
e) The final portable version of the software will be made available to interested government parties for assessment and use.
f) Interested users in the academia and private industry will receive access to the software under appropriate licensing agreements.
g) Theoretical and numerical results of the study will be published in the peer-reviewed literature.
h) A comprehensive set of software documentation will be prepared and made available to users.
i) A long-term program for maintenance and subsequent improvement of the software will be created.
j) The company will set up a support service for both existing and new users capable of addressing installation issues and correcting bugs. This will include creating a web site with the latest news, FAQs, users' forum, etc.

PHASE III DUAL USE APPLICATIONS:
The technology developed under this topic will substantially improve the performance of the existing unsteady wave propagation codes, such as in electromagnetism or acoustics. It will remove the long-time instability and will keep the error due to the treatment of the artificial boundary bounded at all times regardless of the source of the error. This will lead to significant speed-ups in the design time of the military detection, imaging, surveillance, and communication systems, and will be equally useful for the design of similar systems in commercial applications.

REFERENCES:
1) S. V. Tsynkov. Numerical solution of problems on unbounded domains. A review. Appl. Numer. Math., 27(4):465–532, 1998.

2) Thomas Hagstrom. Radiation boundary conditions for the numerical simulation of waves. Acta Numerica, volume 8, pages 47–106, Cambridge Univ. Press, Cambridge, 1999.

3) S. Abarbanel and D. Gottlieb. On the construction and analysis of absorbing layers in CEM. Appl. Numer. Math., 27(4):331–340, 1998.

4) H. Qasimov and S. Tsynkov. Lacunae based stabilization of PMLs. J. Comput. Phys., 227:7322–7345, 2008.

5) Daniel Ruprecht, Achim Schädle, and Frank Schmidt. Transparent boundary conditions based on the pole condition for time-dependent two-dimensional problems. Numerical Methods for Partial Differential Equations, submitted for publication.

6) Dan Givoli and Beny Neta. High-order non-reflecting boundary scheme for time-dependent waves. J. Comput. Phys., 186(1):24–46, 2003.

7) Thomas Hagstrom and Timothy Warburton. Complete radiation boundary conditions: minimizing the long time error growth of local methods. SIAM J. Numer. Anal., 47(5):3678–3704, 2009.

8) Jean-Pierre Bérenger. A perfectly matched layer for the absorption of electromagnetic waves. J. Comput. Phys., 114(2):185–200, 1994.

9) Jean-Pierre Bérenger. Three-dimensional perfectly matched layer for the absorption of electromagnetic waves. J. Comput. Phys., 127(2):363–379, 1996.

10) S. D. Gedney. An anisotropic perfectly matched layer-absorbing medium for the truncation of FDTD lattices. IEEE Trans. Antennas Propagat., 44(12):1630–1639, 1996.

11) J. A. Roden and S. D. Gedney. Convolution PML (CPML): An efficient FDTD implementation of the CFS-PML for arbitrary media. Microwave and Optical Technology Letters, 27(5):334–339, 2000.

12) William D. Henshaw. A high-order accurate parallel solver for Maxwell's equations on overlapping grids. SIAM J. Sci. Comput., 28(5):1730–1765 (electronic), 2006.

KEYWORDS: perfectly matched layer, absorbing boundary conditions

A13A-T009 TITLE: Near Real-Time Quantification of Stochastic Model Parameters

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: To build a framework for the near-real time computation and representation of estimates and uncertainty bounds (uncertainty ellipsoids, confidence bands, etc.) for the nonparametric estimation (via an inverse problem formulation) of functional parameters in probability-based mathematical models.

DESCRIPTION: In the mathematical modeling of physical and biological systems, the case often arises where some facet of the underlying dynamics (in the form of a parameter) is not constant but rather is distributed probabilistically within the system or population under study. While traditional inverse problems involve the estimation, given a set of data/observations, of a fixed parameter contained within some admissible set, models with distributional parameters (especially for use with aggregate data, i.e., data collected by sampling from the population at large as opposed to individual longitudinal data) require the estimation of a probability measure over the set of admissible parameters. Examples arise in the estimation of viscoelastic relaxation times in models of material deformation, estimation of polarization relaxation times in electromagnetic models, analysis of patient-specific pharmacokinetic data, growth rate estimation using size-structured population models, quantification of delays in cellular models of disease progression, in the estimation of division and death times for a model of dividing lymphocytes in culture, etc. This is a more complex modeling and estimation problem involving several interesting practical (i.e., computational) as well as fundamental theoretical questions. Bayesian methods have been extensively, almost universally, developed to tackle this important class of problems, but they suffer from combinatorial explosion, which makes this approach unsuitable for situations which require rapid, near-real time estimation. Several computational approximations to Bayesian methods have been attempted, but performance is still super-algebraic and fidelity is greatly diminished. Promising work in non-Bayesian (i.e, frequentist) methods has been demonstrated recently ([1]-[4]) and is being pursued as a fundamentally different alternative. In particular, standard results on uncertainty quantification for the estimated parameters need to be revisited and reformulated for this more general problem. This work on the rigorous quantification of uncertainty has numerous applications of computational and theoretical interest, such as the optimal design of experiments and model selection criteria.

PHASE I: In Phase I, the following shall be accomplished:
a) Survey existing techniques and select candidate methods for extension that are capable of performing near real-time estimation of probabilistic parameters (i.e., probability distributions) that are embedded as parameters in dynamical systems. This will necessitate non-Bayesian (e.g., frequentist) methods.
b) Develop and present theoretical and computational ideas which provide convincing provable and/or experimental validation of the capability for near real-time parameter description.
c) Develop a general methodology built upon the preceding ideas. This will accept user input on distributional assumptions on data collection procedures (e.g., i.i.d. absolute error, relative error, or other specific data collection assumptions). This will also accept user input on information about the class of distribution on which they wish to search (e.g., any parametric or semi-parametric assumptions, restrictions on means, variances, or other distribution

restrictions). Inputs will be used to specify appropriate inverse problems (least squares, weighted or generalized least squares, maximum likelihood, etc.) to be used in formulation and implementation of inverse problems. Outputs will include parametric and possible non-parametric properties of the estimated distribution.
d) Conduct a comprehensive analysis of the proposed methodology aimed at proving/demonstrating the bias and convergence characteristics of various point/interval/domain estimates.
e) Conduct proof-of-concept 3D computations to prove/demonstrate the bias, complexity bounds, and computational cost bounds of the proposed methodology, demonstrating its capabilities for near real-time computation.

PHASE II: In Phase II, the following shall be accomplished:
a) The methodology for rigorous uncertainty quantification for the estimation of functional parameters in inverse problems designed during Phase I will be implemented in software, to include either adding the proposed extension methodology to chosen production codes (which may currently be non-real-time analysis packages) or developing a new package, or both.
b) A complete series of tests will be conducted, showing the performance (in fidelity, convergence, and run-time) of the proposed methodology in a production computational environment. Demonstration of parameter estimation, confidence intervals and general uncertainty quantification techniques will be a major part of this effort. The pathway to optimal design formulations in the context of aggregate data infinite dimensional inverse problems will be demonstrated and articulated.
c) Theoretical and numerical results of the study will be published in the peer-reviewed literature.
d) The portability of the designed software to a variety of available architectures/platforms will be demonstrated.
e) The final portable version of the software will be made available to interested government parties for assessment and use.
f) Interested users in the academia and private industry will receive access to the software under appropriate licensing agreements.
g) A comprehensive set of software documentation will be prepared and made available to users.
h) A long-term program for maintenance and subsequent improvement of the software will be created.
i) The company will set up a support service for both existing and new users capable of addressing version control, suggested features and applications, and correcting bugs. This will include creating a web site with the latest news, FAQs, users' forum, etc.

PHASE III DUAL USE APPLICATIONS:
The technology developed under this topic will substantially improve the performance of existing parametric estimation codes, both in fidelity of description and in run time. It will accept user input on distributional assumptions and constraints, and will be suitable for near real-time applications. This will lead to significant new capabilities for on-the-ground analysis and prediction in military detection, imaging and surveillance motion prediction, biological monitoring systems, and other applications, and will be equally useful for the design of similar systems in commercial applications.

REFERENCES:
1) A. Mallet, A maximum likelihood estimation method for random coefficient regression models, Biometrika, 73:3 (1986), pgs 645-656.

2) G.A. Seber and C.J. Wild, Nonlinear Regression, Wiley, Hoboken, 2003.

3) J. Kaipio and E. Somersalo, Statistical and Computational Inverse Problems, Vol 160, Applied Mathematical Sciences, Springer, 2004.

4) H.T. Banks, Zackary R. Kenz, and W. Clayton Thompson, A review of selected techniques in inverse problem nonparametric probability distribution estimation, CRSC-TR12-13, North Carolina State University, May 2012; J. Inverse and Ill-Posed Problems.

KEYWORDS: uncertainty quantification, frequentist

A13A-T010 TITLE: Additive Manufacturing of Multifunctional Nanocomposites

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Investigate the feasibility of additive manufacturing techniques, also known as 3-D printing, to produce multifunctional materials to facilitate the development of multiscale hierarchical energy dissipation at the nano- and microscale level enabled by creating microstructures that eliminate traditional inverse material property relationships. There is a vital need for the development of agile manufacturing for defense systems. New manufacturing techniques utilizing advanced materials engineered at multiple length scales may potentially accelerate technological advances in military applications for years to come.

DESCRIPTION: Structures with radically improved performance and novel functionality have not been realized because they often require material property sets that are competing such as yield strength and ductility, hardness and density, and stiffness and toughness. The capability to realize structures that would surmount these barriers have been demonstrated separately by nature or in selected polymer-based systems, by advanced modeling results, and by experiments that span the nano to the micro scales. The integration of multiple components and subcomponents at different length scales may aid in actuation across a variety of vehicle platforms, material state-awareness to enable structural health monitoring for condition-based maintenance, or embedded multifunctional capabilities for semi-autonomous micro-vehicles.

Often, material synthesis methods are based on random processes rather than structured approaches across multiple scales as seen in nature, resulting in limited success. The design and synthesis of materials from the bottom-up, to create hierarchical structures and multifunctional materials in which the conventional concepts of structure and materials are merged will provide a fundamentally new direction for materials development that would change the way new structures are developed in the decades to come. Further, the integration of materials design and structural fabrication with active feedback processes (sensing, signaling, and control systems) to augment additive manufacturing will provide an innovative approach to enhance performance of materials under changing environmental conditions, and create a new generation of tunable structures capable of responding differently to various loading conditions. Advanced manufacturing capable of exploiting tunable hierarchical materials will enable the emergence of novel structures based upon techniques of hierarchical design principles, self-assembly, material characterization, and synthesis methods.

PHASE I: Develop multi-scale modeling and experimental characterization to investigate the inelastic response of high strength (>300 MPa) hierarchical structures composed of engineering materials. Demonstrate additive methods to produce a material system with a minimum of two hierarchical levels that can respond autonomously to diverse loading conditions and/or external stimuli.

PHASE II: Additively construct a material system that has the capability to eliminate traditional material property trade-off relations (strength and toughness, strength and density, hardness and ductility) when subjected to at least two significantly different loading conditions.

PHASE III DUAL USE APPLICATIONS: After constructing a material system outlined in Phase II the additive process should be scaled-up for large scale manufacturing. Optimization of commercial design codes to develop materials for both DoD and Civilian platforms where damage tolerance and survivability are critical. Efforts should be made to commercialize technology that focuses on components that undergo a full spectrum of loading conditions including fatigue, creep, and high rate loading.

REFERENCES:
1) Scott, J., Gupta, N, Weber, C., Newsome, S., Wohlers, T., Caffrey, T., “Additive Manufacturing: Status and Opportunities,” IDA/Science and Technology Institute Report, 2012.

2) Wohlers, T.,”Wohlers Report 2011: Additive Manufacturing and 3D Printing, State of the Industry,” Wohlers Associates, 2011.

3) Gibson, I., Rosen, D. W., and Stucker, B., Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, New York, Springer, 2010.

KEYWORDS: hierarchical structures, self-assemble, multiscale, tunable materials

A13A-T011 TITLE: Chemical Analyzer System for In Situ and Real Time Surface Monitoring for Composition Control During Synthesis of Compound Semiconductor Films

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Conduct research and develop a new capability for in situ, real time, chemical analysis of the surfaces for control of the composition of films grown in a molecular beam epitaxy set up.

DESCRIPTION: Molecular beam epitaxy (MBE) allows the most precise means of atomic layer-by-layer growth of compound semiconductors. The development of certain sophisticated device structures (such as precisely compositionally graded layers) requires even more precision and reproducibility than afforded by most available analytical tools and techniques that currently accompany MBE systems. The most common mode of MBE operation is to perform careful calibrations of beam intensities before the actual film deposition starts. The beams are then assumed to be stable if the source temperatures, and in the case of group V elements, the transmission of the mechanical valve is stable. In other words, the process is actually running in open-loop mode since the real growth parameter (flux) cannot be monitored or used in a feed-back control loop. The assumption of stability may be adequate over a limited time period, i.e. for thin structures that can be grown in a limited amount of time. However, for longer growths, source depletion or stochastic disturbances may invalidate the stability assumption. The problem is significantly exacerbated for more complex structures that require a controlled change of the flux during the deposition process. This is of particular importance in III-V MBE when the compound requires changes in the group V fluxes. Similar arguments apply to II-VI MBE and other materials system where complex alloys are synthesized.

Any method that can provide real-time information about the chemical composition of the growing surface would be highly valuable. Recently, there has been promising developmental work using a new type of Auger analyzer probe that is specifically adapted for the instrumentation requirements of an MBE growth chamber [1]. Preliminary indications are that this approach will allow both in situ and real time diagnostics of the surface elemental composition during growth. However, the long-term stability of the probe, and the accuracy of the in situ diagnostics remains to be systematically investigated.

This solicitation seeks innovative solutions for in situ and real time analysis and control of surface elemental compositions during MBE growth of compound semiconductor materials. It is anticipated that demonstrations will be done on III-V compounds [such as (Al,In,Ga)(As,Sb)], but the methods should be developed in such a way that they could be adapted to other materials systems.

The thrusts for the academic partner are expected to focus on the physics-based modeling and the control algorithm. The industrial partner is expected to be responsible for the hardware development, while the responsibility for the software development may be shared between the two organizations.

PHASE I: Demonstrate the compatibility of a in situ chemical probe (such as Auger) within the environmental constraints of an MBE growth chamber. This should involve instrument operation without impairing either the epitaxial growth process or the long-term stability. Composition accuracy at the percent level should be demonstrated with minimal long-term drift. Any time-dependent drift in accuracy must be characterized and shown to be compatible with normal MBE campaign lengths.

PHASE II: Demonstrate the efficiency of a chemical probe for in situ and real time analysis of the surface composition during MBE growth of compositionally graded buffer layers, such as InAsSb or InGaAlSb alloys. The probe signals should be translated to a final bulk composition preferably using physics-based or empirical or relationships that take in to account the geometry of the surface and the impact of the molecular beams. The chemical information should be used in a real-time feed-back loop.

Demonstrations should be done of graded buffer layers grown with precisely controlled compositions that allow the production of new types of optoelectronic devices with tailored lattice constants and complete flexibility through band gap engineering [2].

The successful completion of Phase II will entail the demonstration of scientific approaches and software implementation leading to the fast conversion of Auger signals to final accurate mole fractions.

PHASE III DUAL USE APPLICATIONS: Develop a commercial product consisting of automated software routines that can operate between the chemical probe and MBE control software. The functionality of this product should allow growth of layers with a predetermined changing chemical composition.

REFERENCES:
1) "In situ real time Auger analyses during oxides and alloy growth using a new spectrometer design" Philippe G. Staib; J. Vac. Sci. Technol. B 29(3), 03C125-1-03C125-6, 2011

2) "Properties of unrelaxed InAs1−XSbX alloys grown on compositionally graded buffers" G. Belenky, D. Donetsky, G. Kipshidze, D. Wang, L. Shterengas, W. L. Sarney, and S. P. Svensson; Appl. Phys. Lett. 99, 141116 (2011)

KEYWORDS: auger electron spectroscopy, molecular beam epitaxy, compositional substrates, compound semiconductors

A13A-T012 TITLE: Self Repairing Antenna Embedded in Composite Structures

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: The objective of this topic is to develop an innovative self-repairing technology that enables rapid repair for composite embedded antennas and other novel application signal architecture.

DESCRIPTION: There is a need to improve force protection through the implementation of novel embedded functional armor composites capable of improving survivability. However, these current and future embedded composite capabilities will require a platform response occupant centric technique for in-theater self-repair post threat. Increasing protection levels for mobile units impacts the capability to send/receive critical tactical intelligence to maintain full spectrum communications by limiting available space for primary and redundant antenna systems. The ability for mobile units to provide timely, accurate and actionable intel is critical to the reduction in unanticipated threat encounters at the squad level and will dramatically increase mission accomplishment and survivability. An autonomous self-repairing technology program will provide support situational awareness and decision making without adding more Soldiers, or significantly increasing the weight or number of devices.

Ballistic polymer panels, which are lightweight and can incorporate embedded electronics, will alleviate space restrictions through dual use and can be utilized for transparent applications. However, the polymer panels can delaminate during threat impacts causing damage to electronics systems and a loss of communication. This topic proposes the utilization of recent advances in self repairing armor composites to be leveraged to provide self-repairing electronic antennae that is conductive, can be inserted into self-repairing transparent armor and both the armor and the electronic articulated antennae can self-repair when subjected to ballistic impacts. A transparent self-repairing antenna is preferred. The proposed solution must be capable of self-repair that is not simply general area in nature, i.e. not specific to antennae architecture, or provide the potential for occlusion for transparent armor implementation.

PHASE I: Explore and define materials for an architecture for incorporating self-repairing antenna technology for use in Army composite applications. This experimentation should substantiate any recommendations made and show that the chosen approach will meet the objectives and criteria set forth herein. The design concept must address the following risks: Compatibility with existing antenna systems; Composite manufacturing compatibility; RF current capability; Development of a reliable mechanism for self-implementation against specific threats.

PHASE II: Finalize and optimize the design(s) chosen in phase I, and build and test a one tenth to full scale prototype. The contractor shall carry out a test plan that exercises the prototype self-repairing antenna for composites. Further, this test plan may include coordination and use of one or more U.S. Army facilities in order to obtain the performance validation. The testing shall demonstrate to the maximum extent possible compliance with all of the goals outlined above.

PHASE III DUAL USE APPLICATIONS: Successful demonstration of this technology will lead to its insertion into the generation-after-next army platforms for the reduction of visual signature. Eventual transition and Demonstration and Validation funding is expected to come from the PMs and program offices within PEO Ground Combat Systems, that have expressed interest in EPAS and SiDEwAyS army programs and are presently researching embedded antenna technologies through Applied and Advanced Technology Development funds. Several top Universities are researching composites and are working on self-healing solutions including Illinois, University of Delaware, Wynona State, Georgia tech, VA tech, with the focus on repairing the ballistic properties of the composite structure. The success of this technology will immediately improve the survivability of the generation after next army platforms without degrading the antenna performance, and shall be at the appropriate TRL to be immediately integratable without impacting any other system components. The same impact would be expected for commercial applications that would utilize embedded antenna technology. It is also expected that once appropriate TRL levels are reached, defense contractors that manufacture combat vehicles will include this technology in their designs. Applications include security and protection such as the transport of high valued accesses for law enforcement, banking and the entertainment industries in which communications is crucial to the success of their mission.

REFERENCES:
1) R. P. Wool "Self-healing materials: a review", Soft Matter, Issue 4, 2008, pp 400-418

2) C. Dry "Procedures developed for self-repair of polymer matrix composite materials" Composite Structures Vol. 35, Issue 3, July 1996, pp 263–269

KEYWORDS: self-repairing, composites, antennae

A13A-T013 TITLE: <u>Conformal Passivation of High Aspect Ratio HgCdTe Surfaces</u>

TECHNOLOGY AREAS: Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.4 of the solicitation.

OBJECTIVE: Recent successes in the production of two-color HgCdTe on low cost alternative substrate have highlighted the need for improved sidewall passivation of 12 μm and smaller reticulated mesa structures. This STTR will develop novel conformal passivation techniques for HgCdTe based infrared devices. The ideal passivation would allow conformal coverage on highly reticulated, anisotropic surfaces. The passivation would perform as an excellent electrical passivation; ie allow no shunt currents, surface inversion, charge trapping, etc. Further, it would act as a chemical passivation; not allow oxide or hydrocarbon formation in the surface, etc.

DESCRIPTION: HgCdTe narrow band gap devices are used to produce many infrared detectors. Many of these advanced devices require complex structures to be processed into them. These structures can include but not limited to delineation structures, vias, micro-lenses, anti-reflective structures, diffraction gratings, and type converting etches. Many result in high aspect ratio surfaces. Often plasma processing is used to produce these structures. The use of these plasmas processes result in clean carbon and oxygen free surfaces with little Hg depletion. However, the moment they are removed from vacuum oxygen and hydrocarbon contamination start to build on the surface. In this study we would like a process to be developed that will chemically and electrically passivate high aspect ratio HgCdTe surfaces. It would be preferable that the passivation be vacuum compatible and not dope the HgCdTe.

PHASE I: Theoretically identify and determine technical feasibility of different passivation materials and appropriate deposition methodology for the passivation of highly reticulated HgCdTe surfaces. Develop initial test methods for the identified passivation techniques. Test the passivation on HgCdTe test devices.

PHASE II: Produce prototype hardware that allows this passivation to be deposited on high aspect ratio HgCdTe surfaces. The quality of this passivation should be evaluated with electrical characterization, examples: current-voltage measurements, lifetime measurements, and Hall measurements. The passivation should also be evaluated using chemical and structural techniques, examples: Auger Electron Spectroscopy, X-ray photoelectron spectroscopy, Scanning Electron Microscopy, and Secondary Ion Mass Spectrometry. The final test of the passivation requires the integration of the novel passivation into the production of infrared focal plane arrays.

Technology Readiness Level: TRL 4 - Component and/or breadboard validation in laboratory environment.

PHASE III DUAL USE APPLICATIONS: The Goal of this phase is to transfer this technology to the Infrared Focal Plane Array (IRFPA) manufacturing houses. This will allow the IR-FPA industry to passivate more complex surfaces than the current state-of-the-art allows. This advancement would enable industry more process flexibility to produce less-expensive more complex focal plane arrays for the DOD and Army. In-turn this technology would enable more advanced infrared sensors for the soldier at a lower cost to the Army. This conformal passivation will lead to less-expensive, better performing FLIRs for platforms like Apache and Abrams. It would enable less expensive, next generation infrared detectors for RSTA and airborne operations. And it would allow sensors with better sensitivity for BMDS.

Commercial applications include smog detectors, temperature arrays for weather satellites, and sensors for the examination of real time manufacturing yield. Other commercial applications, allow the production of larger more sensitive infrared focal plane arrays for astronomy applications like examining red shift, performing real time IR spectroscopy of objects, and enabling more sensitive very large base-line infrared interferometry .

REFERENCES:

1) Nicholas Licausi, Sunil Rao and Ishwara Bhat, "Low-Pressure Chemical Vapor Deposition of CdS and Atomic Layer Deposition of CdTe Films for HgCdTe Surface Passivation", J. Electronic Mater. 40(8), 1668-1673, (2011).

2) A. J. Stoltz, J.D. Benson and P.J. Smith, "Morphology of Inductively Coupled Plasma Processed HgCdTe Surfaces," J. Elec. Mater. 37(9), 1225-1230 (2008).

3) M. Carmody, J.G. Pasko, D. Edwall, E. Piquette, M. Kangas, S. Freeman, J. Arias, R. Jacobs, W. Mason, A. Stoltz, Y. Chen and N.K. Dhar, "Status of LWIR HgCdTe-on-Silicon FPA Technology," J. Elec. Mater. 37(9), 1184-1188 (2008).

KEYWORDS: HgCdTe, passivation, electrical, devices, infrared, IRFPA, FPA, focal plane array, sensors

A13A-T014 TITLE: <u>Develop Advanced Quantum Structures for Large Format Focal Plane Arrays</u>

TECHNOLOGY AREAS: Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.4 of the solicitation.

OBJECTIVE: To develop and demonstrate next generation infrared detectors and focal plane arrays through fundamental study and innovation of advanced quantum materials.

DESCRIPTION: III-V based strained superlattice structure (SLS) is a new infrared detector material that has the theoretical promise to outperform existing materials such as mercury cadmium telluride (HgCdTe) and indium antimonide (InSb). In the past few years, tremendous progress has been made in various research laboratories. Long-wavelength infrared single-element detectors with performances approaching that of HgCdTe are being achieved. SLS focal plane arrays (FPA) with good performance have been successfully demonstrated. However, in order to achieve high-performance FPAs that can provide the best system performance for Army applications, technology and engineering innovations are required in the following areas:

In the detector array processing and FPA fabrication area, novel ideas in passivant selection and passivation scheme perfection are sought. The median dark current density of superlattice FPAs is currently an order of magnitude higher than that of single element large area detectors. This is mostly due to the relatively large amount of surface leakage current associated with small pixel size and mesa structure. Technology innovations in this area are essential in achieving low leakage current for FPAs with small pixel sizes and multiple spectral bands. Many passivation materials, such as silicon dioxide, polyimide, and sulfur, have been experimented on Sb-based superlattice materials and have been applied with various passivation protocols. Semiconductor overgrowth was also experimented. However, further developments in passivant and passivation techniques are solicited. The ultimate passivant and protocol is still to be discovered that offers a stable and highly effective mechanism to eliminate surface leakage as well as compatibility with standard FPA manufacturing processes (i.e. bake stability). In addition, utilization of nano-fabrication and/or processing technologies to enhance light trapping and quantum efficiency of the detector in a very narrow band with sharp cut-on and cut-off wavelengths without contributing to noise are solicited.

Novel ideas are also solicited for the identification of minority carrier lifetime limiting defects for SLS structures. Although the quality of MBE-grown superlattice materials has improved greatly in the past few years, further understanding of material defects and methods for improvement are desired. The relationship between the minority carrier lifetimes of a superlattice and its component layers is not clear at the moment. Modeling and theoretical calculations, as well direct measurements, can enhance the understanding of underlying physics that controls superlattice minority carrier lifetimes and give good guidance for mitigating lifetime killing sources. New growth technologies or procedures for reducing defect occurrence and ways to mitigate defect influence are requested, with a goal of achieving minority carrier lifetimes close to the theoretical limit. Systematic investigations are necessary to reveal the predominant defect types (e.g., point defects, interfaces, and dislocations) and the quantitative contribution from each component. This requires clever use of advanced semiconductor characterization tools, or discovery of unique characterization techniques. Experimental data should be systematically correlated to help gain a complete understanding of material properties and devise ways for their improvement. Novel ideas of instrumentation for testing and characterizing superlattice materials and detectors are strongly encouraged.

PHASE I: In Phase I, SLS materials should be processed to form single-element diodes that meet the following goals: At operating temperatures higher than 77 Kelvin and cutoff wavelength of 12 micron, the quantum efficiency should be larger than 70% and the dark current density should be less than 1 micro-ampere per square centimeter. Close collaboration between research institutions and small businesses with coherent goals and work plans are strongly encouraged.

PHASE II: In Phase II, fabrication of an FPA with a format of 640x480 or larger and pixel pitch of 20 microns or smaller with either single or multiple spectral bands should be the goals for successful demonstration of proposed technologies. Characterization of prototype FPA with improved characteristics than current state of the art is of interest. Highly recommended to collaborate with government contractors to ensure transition and usefulness of technology.

PHASE III DUAL USE APPLICATIONS: Develop and execute a plan to market and manufacture superlattice FPA. Assist Army in transitioning this technology to the appropriate prime contractor(s) for the engineering integration and testing. The contractor shall pursue commercialization of the various technologies and EO/IR components developed in Phase II for potential commercial uses in such diverse fields as law enforcement, rescue and recovery operations, maritime and aviation collision avoidance sensors, medical uses, homeland defense, and other infrared detection and imaging applications.

REFERENCES:
1) L. Zheng, M. Tidrow, et al., Developing High Performance III-V Superlattice IRFPAs for Defense—Challenges and Solutions, Proc. of SPIE Vol. 7660, 76601E, 2010.

2) M. Tidrow, L. Zheng, S. Bandara, N. Supola, L. Aitcheson, "Meeting the technical challenges of SLS, a new infrared detector material for the Army," Proceedings of Army Science Conference (2010).

KEYWORDS: infrared focal plane arrays, strained layer superlattice, passivation, minority carrier lifetime, III-V

A13A-T015 TITLE: Compressed Sensing for Wide Area Chemical and Biological Early Warning

TECHNOLOGY AREAS: Chemical/Bio Defense

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.4 of the solicitation.

OBJECTIVE: Develop a wide area standoff hyperspectral-imaging sensor for chemical and biological early warning based on compressed sensing.

DESCRIPTION: Current hyperspectral imaging (HSI) sensors in use for standoff chemical/biological sensing generate huge amounts of data. To save space or to reduce bandwidth for transmission the data is often compressed. Lossy compression algorithms for hyperspectral imaging have had broad success. Using state-of-the art data compression algorithms researchers have discovered that much of the data from existing HSI sensors can be thrown away with little or no loss in standoff detection capabilities. This fact has led researchers to explore methods that limit data acquisition to data that is not rejected by standard compression algorithms.

The goal of this effort is to examine compressed sensing as a method for reducing the size, weight, power, cost, and bandwidth of current HSI systems, while still providing high sensitivity and the capability of wide area early warning of a chemical or biological attack. Compressed sensing has evolved as a method to simplify HSI sensors and improve standoff chemical/biological sensing. Compressed sensing offers simultaneous compression and sensing processes, based on the existence of a sparse representation of a signal within a set of projected measurements. Compressed sensing looks at possibility of acquiring only the data that is needed for detection and avoiding the acquisition of data that is redundant or not applicable to the problem at hand. Compressed sensing also looks at methods to extract the maximum amount of information from reduced data sets. Most work to date has concentrated on systems with plentiful signal, low noise, and sparse information. HSI sensors for standoff chemical/biological sensing, however, often work in spectral regimes of low signal-to-noise ratio, and therefore may require unique approach to signal compression in both hardware and data processing to maintain signal to noise ratio during the compression process.

Hyperspectral imaging sensors currently in use for wide-area standoff detection of chemical and biological agents are required to utilize large focal-plane-arrays to achieve necessary spatial coverage and spatial resolution for wide area chemical/biological detection. They are also required to interrogate a large number of spectral bands in order to differentiate between target compounds and the background. In addition to these very stringent hyperspectral-imaging requirements, a chemical/biological standoff sensor needs to be small, lightweight, and inexpensive. Current standoff chemical/biological sensors operate in the 8 to 12 μm wavelength range to access important CB and toxic industrial material signatures.

The use of coded apertures and spatial light modulators may provide a method of using compressed sensing in a manner that eliminates the need for an infrared focal-plane-array in a wide-area standoff chemical/biological sensor. Coded apertures may provide a method of extracting spatial and spectral information from a scene using a single-pixel infrared detector. The use of a single pixel detector in the place of a focal-plane-array has the potential to reduce size, weight, power, and cost of a wide area standoff chemical/biological sensor without sacrificing performance parameters. The key factor for long-wave CB monitoring is to develop compression algorithms that maintain detection sensitivity and signal to noise performance, while minimizing the data throughput requirements. The use of adaptive coded apertures may also provide a method of dynamic foveation, where a portion of the dynamic scene can be queried in greater detail if an anomaly is detected. Additionally, signal compression in the spectral domain can be achieved by aperture coding algorithms that employ spectral detection filters to discriminate the analyte signature relative to that of the background with optimum detection sensitivity and false alarm rate.

PHASE I: Design a single-pixel hyperspectral imaging sensor for wide area standoff detection of chemical and biological agents based on compressed sensing. The spectral region of the sensor should be chosen to interrogate spectral signatures of chemical plumes. Traditionally the 8 to 12 ìm region of the electromagnetic spectrum has been used for standoff chemical detection. Examine the use of coded apertures to produce a single pixel sensor with detection and discrimination capabilities comparable to existing HSI chemical/biological sensors. The goal is to passively detect small chemical plumes (25 meters or smaller) of a chemical agent such as sarin at relevant concentrations (a few ppmv) at a distance of 5 kilometers or more under ambient conditions. The system should be designed to reduce size, weight, and power compared to traditional HSI systems while maintaining similar detection limits (equivalent to monitoring differential radiance signals of the order of 1 microflick or less on a 1 second time scale). Examine methods of dynamic foveation within a hyperspectral image using compressed sensing. Examine the use of dynamic coded apertures to query a portion of the dynamic scene based on the detection of an anomaly or other alarm. Examine the use of spectral compression algorithms based on coded apertures to discriminate the chemical plume against the scene background.

PHASE II: Construct a standoff hyperspectral imaging sensor designed for the detection of chemical plumes. Utilize the best methods and technologies for reducing the size of current HSI systems while maintaining required sensitivities. Test and characterize the new HSI sensor. Based on the tests, update the design of the new standoff chemical imaging sensor. Deliver the prototype sensor to the government.

PHASE III DUAL USE APPLICATIONS: Further research and development during Phase III efforts will be directed towards refining a final deployable design, incorporating design modifications based on results from tests conducted during Phase II, and improving engineering/form-factors, equipment hardening, and manufacturability designs to meet U.S. Army CONOPS and end-user requirements. There are many environmental applications for a small chemical standoff sensor. A rugged, sensitive and flexible chemical detector will benefit the manufacturing community by providing finely tuned monitoring of chemical processes. Also first responders such as Civilian Support Teams and Fire Departments have a critical need for a rugged, relatively inexpensive but versatile and rugged sensor that can be transported to the field to test for possible contamination by CW agents and other toxic chemicals.

REFERENCES:
1) Bogdan R. Cosofret, Shin Chang, Michael L. Finson, Christopher M. Gittins, Tracy E. Janov, Daisei Konno, William J. Marinelli, Mark J. Levreault, and Rex K. Miyashiro, “AIRIS standoff multispectral sensor”, Proceedings of the SPIE, volume 7304, pages 73040Y (2009).

2) Vincent Farley, Charles Belzile, Martin Chamberland, Jean-Francois Legault, and Karl R. Schwantes, “Development and testing of a hyperspectral imaging instrument for field spectroscopy”, Proceedings of SPIE, volume 5546, pages 29-36 (2004).

3) Marco F. Duarte, Mark A. Davenport, Dharmpal Takhar, Jason N. Laska, Ting Sun, Kevin F. Kelly, and Richard G. Baraniuk, “Single-Pixel Imaging via Compressive Sampling”, IEEE Signal Processing Magazine, volume 25, issue 2, pages 83-91 (2008).

4) Jianwei Ma, “Single-Pixel Remote Sensing”, IEEE Geoscience and Remote Sensing Letters, volume 6, issue 2, pages 199-203 (2009).

5) D.J. Brady and M.E. Gehm, “Compressive imaging spectrometers using coded apertures,” Proceedings of the SPIE, volume 6246, pages 62460A (2006).

6) D. L. Donoho, "Compressed sensing," IEEE Transactions on Information Theory, volume 52, pages 1289-1306 (2006).

7) E. J. Candes and T. Tao, “Near-optimal signal recovery from random projections: Universal encoding strategies?”, IEEE Transactions on Information Theory, volume 52, page 5406-5425 (2006).

8) Jianwei Ma and F.-X. Le Dimet, “Deblurring From Highly Incomplete Measurements for Remote Sensing”, IEEE Transactions on Geoscience and Remote Sensing, volume 47, issue 3, pages 792-802 (2009).

9) Dharmpal Takhar, Jason N. Laska, Michael B. Wakin, Marco F. Duarte, Dror Baron, Shriram Sarvotham, Kevin F. Kelly, and Richard G. Baraniuk, “A New Compressive Imaging Camera Architecture using Optical-Domain Compression”, Proceedings of the SPIE, volume 6065, pages 43-52 (2006).

10) R. Larcom and T. R. Coffman, “Foveated image formation through compressive sensing”, 2010 IEEE Southwest Symposium on Image Analysis & Interpretation (SSIAI), pages 145-148 (2010).

11) Vujkovic-Cvijin, P., Goldstein, N., Fox, M.J., Higbee, S.D., Becker L.S., and Ooi, T.K. “Adaptive Spectral Imager for Space-Based Sensing,” Proceeding of the SPIE Volume 6206, paper 6206-33 (2006).

12) Goldstein, N., P. Vukovic-Cvijin, M. Fox, S. Adler-Golden, J. Cline, B. Gregor, J. Lee, A. C. Samuels, S. D. Higbee, Latika S. Becker, and Teng Ooi, “Programmable Adaptive Spectral Images for Mission-Specific Application in Chemical/Biological Sensing,” International Journal of High Speed Electronics and Systems, volume 17, issue 4, pages 749-760 (2007).

13) Goldstein, N., P. Vujkovic-Cvijin, M. Fox, B. Gregor, J. Lee, J. Cline, and S. Adler-Golden “DMD-based adaptive spectral imagers for hyperspectral imagery and direct detection of spectral signatures,” Proceedings of the SPIE, volume 7210, pages 721008/1-721008/10 (2009).

KEYWORDS: hyperspectral imaging, compressed sensing, single pixel, chemical detection, biological detection.

A13A-T016 TITLE: Advanced Spectrally Selective Materials for Obscurant Applications

TECHNOLOGY AREAS: Materials/Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 3.4 of the solicitation.

OBJECTIVE: The objective of this topic is to develop a spectrally selective obscurant that can effectively block one area of the electromagnetic (EM) spectrum while allowing other areas to pass through. Novel ideas are encouraged, but traditional efforts in these areas have focused on electrically conductive metals or non-metals structures having unique resonance conditions. Generally, these have been metal nanoparticles with specific sizes and shapes that interact strongly with electromagnetic radiation when light at the resonant wavelength causes conduction electrons in the metal to collectively oscillate, an effect referred to as a surface plasmon resonance (SPR). When these resonances are excited, absorption and scattering intensities can be up to 40 times larger than identically sized particles that are not plasmonic. Plasmonic obscurants have mass extinction coefficients (MECs) as large as 70 m2/g, making this class of materials among the most efficient absorbers and scatterers available.

Additionally, unlike conventional obscurant materials, plasmonic obscurants have absorption and scattering profiles that can be tuned across the visible and NIR spectral regions by changing particle size, shape, and material. This tuning effect is the primary focus of this topic, however existing Plasmon resonance materials usually provides a narrow wavelength band. This topic seeks to improve bandwidth properties and to optimize metal or nonmetal structures. Other areas that can be explored include Electromagnetically induced transparency (EIT) which has recently became possible following advances in micro and nanofabrication techniques. Strongly dispersive phenomenon such as Fano resonances can also be explored to enhance weakly dissipative plasmonic materials. Dramatic variation from forward to backward scattering with only a small change in frequency of the incident light have been observed.

PHASE I: Develop processes and methodologies to synthesize obscurant materials that can spectrally select specific regions of the EM spectrum. It will be up to the proposers to identify which wavelength bands they would like to address, but it should be one or more of the areas of Army interests. Specifically, these regions of interest are defined by Visible, 0.4 to 0.7um); Near Infrared, 0.7-1.2um; Short Wave Infrared (SWIR), 1.5-2um; Mid Infrared, 3.0 – 5.0um; and Far Infrared, 8.-12um. Cost effective materials should be considered as well as easily scalable processes for material manufacturing. From literature searches, some work has be done using gold and silver nano structures including spheres, rods, cylinders, nanoshells (metal shell on a nonconducting core), and plates (triangular and disc-like). For plasmonic materials, properties such as peak wavelengths, peak widths, and absorption/scattering ratios will depend on the particle size and the refractive index and thickness of a non-conducting shell on the metal surface. At the end of this effort, the contractor should be able to produce 5 grams of material to Edgewood Chemical and Biological Command (ECBC) for testing. In process testing can be performed at ECBC as well, or the contractor could set up their own system.

PHASE II: Continue with cost effective scale up material development and fabrication. This phase should concentrate on developing novel ways to aerosolize the developed materials in Phase I. Focus on developing processes that will produce enough materials to fabricate several full size hand grenades based of the M106 geometries. Since efficient dissemination of these materials or any other materials is a problem within itself, several concepts should be investigated. This effort should also include packing of plasmonic materials as it is unknown if any degradation effects will occur while packing, storing or transporting these novel materials. Strategies to increase packing fractions and device yields will improve overall obscurant systems performance and reduce logistics burden. Optimize dispersion techniques will be necessary for the next generation obscurant systems. Full scale prototype devices based off the M016 grenade geometry should be developed in the second year of the phase II effort. Contractors are encouraged to work with ECBC Pyrotechnics branch for developing fully functioning devices near the end of this contracted effort.

REFERENCES:
1) Embury, Janon; Maximizing Infrared Extinction Coefficients for Metal Discs, Rods, and Spheres, ECBC-TR-226, Feb 2002, ADA400404, 77 Page(s)

2) Hinds, William C.; Aerosol Technology - Second Edition, Wiley-Interscience: New York, 1999

3) Bohren, C.F.; Huffman, D.R. Absorption and Scattering of Light by Small Particles; Wiley-Interscience: New York, 1983.

4) Deepak, Adarsh; Dissemination Techniques For Aerosols, Deepak Publishing, 1983

5) S. J. Oldenburg, J. B. Jackson, S. L. Westcott, N. J. Halas, Appl. Phys. Lett. 1999, 75, 2897.

6) [63] S. J. Oldenburg, G. D. Hale, J. B. Jackson, N. J. Halas, Appl. Phys Lett. 1999, 75, 1063.

7) Murray, B.A.; Barnes, W.L.: Plasmonic Materials, Adv. Mater. 2007, 19, 3771–3782. http://m-newton.ex.ac.uk/research/emag/wlb/AdvMat_2007_19_3771.pdf

8) Lukyanchuk, Boris; Zheludev, Nikolay, et al. The Fano resonance in plasmonic nanostructures and metamaterials. Nature Materials 9, 707-715 September 2010, www.nature.com/naturematerials

KEYWORDS: spectrially selective obscurant, surface plasmon resonance (SPR), plasmonic nanomaterials, metamererials, electromagnetically induced transparent windows, fano resonances

A13A-T017 TITLE: Autonomous Broad Spectrum Environmental Sentinels

TECHNOLOGY AREAS: Sensors

OBJECTIVE: To create controllable, motile sensing units capable of environmental surveillance and contaminant detection as well as inter-unit communication networks for precise contamination source localization. The combination of lightweight, low power sensors with a programmable, robotic platform enables a surveillance array capable of rapid and continuous situational monitoring.

DESCRIPTION: The Army has a critical need for rapid, autonomous sensors that are capable of real-time, on-site interrogation of the environment to provide immediate data for force protection as well as environmental monitoring. Due to the current protocols for sampling and testing, there is a significant risk of exposure to hazardous material for personnel collecting samples as well as a high cost in sample handling and shipping to an off-site, distant testing laboratory. The waiting time for actionable results can be days to weeks resulting in an unfavorable delay in the decision making process upon contaminant detection.

Autonomous sensor networks will enable the establishment of an environmental baseline and allow the continued environmental surveillance necessary to facilitate effective risk assessments, mitigation response, and consequence management decisions if a threat is detected. The ability to remotely detect environmental hazards including, but not limited to, full spectrum chemical threats such as toxic industrial chemicals or materials (TICs and TIMs), semi-volatile and volatile organic compounds (VOC) (i.e., pesticides, ammonia, explosives), and low-level chemical or biological (CB) agents will significantly decrease the risk of disease and nonbattle injury (DNBI) occurrences thus protecting our soldiers. Collectively, this information will directly impact the success of deploying, protecting and sustaining Combat Outposts (COPs) and Patrol Bases (PBs) and supporting overall mission readiness.

Since this investigation space is very broad, this proposal focuses solely on flying and hovering robots, with the capability for interactive swarming, with on-board sensors for the detection of contaminants in the vapor phase in a rural outdoor environment, with data transmission functions, and with the potential capacity for self-powering.

PHASE I: In the Phase I effort, a design of the airborne, robotic platform as well as the integrated sensor on the same platform must be completed. The concept will be original or will represent significant advances or extensions of existing approaches.

Favorable metrics include: A flying robotic platform capable of hovering is desired. A functional robotic platform must be demonstrated in laboratory conditions.

The combined sensor-robot device weight should be 5 lbs or less. The size and scale of the sensors and overall robotic platforms must be such that they do not place a significant burden on the user during transport or deployment of the sentinel devices.

An on-board sensor for a volatile compound integrated onto a single flying platform is desired. The sensor must be able to provide quantitative data at a minimum measurement frequency of once every 30 min. A robot that has a modular sensor design that can accept a standardized sensor chip for the highest degree of flexibility is desired. Sensors must be programmable for autonomy as well as user-controllable and not require specialized storage or handling conditions to maintain sensor fidelity.

A prototype functional sensor must be demonstrated in laboratory conditions. The sensor must demonstrate specificity against other environmental contaminants and detection limits for contaminants must fall at or above the stated Military Exposure Guideline levels but below the estimated human lethal concentration (1). Compounds of interest include but are not limited to ammonia, trichloroethane, benzene, formaldehyde, nitroglycerin, 2,4,6-trinitrotoluene, and 2,4-dinitrotoluene, or a compound can be chosen from Tables C-3, C-4, and C-5 given in (1).

The combined sensor-robotic device must be capable of transmitting and receiving a wireless signal to enable individual querying, must have an initial interrogation range of 50 yards, must have an initial battery power for 30 min of uninterrupted operation, must have the ability to simultaneously report the spatial location of the analysis, must be self-powering to extend the operation life, and must have a kill switch to debilitate the robot and a beacon for retrieval.

PHASE II: In the Phase II effort, the integrated sensor-robot prototype device will be developed and tested for the ability to perform autonomous sampling and testing procedures as well as remotely report results back to the control center in outdoor field conditions. The development of a communication network to enable the sensor-robotic units to send inter-unit signals in order to perform wide area screening/surveillance or localized contaminant source identification will be pursued.

Favorable metrics include: units with a total weight under 2 lbs, the capacity to incorporate multiple sensors on a single flying device, the ability to locate the contaminant source and intelligently swarm, return to a specified location, be individually queried, report quantitative data on the targeted compound, have an initial interrogation range of 100 yards, provide location data, and an initial battery power with self-power generation for 90 min uninterrupted operation. The unit must also be self-calibrating for both the analytical data as well as its power supply.

The sensor detection limits for the target contaminant must fall at or above the stated Military Exposure Guideline levels but below the estimated human lethal concentration (1).

A modular sensing platform design that accepts a "universal sensor chip" that would allow the user to select what target contaminant(s) are to be tested are encouraged to offer the highest degree of usability and flexibility in a complex, non-laboratory environment. Replaceable, interchangeable sensing modules for the detection of a suite of chemical threats can be developed.

PHASE III DUAL USE APPLICATIONS: For the Phase III effort, dual use applications will be demonstrated and transitioned to commercial applications. Demonstration of scalability and reproducibility of the integrated sensor-robotic platform to perform the required actions detailed in Phase I and II. The commercialization opportunities for such a technology will include not only the detection of chemical/biological/explosive agents in austere environments but also homeland security operations, disaster response efforts, and environmental monitoring for state and local governments. A well-formulated marketing strategy will be critical for success in these commercial applications.

REFERENCES:
1) Technical Guide 230 Environmental Health Risk Assessment and Chemical Exposure Guidelines for Deployed Military Personnel June 2010 Revision; U.S. Army Public Health Command (Provisional) Environmental Health Risk Assessment Program http://phc.amedd.army.mil/PHC%20Resource%20Library/TG230.pdf

2a) Multi-Service Doctrine for Chemical, Biological, Radiological, and Nuclear Operations, FM 3-11 (7/1/2011), Official Department of the Army Publications and Forms, Doctrine and Training, FM-Field Manual https://armypubs.us.army.mil/doctrine/DR_pubs/dr_aa/pdf/fm3_11.pdf

2(b) Multiservice Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Contamination Avoidance (INCL C-1), FM 3-11.3 (2/2/2006), Official Department of the Army Publications and Forms, Doctrine and Training, FM-Field Manual https://armypubs.us.army.mil/doctrine/DR_pubs/dr_aa/pdf/fm3_11x3.pdf

2c) Multiservice Tactics, Techniques, and Procedures for Chemical, Biological, Radiological, and Nuclear Contamination Avoidance (Change 1 to FM 3-11.3), FM 3-11.3, CHG 1 (4/30/2009), Official Department of the Army Publications and Forms, Doctrine and Training, FM-Field Manual https://armypubs.us.army.mil/doctrine/DR_pubs/dr_aa/pdf/fm3_11x3c1.pdf

3a) Multiservice Tactics, Techniques, and Procedures for Nuclear, Biological, and Chemical (NBC) Protection (INCL C-1), FM 3-11.4 (6/2/2003) Official Department of the Army Publications and Forms, Doctrine and Training, FM-Field Manual https://armypubs.us.army.mil/doctrine/DR_pubs/dr_aa/pdf/fm3_11x4.pdf

3b) Multiservice Tactics, Techniques, and Procedures for Nuclear, Biological, and Chemical (NBC) Protection (Change 1 to FM 3-11.4), FM 3-11.4, CHG 1 (12/31/2009) Official Department of the Army Publications and Forms, Doctrine and Training, FM-Field Manual
https://armypubs.us.army.mil/doctrine/DR_pubs/dr_aa/pdf/fm3_11x4c1.pdf

KEYWORDS: robotic platform, autonomous, air toxicity, sensor, biosensor, contaminant detection, environmental surveillance, air pollutant

A13A-T018 TITLE: Mobile Health Application for Family and Behavioral Health Provider Communication

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: Design, develop, and deploy a mobile application which allows for transmission of information from patient family members to clinicians on current issues, relationship stresses, and situational stressors to provide a thorough picture of patient's current mental health status.

DESCRIPTION: A service member's behavioral health status affects the function and quality of life of military service members and their families and is critical to force readiness. Assessing and monitoring behavioral health status is particularly relevant for supporting service members given the increased rates of traumatic brain injury (TBI) and psychological health problems (including sleep deprivation, substance use, mood and anxiety disorders, and pain conditions, among others) experienced by military service members.

Current practices for assessing and monitoring a service member's behavioral health status is most often through one on one communication between a service member and their behavioral health provider. The service member is assessed and treated according to their specific diagnosis and they are monitored throughout the treatment protocol through appointments and direct communication with their provider. The provider relies heavily on the self-report status provided by the service member. Obtaining ongoing collateral information from family members can serve to enrich the clinical data available to better tailor and monitor treatment. Furthermore this process can be used to more deeply engage family members in the treatment and support of the individual with the goal of fostering better clinical outcomes.

Mobile devices (e.g., smart phones, mp3 players, portable game devices) and their software applications (apps) are in widespread use in military and civilian populations. In 2010, there were more than 7,000 documented smartphone health applications (Kailas, Chia-Chin Chong, & Watanabe, 2010). Experts estimate there will be over 13,000 consumer health applications on the iPhone in the year 2012, one third of which will be dedicated to mental health, sleep, stress/relaxation and smoking cessation (Dolan 2011). The availability and acceptance of these technologies presents an opportunity for the development of a mobile application to allow for behavioral health providers to engage with the service member's family to obtain a more holistic view of the patient's current mental health status.

The objective of this STTR (Small Business Technology Transfer) is to solicit concepts for the design, development, and deployment of a mobile application which allows for transmission of information from patient family members to clinicians on current issues, relationship stresses, and situational stressors to provide a thorough picture of patient's current mental health status. For the present STTR, the goal is to create an application that allows for secure transmission of patient information from the patient's family member to the clinician. The use of mobile devices that are currently available and the adaptation of existing mobile health applications to this purpose is encouraged, and will facilitate the distribution and adoption of this type of therapy adjunct. Clinician burden should also be reduced by focusing on the clinician interface, how and when the clinicians receive information, which includes processing the information submitted from family members to provide some type of priority or level of response needed. The solution should also provide design solutions to encourage family compliance in documenting the service member's current behavioral health status. This could include reminders, uncomplicated user interface, and/or other incentives.

One of the benefits of this type of application is that the mobile platform travels with the family member which allows events to be recorded in real time and saved for immediate or deferred viewing by the clinician. Second, these devices are familiar to most service members and their families, which could result in higher adherence rates. Lastly, the information can be communicated readily easily via routine device synchronization to healthcare providers and others charged with evaluating the service member's behavioral health.

PHASE I: Conceptualize, design, and build a solution for a mobile application which allows for transmission of information from patient family members to clinicians on current issues, relationship stresses, and situational stressors to provide a thorough picture of patient's current mental health status.

Required Phase I deliverables will include: research design; prototype with limited testing in demonstrating proof-of-concept, demonstration of clinical interface; research plans for preclinical testing; and commercialization strategy including regulatory plans. The solution should include ability to have information gathered by the platform to be easily reviewed and obtained both by the treatment provider(s). The solution should be developed on a platform that is compliant with regulations around health care data security and encryption and the proposal should have a plan to address any FDA issues that the proposed solution could engender. Literature and market review should be done as part of the proposal background information and not as a task to be executed during Phase I period. Applications should clearly describe a specific proposed solution and conceptual development of the solution should be performed during the proposal writing process and not as part of Phase I tasks. Although it is anticipated that in vitro testing and consultation form subject matter experts will occur there should be no formal human use testing proposed or executed during this 6-month Phase I period due to requirement of second level DoD (Department of Defense) review, which generally adds more time beyond the 6-month Phase I period.

PHASE II: Assess the proposed solution in a controlled clinical trial. The trial should be designed to assess the benefit of both family engagement, involvement and collateral information on treatment processes and outcomes. The trial should compare the proposed solution with the standard of care for the sample. Applicants are encouraged to seek samples with high military relevance or translation potential.

PHASE III DUAL USE APPLICATIONS: Phase III efforts should be focused towards technology transition, preferably commercialization of STTR research and development. This should include assisting the military in transitioning the technology to widespread deployment and use as well as plans to secure funding from non-STTR/SBIR government sources and /or the private sector to develop or transition the prototype into a viable product for sale in the public and/or private sector markets.

REFERENCES:
1) Brian Dolan, Mobihealthnews, 2011: http://mobihealthnews.com/13368/report-13k-iphone-consumer-health-apps-in-2012/

2) Kailas, A., Chia-Chin Chong, & Watanabe, F. (2010). From Mobile Phones to Personal Wellness Dashboards. IEEE Pulse, 1(1), 57–63.

KEYWORDS: mobile health, apps, smart phone, military family

A13A-T019 TITLE: Technologies that Promote Reinnervation of Muscle

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: The objective of this effort is to develop a new innovative technology that accelerates or directs muscle reinnervation and the establishment of neuromuscular junctions following peripheral nerve denervation.

DESCRIPTION: Segmental nerve defects have limited potential for spontaneous recovery and are often associated with devastating functional deficiencies. It is known that 5-6% of all military injuries involve major injury to a peripheral nerve. Before World War II (WW II) nerve injuries were repaired as simple reapproximation and suturing procedures often conducted under tension. They were often further complicated by surrounding tissue damage and infection. Poor outcomes from these procedures were discovered to be the result of failed axonal regeneration at the site of repair. In addition to physically bridging the defect, we recognize the need for medical interventions to promote or direct muscle reinnervation primarily the reestablishment of neuromuscular junctions. The literature suggests the application of mechanical stimulation and growth factors show promise as potential therapies. The inducible expression of neurotrophic factors by mesenchymal progenitor cells within damaged muscle may speak to an endogenous pathway that could also be enhanced to promote reinnervation. As the therapeutic field continues to advance, it is likely more nanotechnology, cellular, mechanical, biologic or pharmacological components may also be incorporated into therapeutic strategies to promote or direct muscle reinnervation and create neuromuscular junctions to facilitate the repair of peripheral nerve defects and enhance functional muscle recovery.

PHASE I: Conceptualize and design an innovative solution for repair and regeneration that will promote or direct the formation of neuromuscular junctions thereby facilitating the repair of peripheral nerve defects. Such constructs should be biomaterial driven and may include nanotopology, cellular, tissue or biological components meant to facilitate controlled axonal outgrowth or promote ensheathment. It is likely that the most successful constructs would incorporate two or more of the described components. The required Phase I deliverables will include: 1) a research design for engineering the scaffold and 2) A preliminary prototype with limited testing to demonstrate in vitro proof-of-concept evidence that demonstrate axonal bridging via the scaffold conduit (to be executed at Phase I). Other supportive data from in vivo proof-of-feasibility studies demonstrating muscle reinnervation which lead to functional improvement may also be provided during this 6-month Phase I period.

PHASE II: The researcher shall design, develop, test, and demonstrate a prototype therapeutic that implements the Phase I methodology to promote or direct muscle reinnervation. The researcher shall describe in detail the plan for the Phase III effort.

PHASE III DUAL USE APPLICATIONS: Plans on the commercialization/technology transition and regulatory pathway should be executed here and lead to FDA clearance/approval. They include: 1) identifying a relevant patient population for clinical testing to evaluate safety and efficacy and 2) GMP manufacturing sufficient materials for evaluation. The small business should also provide a strategy to secure additional funding from non-SBIR government sources and /or the private sector to support these efforts. Military application: The desired therapy will allow military practitioners to apply the therapy. Commercial application: Healthcare professionals world-wide could utilize this product as a therapy meant to improve the standard of care presently available to patients suffering from peripheral nerve denervation.

REFERENCES:
1) “Immediate Care of the Wounded.” Clifford C. Cloonan. Copyright 2007 The Brookside Associates, Ltd. All Rights Reserved http://www.operationalmedicine.org/TextbookFiles/Cloonan/Disability.pdf

2) “Acute nerve injury.” Medscape Reference., Sep 23, 2011.
http://emedicine.medscape.com/article/249621-overview#

3) “Mechanical stimulation of paralyzed vibrissal muscles following facial nerve injury in adult rat promotes full recovery of whisking.” Neurobiol Dis., April 2007; Vol. 26, No. 1; p 229-42.

4) “Enhanced reinnervation of the paralyzed orbicularis oculi muscle after insulin-like growth factor-I (IGF-I) delivery to a nerve graft.” J Reconstr Microsurg., July 2001; Vol. 17, No. 5; p 357-62.

5) "Inducible Expression of Neurotrophic Factors by Mesenchymal Progenitor Cells Derived from Traumatically Injured Human Muscle.” Mol Biotechnol., Sep 9, 2011. Ahead of press.
http://www.springerlink.com/content/v086x68275386vj0/fulltext.pdf

KEYWORDS: reinnervation, neuromuscular, regeneration

A13A-T020 TITLE: Durable Coatings on Military Fabrics that Provide Multi-threat Capabilities

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: To advance durable coatings and associated manufacturing processes for enhanced multi-functional capabilities such as antistatic, conductive, flame resistance, improved abrasion resistance / field durability, and ballistic/stab protection to existing military clothing/fabric systems. It is desired to impart functionality at the fiber surface level, in a conformal manner, with minimal add-on weight, preserving existing fabric structure and porosity.

DESCRIPTION: The military faces a spectrum of threats that are environmentally complex. The Army needs new cost effective technologies that will deliver enhanced capabilities with little or no weight penalty or increase on soldier load using existing fabric clothing/equipment systems. Proposed material coating treatment and/or applications should be compatible with military fabrics as to not affect the structural integrity/strength, stiffness, color fastness, and IR (infrared) signature. These multi-functional coatings for the various threats should be durable to allow standard laundering protocols and maintain both capability and protection in varied military operational environments. It is preferred that the cost of this technology be minimal and that the coating process be environmentally benign. An approach that is amenable to manufacturing scale-up is essential to transition the technology from concept research to production processing. An example of a scaled up benign manufacturing process could be use of roll-to-roll process or similar technology to impart the functional coatings. Preferences will be given to those technologies that can be applied to the current NYCO (i.e., 50/50 nylon/cotton blend fabric used in the Army Combat Uniform); nylon and ballistic materials such as para-aramids (e.g., Kevlar or related fibers), ultra high molecular weight polyethylene UHMPE (e.g., Spectra, Dyneema); and other materials currently used or candidates for use. Novel innovative technologies are sought. A key issue is to ensure that multifunctionality is maintained throughout the manufacturing cycle and in actual use i.e., that the functionality imparted by one treatment is not hindered by subsequent processing steps used to incorporate other functionalities.

PHASE I: Develop coating concepts and compatible chemical compounds and detail feasibility by evaluating functional coating through standard testing procedures documenting performance of functional capabilities. Phase 1 of this call involves research and testing of the functional coatings on various fabric systems used by the military. The emphasis is on demonstrating the conceptual feasibility of the coating process and the resulting functional performance of the coated fabric through small-scale fabric swatch level trials. Examples of testing procedures on fabric could include but not limited to ASTM F-1790, ASTM E-1354, and ASTM D-6413. Provide samples of fabrics treated with functional coating for Army researchers to conduct iterative testing depending on functional capabilities.

PHASE II: Optimize coatings and material performance on military relevant fabrics. Scale up production process to show larger-scale manufacturing feasibility. In Phase II it is required that a prototype coating production process be demonstrated at a scale sufficient to provide coated fabrics in runs of several yards in length. The fabric materials coated in Phase II will be provided to the Army for evaluation and assembly of prototype garments for demonstration purposes.

PHASE III DUAL USE APPLICATIONS: The Phase III work will demonstrate scalability and repeatability of new multi-functional fabrics produced by the coating process for military use in uniforms. In Phase III a mature continuous coating process will be implemented and the proposing contractor will partner with a military clothing manufacturer to coat fabrics for assembly into functional end item combat clothing garments. The end item garments will be delivered to the Army for evaluation of multifunctional performance and durability in operational field/wear testing. The multi-functional fabrics produced from the technology platform will have commercialization opportunities for military relevant applications such as force protection against various threats including weapon, blast, stab to name a few. The same technology will have dual-use commercial applications for personal protective equipment used by first responders. The multi-functional fabrics could be used by first responders such as civilian firefighters and rescue workers.

REFERENCES:
1) ASTM D6413 Standard Test Method for Flame Resistance of Textiles (Vertical Test)

2) ASTM F1790 Measuring Cut Resistance of Materials Used in Protective Clothing

3) ASTM E-1354 Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter

4) ASTM F-2757 Standard guide for Home laundering Care and maintenance of flame, thermal and arc resistant clothing

5) The Berry Amendment: Requiring Defense Procurement to come from Domestic Sources, VB Grasso, Congressional Research Service, July 20, 2012

KEYWORDS: material coating, fabric, NYCO

A13A-T021 TITLE: Low Cost Fabrication of Armor Protection Systems for Military Tactical Vehicles

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Design, develop, computer simulate and demonstrate a low cost manufacturing process for tile based composite armor systems that reduces the time to manufacture, assemble, and integrate armor protection system components.

DESCRIPTION: The Army has a need to develop and demonstrate a low cost armor manufacturing process technology which is aimed at reducing the time to manufacture armor protection systems as well as the assembly and integration process.

The current integration burden of fasteners and multi-panel assemblies requires detailed design and engineering for each component to ensure that the attachment can adequately sustain mobility and survivability requirements (dynamic loading, ballistic windows, etc.). As a result, the armor system becomes overweight, which places additional requirements on the vehicle drive train and substructure. Therefore, a study needs to be conducted to introduce new, innovative production methods to reduce the manufacturing costs of composite armor systems.

The current method by which both aluminum oxide and silicon carbide tile based composite (primarily fiberglass) armor systems are fabricated is called Vacuum Assisted Resin Transfer Molding (VARTM). It is high cost due to the labor intensive processes required to assemble the constituent materials (armor tiles, resins, performs, etc.). In general, the geometries required for protection systems are flat or faceted and require secondary bolting or bonding to the platform's geometric envelope. The composite armor will require integration to multiple vehicle platforms, including tactical (example: the Joint Light Tactical Vehicle) and combat vehicles (example: Ground Combat Vehicle). Thus the method of production should provide a means of producing stock shapes which can be used to produce armor systems common across various vehicle families. Required shape width of 3 feet is desired with varying lengths up to 12 feet. Ability to encapsulate tiles thickness of ¼" to 1 ½" and diameter of 1" to 4" is required. Integration will require the presence of holes (approximately ¾" diameter) in predetermined areas.

PHASE I: Phase I of this study will focus on developing the basic manufacturing technology used to produce the fundamental armor protection system. A continuous manufacturing method (example: pulltrusion) is desirable, as it allows for unlimited product length. But, alternative manufacturing methods which can satisfy the requirements will also be considered. As an example, a pulltrusion based proposal would have to address how to overcome the limitations of current pulltrusion systems used for armor manufacturing. These systems are generally limited to thicknesses of 1" or less and are slow due to the thermal curing process. Further, it would be necessary to develop technology that integrates and manages the inputs into the system (armor tiles, resin, fillers, and complex shaped performs) to eliminate/significantly reduce the downstream assembly and integration cost burden, which is typical of today's technology.

Phase I will involve the design and computer simulation of a manufacturing process capable of fabricating encapsulated aluminum oxide and silicon carbide tiles into an armor system in a variety of planar shapes at a low cost. This process must have significantly higher throughput (lower cycle time) than current thermal processing systems, and be a flexible and agile manufacturing process that can convert raw materials into shapes and constructions that meet mobility and ballistic performance requirements. This phase must also address the design and material handling system of the tiles, resin systems, and complex performs that are characteristic of an “armor system.” The design and manufacturing of integrated features in the armor package should address the elimination or significant reduction in the cost burden of downstream assembly and integration of the armor onto the vehicle system.

PHASE II: Phase II of the study will focus on translating the designs and technology of phase I into a manufacturing process which will produce physical articles that can be used to validate the cost, cycle time, and reduction in integration burden due to the new manufacturing process. The ability to produce, at low cost, armor systems containing characteristic features and that allow the variability in shape while providing for minimum integration burden needs to be demonstrated. Several panels of differing shape will be fabricated according to a test plan. Upon completion the US Army TARDEC will test the supplied panels to validate the performance of the armor systems produced by the process equals or exceeds armor produced by the Vacuum Assisted Resin Transfer Molding (VARTM) process. In addition, the relevant manufacturing requirements necessary to successfully commercialize the developed process should be identified, so the technology can be transitioned in phase III.

PHASE III DUAL USE APPLICATIONS: Phase III will focus on the transition of the technology to commercialization. The commercial equipment used to produce the armor systems at a low cost will be designed and fabricated. The prove out of the manufacturing process (equipment) will be demonstrated (cycle time at scale, product variability, process control, etc.) by producing an armor system for a platform identified by the Army. The system will consist of the minimum number of components required to meet the ballistic requirements of the platform specified. The manufacturing cost and performance will validated by both ballistic and/or mobility testing.

REFERENCES:
1) Joseph E. Sumerak , Pultrusion Process Optimization Using On-Line and Off-Line Techniques, Composites in Manufacturing v.13 n.2, pages 1-7, 2cd Quarter 1997.

2) Eric D. Wetzel, William A. Spurgeon, and Christian J. Yungwirth, Induction Bonding for Structural Composite Tubes, Army Research Laboratory, ARL-TR-2818, September 2002.

3) Chistian J. Yungwirth, Eric D. Wetzel, and James M. Sands, Induction curing of a Phase - Toughened Adhesive, Army Research Laboratory, ARL-TR-2999, June 2003.

KEYWORDS: low cost, manufacturing, assembly, composite armor systems, integration burden, process efficiency