MISSILE DEFENSE AGENCY (MDA)
SMALL BUSINESS TECHNOLOGY TRANSFER (STTR)
STTR 04 PROPOSAL SUBMISSION INSTRUCTIONS

INTRODUCTION

The MDA STTR program is implemented, administrated and managed by the MDA Office of Small and Disadvantaged Business Utilization (SADBU). If you have any questions regarding the administration of the MDA STTR program please call 1-800-WIN-BMDO. Additional information on the MDA STTR Program can be found on the MDA STTR home page at http://www.winbmdo.com/. Information regarding the MDA mission and programs can be found at http://www.acq.osd.mil/bmdo.

For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (1-866-SBIRHLP) (8am to 5pm EST). For technical questions about the topic during the pre-solicitation period (2 Jan 2004 through 29 February 2004), contact the Topic Authors listed under each topic on the http://www.dodsbir.net website before **1 March 2004.**

As funding is limited, MDA will select and fund only those proposals considered to be superior in overall technical quality and most critical. MDA may fund more than one proposal in a specific topic area if the technical quality of the proposal is deemed superior, or it may fund no proposals in a topic area.

PHASE I GUIDELINES

MDA intends for Phase I to be only an examination of the merit of the concept or technology that still involves technical risk, with a cost not exceeding $100,000.

A list of the topics currently eligible for proposal submission is included in this section followed by full topic descriptions. These are the only topics for which proposals will be accepted at this time. The topics originated from the MDA Programs and are directly linked to their core research and development requirements.

Please assure that your e-mail address listed in your proposal is current and accurate. MDA cannot be responsible for notification to companies that change their mailing address, their e-mail address, or company official after proposal submission.

Phase I Proposal Submission

Read the DoD front section of this solicitation for detailed instructions on proposal format and program requirements. When you prepare your proposal submission, keep in mind that Phase I should address the feasibility of a solution to the topic. Only UNCLASSIFIED proposals will be entertained. MDA accepts Phase I proposals not exceeding $100,000. The technical period of performance for the Phase I should be 6 months. MDA will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, MDA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

If you plan to employ NON-U.S. Citizens in the performance of a MDA STTR contract, please identify these individuals in your proposal as specified in Section 3.5.b (7) of the program solicitation.

It is mandatory that the ENTIRE technical proposal, DoD Proposal Cover Sheet, Cost Proposal, and the Company Commercialization Report are submitted electronically through the DoD website at http://www.dodsbir.net/submission. If you have any questions or problems with the electronic proposal submission contact the DoD Helpdesk at 1-866-724-7457.

This COMPLETE electronic proposal submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the ENTIRE technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site http://www.dodsbir.net/submission will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal submission must be submitted via the submission site on or before the 6 a.m.15 April 2004 deadline. Proposal submissions received after the closing date will not be processed.

PHASE II GUIDELINES

This solicitation solicits Phase I Proposals. MDA makes no commitments to any offeror for the invitation of a Phase II Proposal. Phase II is the prototype/demonstration of the technology that was found feasible in Phase I. Only those successful Phase I efforts that are **invited** to submit a Phase II proposal and all FAST TRACK applicants will be eligible to submit a Phase II proposal.

Invitations to submit a Phase II proposal will be made by the MDA STTR Program Manager (PM) or one of MDA's executing agents for STTR. Fast Track submissions do not require an invitation. Phase II proposals may be submitted for an amount normally not to exceed $750,000. Companies may, however, identify requirements with justification for amounts in excess of $750,000.

PHASE II PROPOSAL INVITATION

An MDA Program begins the process for a Phase II Invitation by making a recommendation (all MDA Topics are sponsored by MDA Programs). The MDA Program recommendation is based on several criteria. The Phase II Prototype/Demonstration (*What is being offered at the end of Phase II?),* Phase II Benefits/Capabilities (*Why it is important),* Phase II Program Benefit (*Why it is important to an MDA Program),* Phase II Partnership (*Who are the partners and what are their commitment? Funding? Facilities? Etc? This also can include Phase III partners*), and the Potential Phase II Cost. This is the basic business case for a Phase II invitation and requires communication between the MDA Program, the Phase I STTR Offeror, and the Phase I Technical Monitor.

The MDA Program Phase II Invitation recommendation is made to the MDA SBIR Working Group. The MDA SBIR Working Group will review the Phase II invitation recommendations and make a recommendation to the MDA SBIR Steering Group based on the same criteria and the availability of funding. The MDA SBIR Steering Group will review and make their recommendation based on the same criteria as the MDA SBIR Working Group to the MDA Selection Official. The MDA Selection Official has the final authority. If approved by the MDA Selection Official then a Phase II Invitation is issued.

Phase II Proposal Submission

If you have been invited to submit a Phase II proposal, please see the MDA STTR website http://www.winbmdo.com/ for further instructions.

All Phase II proposals must have a complete electronic submission. Complete electronic submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the ENTIRE technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site **http://www.dodsbir.net/submission** will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal must be submitted via the submission site on or before the MDA specified deadline or may be declined. .

MDA FASTTRACK Dates and Requirements:

The complete Fast Track application must be received by MDA 120 days from the Phase I award start date. The Phase II Proposal must be submitted within 180 days of the Phase I award start date. Any Fast Track applications or proposals not meeting these dates may be declined. All Fast Track applications and required information must be sent to the MDA STTR Program Manager at the address listed below, to the designated Contracting Officer's Technical Monitor (the Technical Point of Contact (TPOC)) for the contract, and the appropriate Execution Activity STTR Program Manager.

Missile Defense Agency
MDA/SB Attn STTR Program Manager
7100 Defense Pentagon
Washington, DC 20301-7100

The information required by MDA, is the same as the information required under the DoD FastTrack described in the front part of this solicitation. Phase I interim funding is not guaranteed. If awarded, it is expected that interim funding will generally not exceed $30,000. Selection and award of a Fast Track proposal is not mandated and MDA retains the discretion not to select or fund any Fast Track proposal.

MDA STTR PHASE II ENHANCEMENT PROGRAM

To encourage transition of STTR into DoD Systems, MDA has a Phase II Enhancement policy. While not guaranteed, MDA may consider a limited number of Phase II enhancements on a case-by-case basis. MDA will generally provide the additional Phase II enhancement funds by modifying the Phase II contract.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria must be met or your proposal will be REJECTED.

____1. Your technical proposal, the DoD Proposal Cover Sheet, the DoD Company Commercialization Report (required even if your firm has no prior STTRs), and the Cost Proposal have been submitted electronically through the DoD submission site by 6 a.m. 15 April 2004.

____2. The Phase I proposed cost does not exceed $100,000.

MDA 04 STTR Topic Index

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MDA 04 STTR Topic Descriptions

MDA04-T001 TITLE: Surface Contour Design Models for Foveated Optical Systems

TECHNOLOGY AREAS: Air Platform, Information Systems, Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS-MDA/AB

OBJECTIVE: To develop computational design tools to specify the surface profile of reflective, optical components for foveated systems. The computational tool must be able to translate object field into nonlinear image field based on resolution function requirements and accommodate the impact of secondary reflective components.

DESCRIPTION: High speed, agile missile threats must be countered by even higher speed, more dramatically agile interceptors. The rapid engagement time-lines and dynamic geometries for interceptors are placing significant demands on optical seeker subsystems. This forces higher resolution spatial, temporal, and even spectral sampling of the engagement volume, introducing complex, high data volume image processing tasks for threat ID and tracking. The Aegis Ballistic Missile Defense (Aegis BMD) Office is considering the use of reflective foveated seeker optics to alleviate the computational load of the image processor function. Reflective foveated optical systems, such as the one shown in the figure below, provide a panoramic view of the engagement volume while incorporating a nonlinear, instantaneous fields-of-view that allows high resolution inspection of objects at the center of the image field. The all reflective component designs will allow broad spectral operation.

Computational design tools are needed to determine the surface contours of these reflective optical components to support component specification and testing. Aegis BMD is seeking computational tools that generate these surface contours based on resolution functions derived from engagement requirements. The tool's translation of object field angular space to image field angular space should also consider the impact of inserting adaptive secondary components (also reflective) for active control of the image field non-linearities.

PHASE I: The Phase I contractor shall describe the concept and theory of operation of their proposed computational tool(s). Supporting analysis on surface profile generation, surface collecting power estimations, surface boundary settings, and surface figure examination shall be provided. The contractor shall provide evidence showing that adjustments in the input resolution function will result in a change in the surface profile. Cosine and parabolic resolution functions should be considered for initial tool assessment. The contractor shall note likely idiosyncrasies or irregularities in tool operation.

PHASE II: The Phase II contractor shall expand upon Phase I achievements by developing a detailed design tool. Analysis and software testing shall be provided to establish the reliability and maturity of the computational tool. Idiosyncrasies or irregularities in tool operation that would generate deficiencies or discontinuities in output shall be identified. The contractor shall describe likely production risks and cost drivers.

PHASE III: If Phase II achievements are substantial, the contractor will transition their computational tool into the optical systems analysis market. A Phase III a software product will be developed and tested for insertion into existing commercial software or as an independent capability.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Adaptive, foveated systems have a range of potential applications for commercial aviation (collision avoidance) and property security (perimeter surveillance). Proper specification and design of such systems will require a fully validated design tool.

REFERENCES:
1. P.T. Kortum and W.S. Geisler, "A Real-time Foveated Multi-Resolution System for Low-Bandwidth Video Communication", In B. Rogowitz and T. Pappas (Eds.), "Human Vision and Electronic Imaging", 3299, 294-305, 1998
2. D. V. Wick, T. Martinez, and S. R. Restaino, "Wide-Field-of-View Foveated Imaging System", Air Force Research Lab. [4715-06], Unmanned Ground Vehicle Technology IV Conference, April 2002, Pro. SPIE Vol. #4715
3. W.J. Smith, "Modern Optical Design", Chapter 5: Eye and Color, McGraw-Hill, 1966
4. D. Marr, "Vision", W.H. Freeman, 1982

KEYWORDS: seeker systems, foveated optical systems, panoramic optics, nonlinear imaging

MDA04-T002 TITLE: IR Seeker Window Concepts and Materials for Hypersonic Interceptors

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS-MDA/AB

OBJECTIVE: To develop innovative window design concepts and/or materials that facilitates the IR seeker function for hypersonic environments. Solutions must address the mitigation and/or nullification of aero-thermal heating effects as these effects introduce background radiation into the seeker aperture, degrade or alter window optical specifications, and/or induce window failure.

DESCRIPTION: Current kinetic kill vehicle designs used for ballistic missile intercept lack the appropriate aerodynamic profile to execute intercepts at even modest levels of atmospheric drag. To evolve a kinetic kill vehicle with a broader engagement envelope that retains an EO/IR seeker function, MDA/AB is searching for new and innovative seeker window concepts and/or materials technologies that will support efficient and predictable aerodynamic behavior in endo-atmospheric flight regimes.

MDA/AB would like to consider new, revolutionary IR window concepts and/or materials technologies that address such factors as thermally induced warping and stress effects, increased attenuation/degraded spectral properties, adverse chemical reaction with the atmosphere, fracturing and mechanical failure, interfering IR radiation emitted by heat producing phenomenology such as the bow compression wave or surface flow friction, and production costs. Window concepts and/or materials technologies that survive, mitigate, and/or nullify these and other degrading effects caused by hypersonic environments will be considered.

PHASE I: The Phase I contractor shall describe the concept and theory of operation of their proposed concept and/or material. Supporting analysis showing probable performance characteristics and durations shall be provided. The contractor shall consider the impact of slanted flat (60° incline), conical (60° incline), and hemi-spherical geometric window profiles in their analysis. Performance and endurance assessments shall, at a minimum, consider flight velocities ranging from 5 to 8 km/s at altitude equivalent air densities ranging from 25 km to 45 km.

PHASE II: The Phase II contractor shall expand upon the Phase I achievements by providing detailed modeling and design analysis of their proposed window concept. Analysis shall include the impact of varying incident angle aerodynamic flows on performance. The contractor shall identify any performance idiosyncrasies or deficiencies. Construction and preliminary testing of a prototype window will enhance assessments of the contractor's effort. The contractor shall provide evidence showing that the proposed window concept and/or technology will fit within the confines of a hypothetical kill vehicle (30 cm in diameter, 60 cm tall cone) by giving estimates of volume, weight, and any power source features. The contractor shall describe likely production risks and cost drivers.

PHASE III: If Phase II achievements are substantial, the contractor will transition their window concept into a prototype system component in coordination with an appropriately associated prime contractor. The Phase III prototype will be used to conduct performance analysis and testing in preparation for production.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Passive IR sensors are seeing increased application on high speed platforms such as hypersonic missies and remotely piloted space launch/reentry vehicles. The most likely commercial applications for this technology is in proving a protect barrier between IR camera equipment and high heat environments.

REFERENCES:

5. J. Anderson, "Hypersonic and High Temperature Gas Dynamics", McGraw-Hill, 1989
6. G.W. Sutton, "Effect of Turbulent Fluctuations in an Optically Active Fluid Medium", AIAA Journal, Vol. 7, No. 9, September 1969, pp. 1737-1743
7. F.M. White, "Viscous Fluid Flow", McGraw-Hill, 1974
8. B. Moylan, J. Pond, Y. Hwang, G. Jones, "Analysis of Actively Cooled IR Windows for Hypersonic Endo-Atmospheric Flight Designs", Proceedings, 6th DoD Electromagnetic Window Symposium, (1995) 27-32

9. E.F. Cross (EFC Research Associates, Los Angeles, CA), "Analytical Method to Calculate Window Heating Effects on IR Seeker Performance", SPIE Proceedings, Vol. 2286, Paper # 2286-58
10. L.D. Lorah, E. Rubin, "Aerodynamic Influences on Infrared System Design", The Infrared Handbook, W.L. Wolfe and G.J. Zissis, Eds., The Environmental Research Institute of Michigan, Ann Arbor, MI, Revised 1985
11. J.E. Craig, W.C. Rose, "The Optics of Aircraft Shear Flows", AIAA Paper 85-0557, March 1985

KEYWORDS: IR window, hypersonic, seeker, interceptor

MDA04-T003 TITLE: Integrated Design of Kinetic Kill Vehicle With Internal Attitude Control System

TECHNOLOGY AREAS: Air Platform, Materials/Processes, Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS-MDA/AB

OBJECTIVE: To develop innovative designs for a kinetic kill vehicle capable of seamless operation in both endo-atmospheric and exo-atmospheric flight regimes from low to high supersonic speeds. The kill vehicle attitude control mechanism is to be entirely contained within the vehicle body. The control mechanism should involve no mass expulsion other than that provided by a single axial thrust motor. The aerodynamic profile of the vehicle must take into account both the selected internal control mechanism and the expected flight environment. The integrated design should provide effective attitude and divert control for enabling interception of high speed maneuvering targets.

This concept applies equally well to both endo and exo regimes. For exo-operation, an internal control mechanism (the exact nature of which is unspecified) is used in combination with an axial thrust. The internal control causes torques that change vehicle attitude and vector the thrust into the desired maneuver direction for exo-intercept. For endo-operation, a similar principal applies, except that the vectored force is thrust minus drag or simply drag. In endo flight, the need for external aero surfaces is avoided to exploit the benefits of a more efficient aerodynamic profile. Vectoring of the thrust and/or drag during endo provides the required maneuver forces to achieve the necessary cross range corrections for intercept.

DESCRIPTION: Current kinetic kill vehicle designs used for ballistic missile intercept typically utilize solid propellant divert and attitude control thrusters that eject combustion products into the airstream and may contaminate seeker optics. Such devices are complex, expensive and prone to reliability problems. In addition, traditional kill vehicle designs typically have non-streamlined aerodynamic contours intended mainly for exo-atmospheric operation. As such, these vehicles lack the appropriate aerodynamic profile and attitude control mechanisms to allow intercepts at even modest levels of atmospheric drag. To evolve a kinetic kill vehicle with a broader engagement envelope, MDA/AB is seeking concepts and associated technologies that will allow effective vehicle attitude and divert control in both exo- and endo-atmospheric flight regimes. In addition, it is desired that new concepts for internal vehicle control be developed that do not rely on side thrusters and ejection of propellant products. Examples of some possible internal control mechanisms include the use of flywheels where gyroscopic forces provide attitude torque, internal moving solid masses or fluids where center-of-mass offsets coupled with thrust and/or drag forces produce attitude torque, and other hybrid mechanisms that provides effective attitude control. These approaches may include novel actuators/servomechanisms for moving internal masses and advanced control algorithms for the flight control (autopilot) function.

PHASE I: The Phase I contractor shall develop a preliminary concept and theory of operation for their proposed airframe and internal attitude control mechanism. Supporting analysis showing torque levels, power requirements, attitude response times and achieved maneuver levels for open-loop acceleration commands at endo and exo flight conditions shall be provided. The contractor shall provide evidence showing that the proposed attitude control mechanism(s) will fit within the confines of a hypothetical vehicle (50 Kg total mass, not exceeding 30 cm diameter and 60 cm length). In developing this evidence, the contractor shall consider the impact of seeker, guidance and control processors, and propulsion subsystems; by giving estimates of concept volume, weight, and control mass travel. The contractor shall note the use and fabrication procedures of any specially developed materials required for their concept. The rationale for the aerodynamic design shall be provided and the impact of aerodynamically induced disturbance torques shall be assessed. Using a simplified 6 degree-of-freedom flight simulation, the contractor shall demonstrate the feasibility of controlled flight in both endo and exo-atmospheric scenarios. Control demonstrations should consider the performance capabilities necessary to intercept high speed maneuvering targets.

PHASE II: The contractor shall expand upon the Phase I achievements by conducting detailed modeling and design of their proposed attitude control concept. The contractor shall develop a detailed 6 degree-of-freedom flight simulation and exercise it over the full endo and exo-atmospheric flight envelope to determine expected performance. Parametric sensitivity studies shall be performed to determine boundaries of performance against specified threat scenarios. Design excursions shall be performed which optimize the vehicle's achievable divert accelerations, attitude control response times, and zero effort miss performance. Analysis shall include optimization of the aerodynamic profile and attitude control mechanism. The contractor shall construct a prototype vehicle with internal control mechanism and perform laboratory experiments to demonstrate control authority and response times for open-loop control commands. The contractor shall identify any performance idiosyncrasies or deficiencies and describe the likely production risks and cost drivers.

PHASE III: If Phase II achievements are substantial, the contractor will transition their kill vehicle concept in coordination with a selected prime contractor. They will jointly conduct detailed performance analyses and testing in preparation for a technology demonstration involving captive carry and full scale missile flight tests. At the conclusion of the technology demonstration, a decision will be made relative to a transition to production.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Internal attitude control systems of the type generated under this topic are in increasing need for commercial applications, such as stabilizing single or two wheeled vehicles, attitude control for mini- or micro-spacecraft, and attitude stabilization for mini- or micro-UAV payloads.

REFERENCES:
[1] Chadwick, W. R. and Malyevac, D. S., "Considerations on the Design of Kinetic Kill Interceptor with Moving Mass Control", Draft Report NSWCDD TR-00/87, Naval Surface Warfare Center, Dahlgren, VA, August 2000.
[2] Menon, P. K. and Sweriduk, G. D., "Integrated Guidance and Control of Moving Mass Actuated Kinetic Warheads", Final Report Submitted under Navy Phase I SBIR Contract No. N00178-01-C-1020, Optimal Synthesis Inc., Los Altos, CA, November 1, 2001.
[3] Menon, P. K., Ohlmeyer, E. J., et al., "Integrated Guidance and Control of Moving Mass Actuated Kinetic Warheads," AIAA/MDA Technology Conference, Monterey, CA, 29 July-2 August, 2002. To appear, AIAA Journal of Guidance, Control and Dynamics, 2003.
[4] Regan, F. J. and Anandakrishnan, S. M., Dynamics of Atmospheric Re-Entry, AIAA Education Series, American Institute of Aeronautics and Astronautics, Washington, DC, 1993, pp. 129-136.
[5] Kane, T. R. and Levinson, D. A., Dynamics: Theory and Applications, McGraw-Hill, New York, NY, 1985.
[6] Anderson, J. D., Modern Compressible Flow, With Historical Perspective, 2nd Ed., McGraw-Hill, New York, NY, 1990.

KEYWORDS: kinetic kill vehicle, attitude control, flight control, flywheel, mass moment control

MDA04-T004 TITLE: Onboard Fire Protection

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: BMDS-MDA/AL

OBJECTIVE: Provide improved protection against in-flight fire resulting from spills of 70% Hydrogen Peroxide

DESCRIPTION: Fires onboard aircraft may result in catastrophic consequences. The addition of a strong oxidizer, 70% H_2O_2 makes the problem much more severe. Currently Halon 1301 is used to suppress but not extinguish ABL onboard fires. A continuing resupply of Halon is required to maintain the suppressed condition for the maximum time that might be required to return to a safe landing location. This results in a significant weight penalty. Preliminary experiments demonstrated that water as a mist or direct application stream is capable of fully extinguishing the same H_2O_2 oxidizer fires with 23 pounds of water vs 67 pounds of halon.

PHASE I: Develop a system design for a water based Fire Extinguishing System able to extinguish an obscured fire of one-half pound "Red Mechanic's Rags" at any location on the floor in a 10x10x10 ft volume. The total system weight including all water and hardware must be less than 75 pounds. The fire test procedure is described in detail in the reference. Provide a test item for evaluation.

PHASE II: Develop and provide for test the Fire Extinguishing System scaled to protect all likely H2O2 spill locations in the laser and laser chemical supply areas of the Airborne Laser, Block 08. The complete system weight must be substantially lower than current Halon 1301 systems. The estimated weight of the Block 08 aircraft fire protection system, is >10,000 lbs. using Halon technology.

PHASE III: Manufacture flight qualified components to permit installation of the Fire Extinguishing System on ABL, Block 08 or subsequent aircraft.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This system could be applied in any area where high risk of oxidizer leaks makes conventional fire extinguishing systems impractical.

REFERENCES:
1. Wells, S. and Dierdorf, D., ABL FIRE PROTECTION TECHNOLOGIES, Air Force Research Laboratory, Materials and Manufacturing Directorate, AFRL-ML-TY-TR-2000-4531, Distribution authorized to Department of Defense and US DoD contractors only; Test & Evaluation, April 2000. Other requests for this information shall be referred to AFRL/MLQD, 139 Barnes Drive, Ste. 2, Tyndall AFB, FL 32403-5323
2. "Case Study: Halon Replacements For Aircraft Fire & Explosion Protection" Vitali, Juan A. Phd. presented to NDIA Conference, Vancouver, Canada, 02 Mar 2002
3. ICSC – 0164 dated April 2000
4. International Conference on Automatic Fire Detection "AUBE '01", 12th. Proceedings. National Institute of Standards and Technology. March 25-28, 2001. Gaithersburg, MD.
5. MSDS Reference Number 7722-84-1-4
6. ICSC – 0164 dated April 2000
7. Minimum Performance Standard for Aircraft Cargo Compartment Halon Replacement Fire Suppression System – DOT/FAA/AR-TN03/5 dated April 2003

KEYWORDS: Airborne Laser, fire protection, halon, water, hydrogen peroxide.

MDA04-T005 TITLE: Rapid Mirror Fabrication with Nanolaminate Surface

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: BMDS-MDA/AL

OBJECTIVE: Efforts to produce meter-class mirrors in infrared and visible wavelengths have been evolving through the use of mandrels for creating near-net-shape composites and nano-laminates for optical quality facesheets. Combining these two technologies could produce a mirror of sufficient figure and roughness to function as a diffraction limited optic. This proposed technology would significantly decrease the production time of making multiple aperture optics by eliminating the polishing step.

DESCRIPTION: An optically polished mandrel mold would first have to be acquired/produced. Multiple backing structures with similar figure errors could be cast (replicated) against each mandrel and then combined with a prefabricated thin substrate to remove any small figure or roughness errors. The thin substrate (nanolaminate) could be fabricated from a number of engineered layers. Carbon reinforced polymer composites can be made with thick resin layers made up against an optical quality mandrel to mitigate fiber print through. Composite backing structures built using this technology combined with membrane/nano-laminate technology could demonstrate a method for rapidly producing an aperture optic. Alternate material systems are also acceptable. This proposal seeks to examine mirror production methods that combine structurally stiff backing structures, built against optical mandrels, with nanolaminate mirror casting techniques to rapidly produce low-cost, large aperture mirrors with low mass.

PHASE I: Through design, analysis and small-scale experiments develop and demonstrate a path towards the production of lightweight mirrors (<10Kg/sq.meter).

PHASE II: Develop technology towards the fabrication and testing of a 0.5 meter diameter spherical lightweight optic with 10 meter radius of curvature, 1/4 wave rms surface figure error and 4nm rms roughness. Develop cost and schedule estimates for a less than 2 months production time.

PHASE III: Develop facility for rapid prototyping and mass production of 1.0-2.0 meter diameter mirrors. Seek technology development towards the manufacture of smaller spherical mirrors (<10cm diameter) with an order of magnitude less cost and schedule.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The design and manufacturing technology could be used for the optical lithography and semiconductor industry.

REFERENCES:
1. Chen, P. C., et. al., "Advances in Very Lightweight Composite Mirror Technology," Opt. Eng., Vol. 39, pp. 2320-2329, September 2000.
2. Connell, S. J. and Abusafieh, Abdel. (2002). "Lightweight Space Mirrors from Carbon Fiber Composites." SAMPE Journal 38.4: 46-55.
3. Denoyer S. J. and Maji A., "Lightweight Adaptable Space Optics: The Advanced Mirror System Demonstrator", Proc. of 51st International Astronautical Congress, Rio de Janeiro, Brazil, Oct, 2000.
4. Hochhalter J., Maji A. K., Reicher D. W., "Process Induced Errors in Replicated Carbon Fiber Reinforced Polymer Mirrors, Proceedings of ASCE, SPACE 2004, Houston, TX, March, 2004.

KEYWORDS: Sensor; Mirror; lightweight; optics; nanolaminate

MDA04-T006 TITLE: Polymer System for Aerospace Mirror Applications

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: BMDS-MDA/AL

OBJECTIVE: Perform research and development on polymer systems tailored for use in aerospace mirror applications.

DESCRIPTION: Missile defense systems such as the Airborne Laser have requirements for high quality mirrors to enable functions such as high-data-rate laser communications, sensing, tracking, targeting, and high energy laser projection and relay. Key issues with conventional mirror materials (low CTE glass / ceramics) which limit their practical use include: high material and manufacturing cost, long production times, poor reproducibility, difficulty in scale up to large areas, and high system mass. Polymer systems, through their incorporation into polymer matrix composites, syntactic foams, use as adhesives, and use as replicable (moldable) optical surfaces, and ultimately as polymer thin film (membrane) mirror systems, have the potential to replace current materials while providing considerable weight and cost savings. Issues exist with current polymer systems that prevent their current adoption for aerospace mirror applications. These issues include but are not limited to: high coefficient of thermal expansion (CTE), high coefficient of moisture expansion (CME), high cure shrinkage, outgassing, and degradation in the application environment. High coefficient of thermal expansion affects the mirror in application by leading to shape deformation as well as leading to mirror distortions during manufacture due to thermal expansion mismatch between molds and the polymer system at cure temperatures, therefore, a room temperature curing polymer system is highly desired.

PHASE I: Show proof of concept addressing 1 or more of the issues stated in the description.

PHASE II: Perform research and development to reduce or eliminate issues with current polymer systems. Produce and evaluate polymer system in representative, scalable geometries. Demonstrate the polymer system's capability to function in aerospace mirror applications.

PHASE III: Scale polymer systems to produce application size laboratory prototype and demonstrate polymer system utility and effectiveness.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Private-sector application of polymer-based mirrors includes space applications such as commercial imaging and high data rate laser telecommunication as well as terrestrial uses in laser manufacturing, image projection, and precision polymer structures and optics.

REFERENCES:
1. Dr. Lawrence E. Matson, Dr. David Mollenhauer, “Advanced Materials and Processes for Large, Lightweight, Space-Based Mirrors,” paper IEEE 8.0401, IEEE Aerospace Conference, 18-25 2000.
2. Patrick S. Carlin, “Lightweight Mirror Systems for Spacecraft - An Overview of Materials & Manufacturing Needs,” paper IEEE 8.0401, IEEE Aerospace Conference, 18-25 2000.
3. Richard A. Carreras, “On Near-Net Shape Membrane Optics,” paper AIAA 99-4642, AIAA Space Technology Conference and Exposition, 28-30 September 1999.

KEYWORDS: Polymer; mirror; low coefficient of thermal expansion; low coefficient of moisture expansion; low temperature cure; replication; membrane optics.

MDA04-T007 TITLE: Advanced Optical System Technologies

TECHNOLOGY AREAS: Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS-MDA/AS

OBJECTIVE: Develop advanced optical systems and supporting technologies to provide multiband (IR and Visible) imagery for surveillance, target detection, tracking and discrimination. This encompasses advanced optical telescopes, high pixel density visible and multicolor infrared (IR) focal plane arrays, and imaging LADARs.

DESCRIPTION: Advanced optical systems are required to provide for enhanced surveillance, early warning systems and battle management in missile defense applications. These systems should be compatible with the existing and planned MDA assets. The specific technology areas to be investigated are innovative system level application of advanced optical telescope designs, advanced window designs, multicolor focal plane arrays (FPA), and Range-Resolved Doppler Imaging LADAR capabilities.

PHASE I: Develop advanced capability concepts and identify technical challenge and risk reduction needed for advanced optical system technologies.

PHASE II: Perform risk reduction and prototype design, fabrication and demonstration.

PHASE III: Integrate sensor and telescope technology into a system suitable for manned and unmanned platforms. Demonstrate these in a simulated flight environment. These tests should include environmental testing to ensure reliable operation in a stressing, realistic operational environment.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The system technologies being developed in this effort will have application in homeland security, industrial security and industrial process control.

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[1] G. W. Kamerman, Laser Radar Technology and Applications VII, SPIE Proceedings Vol. 5086, Aug 2003
[2] T. Reed, S. Kendrick, R. Brown et al Final results of the Subscale Beryllium Mirror Demonstrator Program, Proc. SPIE Vol 4451 , Dec 2001
[3] P.C Hobbs, Building Electro-Optical Systems: Making It All Work, Wiley (2000).
[4] T.L. Williams, The Optical Transfer Function Of Imaging Systems, Institute of Physics Publishing 1999.
[5] J. Shamir, Optical Systems and Processes, SPIE (1999).

KEYWORDS: Optical system, Sensor, Multicolor Focal Plane Array, LADAR, MWIR, LWIR, VLWIR

MDA04-T008 TITLE: Lightweight Energy Production and Storage

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: BMDS-MDA/AS

OBJECTIVE: Develop improved lightweight, high energy density, energy production and storage technologies to supplement primary power systems in high altitude airships (HAA).

DESCRIPTION: Improved lightweight renewable energy production and storage devices are needed to supplement the primary power systems for HAAs in order to sustain long-term flights. Technologies must be able to support HAA stationkeeping and operation at 70,000 feet for one continuous year or more. Environmental factors encountered at an altitude of 70,000 ft. must be considered when developing energy storage. Candidate technologies will likely support nighttime operations (up to 16 hours, cycled one time per day), with power drawn during daytime hours from photovoltaics or other energy sources. A host of interrelated technologies, including, but not limited to, photovoltaics, fuel cells, and rechargeable battery arrays, are of interest. Components must accommodate high current draw and have the potential to operate as a system requiring no maintenance. New technologies and improvements to existing technologies (e.g. life-expanding or performance-enhancing technologies for existing designs) will be considered.

Examples of desirable performance characteristics include:
- Solar arrays: 200-400 volts, 500 kW, 15-20% efficient
- Electrolyzers: Generate 1500-1800 SCF of Hydrogen in 16 hours
- Fuel Cells: Generate 600-900 kW-hrs for 16 hours

PHASE I: Conduct feasibility studies, technical analysis and simulation, or small-scale proof-of-concept studies, according to proposed innovations and improvements. Throughput, life-cycle response, temperature response, and other performance properties should be considered and measured, where applicable.

PHASE II: Implement technology assessed in Phase I effort. Phase II effort should include demonstration of power storage capabilities, combination of components to provide additional power, and integration with power systems with high current draw and cycling characteristics similar to those required to sustain a HAA for several hours. Full testing and verification of performance properties should be included.

PHASE III: The contractor shall finalize the technology of the lightweight energy storage and begin commercialization of the product.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would advance renewable energy technologies, with application in a spectrum of areas, in both the government and private sectors.

REFERENECES: (1) http://www.acq.osd.mil/bmdo/barbb/haaactd.htm
(2) Khoury, GA and JD Gillett, Airship Technology, Cambridge University Press, New York, 2002.
(3) "Development of Vehicle Subsystems," Review of the Research Program of the Partnership for a New Generation of Vehicles: Sixth Report, National Academies Press, Washington, DC, 2000.

KEYWORDS: energy storage, renewable energy, fuel cell stack, rechargeable battery, regenerable power, high altitude airship

MDA04-T009 TITLE: Compact High Power Microwave Systems

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: BMDS-MDA/AS

OBJECTIVE: Develop the Components of Compact High Power Microwave Systems for Sensors to be used on Small Vehicles in High Stress Environments.

DESCRIPTION: The objective of this effort is to develop the components of compact high power microwave systems capable of providing high powers in a single pulse or at repetition rates greater than 10 Hz in the 1 – 10 GHz band and are capable of surviving the high g-forces of launch. The major components of these high power microwave systems include pulsed power, microwave and ultra wideband sources, and ultra wideband (UWB) antennas. These systems could be integrated into small vehicles that are to be deployed for the purposes of interactive discrimination and defeating certain types of jammers. In order to meet the severe electrical, mass, and size requirements and the stressing environments, innovative approaches are required.

PHASE I: The objectives of Phase I are to identify and verify through modeling and feasibility demonstrations the key components of compact HPM systems; pulsed power units, high power microwave and ultra wideband sources, and compact ultra wideband antennas. Designs may address devices which generate very high peak power in a single pulse, or which generate high energy via a pulse train, depending on the application; that is, jammer defeat vs. discrimination.

PHASE II: The objective of Phase II is to develop, build, and test these high power microwave and ultra wideband system components to verify their electrical characteristics in different environments, their ability to survive high-g stresses, their interoperability with other system components, and their suitability for integration into platforms such as miniature space vehicles or UAVs.

PHASE III: The Objective of Phase III is to modify these components as required for integration into such vehicles as the Miniature Kill Vehicle, UAVs, missile systems, and/or munitions.

PRIVATE SECTOR COMMERCIAL POTENTIAL The pulsed power technology would benefit those companies using pulsed power for various industrial processes (drying, catalyzing reactions, nondestructive testing), the medical industry that uses pulsed power to generate X-rays, MRI, and particle beams, and the Services in developing advanced weapon systems. The high power microwave sources would benefit those companies using high power microwave communication systems, developing UWB sensors for locating underground objects and damage in structures, and utilizing industrial processes such as drying materials or catalyzing chemical reactions, as well as various law enforcement and medical applications. The antenna technology would benefit those companies developing UWB communication systems and UWB sensors for locating underground objects and damage in structures and for medical applications, as well as various law enforcement applications.

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[1] J. Benford and J. Swegle, High Power Microwaves, Artech House, Boston (1992).
[2] L. Altgilbers, M. Brown, I. Grishnaev, B. Novac, S. Tkach, Y. Tkach, Magnetocumulative Generators, Springer-Verlag, New York (1999).
[3] S.I. Shkuratov, E.F. Talantsev, L.L. Hatfield, J.C. Dickens, and M. Kristiansen, Single-Shot, Repetitive and Life-Time High Voltage Testing of Capacitors, IEEE Transactions on Plasma Science, Special Issue on Pulsed Power Science and Technology, November 2002.
[4] S.I. Shkuratov, M. Kristiansen, J. Dickens, L.L. Hatfield, and E. Horrocks, High Current and High Voltage Pulsed Testing of Resistors, IEEE Transactions on Plasma Science, 28, No. 5 (2000) 1607-1614.
[5] C.D. Taylor and D.V. Giri, High Power Microwave Systems and Effects, Taylor and Francis, London (1994).
[6] J.D. Kraus, Antennas, McGraw Hill, New York (1950).

KEYWORDS: Pulsed Power, Marx generators, batteries, magnetohydrodynamics, piezoelectric generators, ferromagnetic generators, magnetocumulative generators, capacitors, inductors, ultra wideband, microwaves, antennas

MDA04-T010 TITLE: High rate and effective thermal energy storage system using phase change material for transient high power thermal management

TECHNOLOGY AREAS: Ground/Sea Vehicles, Materials/Processes, Weapons

ACQUISITION PROGRAM: BMDS-MDA/AS/SL

OBJECTIVE: The objective of this program is to develop a high rate and effective thermal energy storage system using phase change material for high power electronics and directed energy system thermal management application.

DESCRIPTION: High power density electronics and directed energy weapons, such as high power laser, operate at pulse mode, generating enormous heat during a short period of time, creating a significant challenge for thermal management. Thermal energy storage approach will average out the high heat flux, allowing more compact final heat rejection. Phase change material has a very large theoretical capacity to absorb and reject heat at near constant temperature without significant volume change, ideal for thermal energy storage. However without enhancement, PCM has very low thermal conductivity, typically 0.2-0.3 W/mK. There have been many efforts to enhance the thermal conductivity of PCMs to enable their use in thermal management systems. High thermal conductivity foam filled with the phase change material is one example. Thermal conductivity as high as 200 W/mK was reported. Without further interface area and thermal conductivity increases, high rate thermal transfer is not achievable for certain applications such as cooling of a laser slab. This program seeks novel approaches and technologies to enhance the heat transfer rate of phase change materials and their interface for heat absorption and rejection. The goal for this development program is a thermal management system capable of transferring a heat flux up to 100 W/cm^2 for 300 seconds, maintain a temperature variation within 25 degree C, and be scalable to larger power and area.

PHASE I: Develop a feasibility study of proposed innovation, including analysis, design, and experimental approach for demonstration of the concept of heat transfer rate and storage enhancement. The collection of preliminary test data to support the analysis is strongly encouraged.

PHASE II: Perform detailed analysis, design, fabrication, and testing of the proposed heat transfer enhancement of the thermal energy storage system demonstrator. Validate models for the design using data from appropriate diagnostics. Assess performance of the design in simulated or actual application environments.

PHASE III: Perform integration and packaging of the high rate thermal energy storage system into thermal management systems for civilian and military applications, such as electronics, satellite, laser, radar, and high power microwave cooling.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The high rate thermal energy storage material and packaging system could be applied in any high power or pulsed power thermal management systems. Commercial electronics, computers, and high power laser and radar manufacturing industries will benefit.

References: Shanmugasundaram, V., Brown, J. R. and Yerkes, K. L., “Thermal management of high heat flux sources using phase change material: a design optimization procedure”, AIAA paper 97-2451 presented at the 32nd thermophysics conference, June 23-25, 1997 in Atlanta.

D. L. Vrable, K. L. Yerkes, “A thermal management concept for more electric aircraft power system application”, SAE Aerospace Power Systems Conference Proceedings, P-332 in Williamsburg, Virginia, April 21-23,1998.

REFERENCES: D. L. Vrable, K. L. Yerkes, "A thermal management concept for more electric aircraft power system application", SAE 1998 TRANSACTIONS, Journal of Aerospace, Section 1, VOL 107, pp 181-187.

KEYWORDS: thermal management, phase change material, thermal energy storage, heat conductivity, heat transfer enhancement

MDA04-T011 TITLE: Innovations Leading to Greater Safety, Lower Cost, and Increased Availability in the Manufacture of Components for Missile Interceptors and Spacecraft Using Beryllium and Beryllium Alloys.

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Weapons

ACQUISITION PROGRAM: BMDS-MDA/GM

OBJECTIVE: Develop innovative processes and/or technologies that improve safety, lower cost, and increase availability of fabricated Be/Be alloy structures, optics, and/or electronics used in missile interceptors and spacecraft.

DESCRIPTION: Be/Be alloy's low atomic number, its ability to withstand extreme heat, its stability over a wide range of temperatures, and its exceptional thermal conductivity, make it the material of choice in many defense/aerospace applications. Health hazards associated with material handling, per unit cost, and availability must be balanced against the need for the exceptional properties of Be/Be alloys. Efforts are underway to find substitute materials that match the most critical Be/Be alloy properties; however, innovative solutions that enable technology developers to continue to utilize Be/Be alloys in critical applications while addressing health and safety concerns are equally desirable. Currently, OSHA regulations require a maximum 8-hour beryllium permissible exposure limit (PEL) of 2.0 micrograms per cubic meter. AT the writing of this topic, OSHA is preparing a ruling on the reduction of the beryllium PEL. Technical studies (Yoshida, et al) have indicated that beryllium sensitivity begins around 0.1 micrograms per cubic meter. Reductions of this magnitude may be the impetuous for several Be/Be Alloy product fabricators to exit the business due to current safety equipment limitations. Manufacturers of mirrors, structures, and electronics used in hit-to-kill missile interceptors and satellites would benefit greatly from innovations developed under this topic resulting in safer, less costly, and more readily available fabrication of Be/Be alloy based components.

PHASE I: Identify existing Be/Be Alloy fabrication process or technology that can be improved or supplanted through proposed innovation, thereby lowering Be exposure to the workforce. Based on analysis, describe improvements relative to existing process or technology with particular emphasis on safety, cost, benefits to the workforce, and availability. Develop plan to implement proposed innovation. Develop proof-of-concept demonstration.

PHASE II: Upon successful completion of Phase I, execute implementation plan develop in Phase I by building a working prototype. Additionally, create a test system to validate process improvement over existing state of the art. The prototype(s) and test system(s) shall meet or exceed industry standards. Both should be capable of being duplicated in small and large manufacturing environments.

PHASE III: Work with existing manufacturers (raw material suppliers and end product fabricators) to implement changes in small-scale operation with provision for expansion to production levels.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The use of beryllium, as an alloy, metal and oxide, in electronic and electrical components, and in aerospace and defense applications accounted for an estimated 80% of the total 2000 US consumption. Beryllium and beryllium alloys are used as base metal in battery contacts and electronic connectors in cell phones and base stations. Beryllium-Copper alloys are often the only material that meets the need for high reliability and miniaturization in these applications as well as being used as castings in the aerospace industry. FM radio, high-definition and cable television and underwater fiber optic cable systems also depend on beryllium. Beryllium metal is used principally in aerospace and defense applications, such as surveillance satellite and space vehicle structures, inertial guidance systems, military aircraft brakes and space optical system components. Military electronic targeting and infrared countermeasure systems use beryllium components, as do radar navigation systems. Beryllium is also a staple material in Apache helicopters, fighter aircraft and tanks, and aircraft landing gear components. In the US space shuttles, several structural parts and brake components use metallic beryllium. Beryllium oxide is an excellent heat conductor and acts as an electrical insulator in some applications. However, beryllium oxide serves mainly as a substrate for high-density electronic circuits for high-speed computers, and automotive ignition systems. The medical profession relies on beryllium for applications in pacemakers and lasers to analyze blood for HIV and other diseases and for X-ray windows since it is transparent to X-rays. The uses for Be/Be alloys span an enormous range of commercial as well as defense applications. Any improvements in safety, cost or availability would provide enormous benefit to the manufacturing workforce producing these items and the industries procuring them.

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105-111, 2002.
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6. Report on Carcinogens, Tenth Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, December 2002, http://ehp.niehs.nih.gov/
roc/tenth/profiles/s022bery.pdf
7. Yoshida, Tsutomu, et al., A study on the Beryllium Lymphocyte Transformation Test and the Beryllium Levels in the Working Place, National Institute of Industrial Health, 1997 Vol. 35, pgs 374-379, http://www.niih.go.jp/en/indu_hel/1997/1997_45.htm

KEYWORDS: Beryllium; Safety; Hazards; Toxicity; Manufacturing; Fabrication

MDA04-T012 TITLE: <u>Techniques For Radiation Hardening of EKV Through Incorporation of Shielding In Component Structures Fabricated From Be/Be Alloy Substitute Materials</u>

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Weapons

ACQUISITION PROGRAM: BMDS-MDA/GM

OBJECTIVE: Develop innovative component and system design concepts which utilize composite or polymer technologies to reduce or produce a net zero increase in mass of the GMD EKV configuration while providing a means to increase the radiation hardening level of the EKV. Replacement of Be/Be alloys with such material in strategic components throughout the EKV configuration is also a desired result.

DESCRIPTION: GMD EKV systems must function reliably when exposed to background radiation from space and radiation resulting from nuclear events (including x-ray, prompt and persistent gamma, single event effects, total ionizing dose, space radiation, etc.). Systems must also survive and function after prolonged periods in battlefield/storage environments (Shock, vibrations, thermal, etc). Current designs rely on Commercial-Off-the-Shelf (COTS) technology. Optimal utilization of mass in a lightweight EKV precludes exclusive reliance on traditional shielding methods as a means of countering the adverse effects of radiation. Current efforts to replace Be/Be alloys with alternate materials provide an opportunity to reduce or maintain a net zero impact in mass while incorporating shielding materials into component structures thereby increasing the radiation hardening of the EKV without the traditional corresponding mass penalty.

PHASE I: Conduct research and experimental efforts to demonstrate proof-of-principle of the proposed concepts. Determine feasibility of radiation hardening various Be/Be alloy substitute materials without sacrificing material performance characteristics. Consider implications for practical handling and fabrication of materials after radiation hardening.

PHASE II: Demonstrate feasibility of proposed concept/technology; identify and address technological hurdles. Finalize Phase I design and develop a prototype component utilizing radiation hardened Be/Be alloy substitute material. Demonstrate applicability to both selected military and commercial applications.

PHASE III: There may be opportunities for the advancement of this technology for use in both commercial and military space activities during phase III program. Partnership with traditional DOD prime-contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Primary beneficiary will be space based systems.

REFERENCES:
1. J.B.Hill, N.J.Redmond, W.B.Margopoulos, L.J.Gunther, J.Florian, C.E.Mallon, P.R.Mackin, and A. Andrews," Pulsed Gamma/Beta Noise effects on Interceptor System target selection" Heart Conference 1997.

2. Glastone, Samuel, The Effects of Nuclear Weapons, USAEC, USGPO, Washington D.C., 1957.

KEYWORDS: Transient radiation; mitigation; Proton; Neutron; single event effects; composites

MDA04-T013 TITLE: Innovative Approaches to Increase Power And Efficiency in Components Based on GaN or Other Materials Offering Performance Enhancements Exceeding that of GaAs Components in X-Band Radars.

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: BMDS-MDA/GM

OBJECTIVE: Develop lithography/circuit/item placement/design iterations leading to increased power and efficiency and/or decreased transmission line loss in high power components based on GaN or other materials offering performance enhancements exceeding that of GaAs based designs currently planned for use in strategic and theater class X-Band Radars.

DESCRIPTION: Most waste heat in a transceiver (Transmit/Receive or T/R) module is from the power output stage. GaN and SiC based technology represent the state of the art in T/R modules. The introduction of power output stages fabricated from GaN or other wide bandgap semiconductor materials will open a door of opportunity for implementation of lithography/circuit/item placement/design iterations leading to increased power and efficiency or decreased transmission line loss. Greater efficiencies would reduce the need for cooling hardware and lessen the burden on logistics. Since exact technical parameters for strategic and theater military X-Band Radar T/R Modules are classified, proof of principle demonstrations or models based on open source X-Band Radar parameters are expected. Provision should be made for scaling performance to higher power levels anticipated in strategic or theater military systems.

PHASE I: Develop and conduct proof-of-principle demonstrations of lithography/ circuit/ item placement/ design iterations that could increase power efficiency or decrease transmission line loss.

PHASE II: Update/develop technology based on Phase I results and demonstrate technology in a realistic environment.

PHASE III: Integrate technology into GMD system and demonstrate the total capability of the updated system. Partnership with traditional DOD prime-contractors will be pursued since the Government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR AND COMMERCIAL APPLICATIONS: The technology is applicable in high power circuit design, radar and communications.

REFERENCES:
1. "Gallium Nitride & Related Wide Bandgap Materials And Devices" DARPAtech 2000 briefing by Dr. Edgar J. Martinez,
http://www.darpa.mil/DARPATech2000/Presentations/mto_pdf/7MartinezGaNandRelatedWBGB&W.pdf
2. "Wide Bandgap Semiconductors for Utility Applications", Leon M. Tolbert, Burak Ozpineci, S. Kamrul Islam, and Madhu S. Chinthavali, University of Tennessee and Oak Ridge National Laboratory, 2003.
http://powerelec.ece.utk.edu/pubs/iasted_2003_wide_bandgap.pdf

KEYWORDS: Lithography; circuit design; component placement; transceiver module; transmit and receive modules, power, efficiency; X-Band Radar, amplifiers, XBR; UEWR

MDA04-T014 TITLE: Target Scene Resolution and Calibration

TECHNOLOGY AREAS: Information Systems, Sensors

ACQUISITION PROGRAM: BMDS-MDA/KI

OBJECTIVES: Develop or identify candidate digital image processing algorithms for determining the physical centroid of ballistic missiles hard body in the presence of their rocket plumes. This problem is widely known as the "Plume to Hard body Handover (PTHH)".

DESCRIPTION: To defeat an ICBM or IRBM during their boosting phase, the interceptor kill vehicle, on collision course with these missiles, will be exposed to a wide range of IR plume intensity. From this intense IR scene, the seeker is to resolve the IR scene and discriminate the missile hard body from the much larger, brighter, hotter and spatially & temporally variant plume.

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PHASE I: Develop or identify candidate PTHH algorithms. Test the algorithms against simulated target digital image sequences generated using plume radiance prediction codes such as CHARM and suitable hard body radiance-prediction codes. Simulated target and plume images should address the diversity of aspect angles, altitude and rocket motor fuel types. Prepare monthly report that documents the algorithms and analysis of their performance.
The successful bidder on this topic is encouraged to develop new algorithms.

PHASE II: Evaluate the PTHH algorithm with a test system that reads in recorded digital image sequences containing ballistic missiles and their rocket plumes, and compute the ballistic missile body centroid and preferred target aim point. The Near Field Infrared Experiment (NFIRE) is expected to collect high-resolution IR images of ballistic missiles during their boost phase at high altitude, and image sequences from this data collection experiment will be made available beginning April 2005. Analyze the NFIRE image sequences and test the candidate PTHH algorithms defined in Phase I. Use NFIRE data to generate tactically representative calibrated scenes for the evaluation of PTHH algorithms. Progress reports are due on bi-monthly basis to MDA/KI program office.

PHASE III: For military applications, it is expected that this technology can be applied to detection and tracking threat objects in the presence of background clutter. Potential commercial spin-offs of this technology would have applications in the medical industry to identify tumors and organ locations in Magnetic Resonance Imaging (MRI) and for security/police forces to identify potential evidence by recognizing objects and individuals in complex photographs or video images.

PRIVATE SECTOR COMMERCIAL POTENTIAL: For military applications, it is expected that this technology can be applied to detection and tracking threat objects in the presence of background clutter . Commercially, this technology would have applications in the medical industry to identify tumors and organ locations in Magnetic Resonance Imaging (MRI). It may also have applications in security/police forces to identify potential evidence objects and individuals in complex photographs or video images.

REFERENCES:
[1] A. J. Abrantes, J. S. Marques, Class of Constrained Clustering Algorithms for Object Boundary Extraction"IEEE Trans. Image Processing, Outubro 1996.
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KEYWORDS: Plume Phenomenology, Radiance Prediction Analysis, Calibrated Images with Plume & Hard body Models, Plume CodeS

MDA04-T015 TITLE: Multispectral Infrared Sensors

TECHNOLOGY AREAS: Information Systems, Sensors, Electronics

ACQUISITION PROGRAM: BMDS-MDA/KI

OBJECTIVE: Design a multi-spectral IR sensor readily integrateable with the existing cellular neural network (CNN) processor using standard integrated-circuit fabrication techniques. The imaging processing throughput should function at 10,000 frames per second.

DESCRIPTION: Most IR sensors are based on materials incompatible with standard silicon IC technology. The resulting separation of sensing and computing functions creates a bottleneck for image processing throughput. In addition, conventional high-resolution imaging array sensor technology does not readily allow detection of multiple IR wavelengths at each pixel. Lithographically-defined nanoantennas promise to satisfy these constraints, namely CMOS compatibility, multispectral sensing, small size, and high speed. Nanoantennas will be composed of lithographically-defined dipoles separated by metal-oxide-metal rectifiers.

PHASE I: Design and simulate multispectral nanoantenna arrays operating within SWIR-, MWIR- or LWIR-band.

PHASE II: Fabricate and test multispectral nanoantenna array. The multispectral nanoantenna array testing should verify operation speeds that allow an integrated system to function at 10,000 frames per second. Additionally, testing should verify the multispectral nanoantenna array interface with the CNN processor is operational.

PHASE III: Build a prototype of the integrated Multispectral nanoantenna array and CNN processor. Test the prototype system in a relevant environment.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Multispectral imaging and processing for remote earth sensing, bio-medical sensing and monitoring, biometric feature sensing and discrimination for Homeland Security, industrial quality control.

REFERENCES:
T. Roska and A. Rodriguez-Vasquez, Towards Visual Microprocessors, J. Wiley, Chichester, 2001.
L.O. Chua and T. Roska, Cellular Neural Networks and Visual Computing, Cambridge University Press, 2002.

KEYWORDS: Multispectral Imaging, Nanoscale Sensor, Cellular Neural Network, Lithographically-defined Nanoantennas.

MDA04-T016 TITLE: Laser Micromachining of Optical Structures and Surfaces

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: BMDS-MDA/MP

OBJECTIVE: MDA is seeking innovative laser-based microfabrication methods for the preparation of optical structures and surfaces. Emphasis is to be placed on fabrication techniques that are 1) cost-effective and innovative and 2) can readily be transferred from the R&D laboratory to manufacturing.

DESCRIPTION: MDA is seeking innovative manufacturing processes to fabricate both optical structures and optical surfaces. As the demand for smaller devices and structures continues to increase, laser fabrication techniques with micron and sub-micron resolution become an attractive manufacturing tool. Fabrication processes of devices with this feature size will require effective processing monitoring and control as well as quality verification through appropriate nondestructive evaluation (NDE) techniques. Optical surfaces prepared through laser machining, surface modification, or coating techniques are also of interest. Fabrication techniques can also include the application of materials uniquely appropriate to laser microfabrication.

Technical areas of interest include, but are not limited to:
- Fabrication of thermal imaging detectors
- Surface texturing and modification
- Sensor fabrication
- Laser machining of features smaller than 1 micron
- Machining of wide bandgap semiconductors
- Micromachining of nanocomposites
- Optical techniques for reduced feature size
- Non-destructive evaluation methods for micromachined features
- Control feedback techniques for laser micromachining
- Laser micro-welding of polymers and metals
- Laser based nanofabrication – nanomachining, nanojoining

PHASE I: Specify the proposed optical structure/surface and the expected performance. The Phase I effort should demonstrate the details of the fabrication process and provide information on the material as well as the effect of the fabrication operations. Phase I results should conclude with a detailed procedure of how the technology will be incorporated into a prototype manufacturing operation in Phase II. Appropriate process monitoring and control features should also be determined and their incorporation in Phase II specified. A preliminary estimate illustrating scalability as well as the cost-effectiveness of the process should also be presented. Additional consideration should also be given to commercial sector applications.

PHASE II: Phase II will emphasize the development of a prototype manufacturing system that is cost-effective and has application within both MDA and the commercial sector. The manufacturing system should include appropriate process monitoring and control for quality assurance. Emphasis should also be given to nondestructive evaluation techniques that can be used either in real time or in situ. Part of the Phase II effort should be the development of a method for developing a rugged manufacturing system in Phase III. The business case for the manufacturing system should be firmly established.

PHASE III: Successfully demonstrate the manufacturing process under actual manufacturing conditions. The demonstration would show near term application to one or more MDA element systems, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Proposals should show how the innovation can benefit both commercial and defense manufacturing methods. The benefits, which can include such factors as cost reduction, improved production methods, improved quality, or improved performance, should be clearly illustrated.

REFERENCES:
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KEYWORDS: laser micromachining, microfabrication, precision joining, nanomachining, surface texturing, process monitor and control, nondestructive evaluation

MDA04-T017 TITLE: <u>Innovative Manufacturing of Multijunction Solar Cells</u>

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

ACQUISITION PROGRAM: BMDS-MDA/MP

OBJECTIVE: Develop innovative multijunction solar cells with improved performance, cost and life.

DESCRIPTION: Solar arrays utilizing crystalline GaInP/GaAs/Ge solar cells with triple junction design are pervasive on DOD space platforms. Recently significant progress in performance of these cells has been made, resulting in 27.5 – 28% efficient commercially available multijunction solar cells. Small area prototypes of 30% efficiency have been demonstrated. However, to meet future DOD needs for higher power space systems, decreased specific power (W/kg), decreased cost ($/W), and decreased stowed volume for solar arrays, further increases in solar cell efficiency are needed, and thus, innovative manufacturing solutions for producing higher efficiency solar cells are sought. Solar cell designs should be capable of cell efficiencies of greater than 35-40%. Approaches include the use of new semiconducting materials and processes such as nitride materials, nanoparticles, and non-monolithically grown multijunction cells. Other approaches could include novel solar cell designs that ultimately lead to improvement in cost, specific power, and stowed volume. The eventual mass production of the proposed devices must be considered.

PHASE I: Develop innovative crystalline solar cells with improved performance and cost estimates for comparison with existing technologies. Through an electrical model of the solar cell, calculate the maximum efficiency possible with the solar cell design.

PHASE II: Demonstrate large area solar cells (>20 cm2) and assess the impacts on cost, specific power, and stowed volume. Products developed in Phase II must withstand preliminary space qualification tests to demonstrate reliable performance in space. Validate the feasibility of the solar array manufacturing by demonstrating, testing and integration of prototype items for MDA element systems, subsystems, or components. Validation would include, but not be limited to simulations, operation in test-beds, or operation in a demonstration sub-system. A partnership with the current or potential supplier of MDA element systems, subsystems or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

PHASE III: Address production issues with solar cell design and demonstrate manufacturing process for solar cell design. Successfully demonstrate new solar cell arrays. Demonstration would include, but not be limited to, demonstration in a real system or operation in a system level test-bed. This demonstration should show near term application to one or more MDA element systems, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Cost-effective multijunction solar cells with improved performance will enable more capable systems with diverse applications in various commercial spacecraft systems. This will have significant impact on both terrestrial and space applications within the consumer, commercial, and government marketplace. The projected benefits of the innovation to commercial applications should be clear, whether they reduce cost, improve producibility, or performance or products that utilize the innovation process technology.

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KEYWORDS: Multijunction solar cell; photovoltaics; Nitrides; Nanoparticles; specific power; stowed volume; power generation

MDA04-T018 TITLE: Wide Bandgap Material and Device Development

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: BMDS-MDA/MP

OBJECTIVE: Develop wide bandgap [silicon carbide (SiC) and gallium nitride (GaN)] semiconductor devices for efficient, reliable, high power electrical generation, control, conversion, and distribution systems for ballistic missile defense ground, airborne and space applications.

DESCRIPTION: Materials [e.g., silicon and gallium arsenide (GaAs)] currently used for the high power amplifier components of T/R modules cannot provide the power, efficiency, or thermal performance needed for predicted future BMD radar capabilities. New high power device technologies utilizing wide bandgap materials such as silicon carbide (SiC) and gallium nitride (GaN) are capable of operation at significantly higher power and hence higher temperature. Wide bandgap material devices are also more efficient than those fabricated with materials such as silicon and GaAs. Implementation of wide bandgap materials/devices in BMD radars may allow for the use of less modules for the same power resulting in significant radar size and cost reductions (and extended module life). Implementation of these devices will allow for significantly higher BMD radar performance and durability while demanding less power, weight, and space. MDA is concerned with WBG device performance, reliability, producibility, schedule, and cost.

PHASE I: Develop high purity, semi-insulating SiC, 4H and 6H polytype, and GaN bulk substrates. Focus is on 3 and 4 inch diameter wafer size with minimal defects; impurities; high resistivity; wafer flatness; minimum total thickness variation across the wafer; and maximum usable surface area; and maximum boule length per run.

PHASE II: Develop wafer slicing and surface preparation/polishing techniques that are quick, efficient, low cost, and minimizes subsurface damage. Development of quick, superior quality epitaxy techniques for SiC and GaN on homo- and heterogeneous substrates. Development of static induction transistors, MESFETs, PHEMPT circuits and MMIC-like devices on these wafers.

PHASE III: Conduct reliability testing of discrete and packaged devices to include short-term performance verification testing; accelerated life-testing; and non-accelerated life testing (1,000-3,000 hour long tests).

PRIVATE SECTOR COMMERCIAL POTENTIAL: These wide bandgap devices can be used in a variety of commercial applications such as: the telecommunications/wireless communications industry; cell phones/cellular base stations; and commercial airport radar systems; and optoelectronics applications such as light emitting diodes/solid state lighting (from traffic lights to automobile dashboard and exterior lights), commercial signs (such as stadium scoreboards), high definition television broadcasts, and commercial power semiconductors for hybrid electric vehicles.

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KEYWORDS: Wide Bandgap, Silicon Carbide, Gallium Nitride, Epitaxy, High Power

MDA04-T019 TITLE: Radiation Hardened Silicon Carbide Devices and Circuits

TECHNOLOGY AREAS: Materials/Processes, Electronics

ACQUISITION PROGRAM: BMDS-MDA/MP

OBJECTIVE: Develop wide bandgap [primarily Silicon Carbide (SiC)] power semiconductor devices and circuitry for very efficient, high temperature and high power electrical generation, control, conversion, and distribution systems for missile defense, ground, airborne and space applications where size, weight and radiation hardness are driving characteristics.

DESCRIPTION: Wide bandgap power devices from materials such as SiC are inherently more radiation tolerant than Silicon but have not been developed expressly for that purpose. The need exists to determine the extent of hardness of these devices and to determine which device configurations are best suited for the various radiation environments. We propose a program that would provide devices, circuits, and the scientific radiation hardness data necessary for harsh environment system development. In addition, after the various devices have been tested, and best configurations determined, programs would be launched to develop power conversion and control circuitry using these devices in missile defense and space systems that operate in a harsh radiation environment.

PHASE I: Develop wide bandgap device configurations, circuits or modify recently developed configurations of this new semiconductor technology specific to functioning in a high temperature, radiation environment.

PHASE II: Develop and test the devices or circuits in radiation environments that will underline their high temperature and radiation hardened capabilities for operation in space oriented defense systems.

PHASE III: Advance power conversion and control technology, by incorporating these devices in actuation, power generation, control and distribution systems for missile defense applications and space vehicles.

PRIVATE SECTOR COMMERCIAL POTENTIAL: These devices and circuits would be applied to any ground based or airborne harsh environment system involving radiation such as nuclear power generation, radiation monitoring and safety sensors, space vehicles, and satellite communications.

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KEYWORDS: Radiation Hardened, Silicon Carbide, High Temperature, Power

MDA04-T020 TITLE: <u>Multi-Spectral Infrared Spatial Light Modulators (SLM)</u>

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace, Weapons

ACQUISITION PROGRAM: BMDS-MDA/SE

OBJECTIVE: Identify, develop, and demonstrate spatial light modulators (SLMs)/agile filters in 1.8-2.5 um near Infrared (NIR), 3-5.5 um middle Infrared (MIR), and 8-14 um long wave infrared (LWIR) bands for scanning, laser protection, and IR Scene Projection. The proposed development effort should address modulation efficiency, dynamic range, resolution, spectrum coverage, light loss, response time, package size, environment stability, and cost.

DESCRIPTION: There are several existing SLM technologies. Conventional liquid crystal (LC) SLMs rely on local phase modulation of the liquid crystal pixels under polarized illumination. "Gray-level" is achieved by altering the voltage at each pixel. Transmissive SLM has problems in large pixels, small "fill-factor", and not very flat surface. Liquid crystal on silicon (LCOS) is an emerging technology for SLM. It employs the same idea as the transmissive SLM, but operates in reflective mode with control voltages supplied from the silicon backplane that is essentially a "memory chip" with reflective mirrors. LCOS devices are small, light-weight, robust, and have very high resolution. Although, LCOS is easy to make on silicon backplane, it has difficulty for a completely flat surface. When these LC SLMs are used in middle and long wave infrared regions, their light efficiency is lower than 50% and contrast is poor due to the wired grid polarizers that cut 50% of the incident light and have a low extinction ratio. Another liquid crystal approach 1 utilizes light scattering mechanism from a nematic liquid crystal, which

eliminates the use of IR polarizers. This SLM is simpler and more compact in size. The disadvantage is the poor modulation depth and slow response speed in excess of several hundred milliseconds. Finally, in all LC SLMs, light absorption by liquid crystal medium becomes a serious problem particularly in the middle and long wave IR regions. This light absorption is reduced significantly by a recently reported post-deuterated liquid crystal technology. 2
SLMs have also been developed from micro-electric machine system (MEMs) analog switching mirror arrays. However, due to the light diffraction at long wavelength the pixel density of the micromirror arrays is limited. Due to its low contrast (in the range around 100:1), MEMs SLMs have to use separate laser intensity modulator or has to linearize the laser source with direct current modulators. Finally, flatness on the mirror surface and scattering from the mirror elements imposes another hurdle limiting micromirror arrays for using under coherent light.
Recently, modulators have been developed 3,4 in the 8-14 µm region from a germanium medium to generate moderate levels of excess carriers for light absorption excited by a diode laser source based on the intervalence band transitions between the light-hole and heavy-hole band. Optical excitation power densities in the order of W/cm2 are required, which impose significant hurdles in real military applications.

The next generation of IR SLMs for use in missile defense systems should be electrically addressable with large pixel numbers (no less than 512 by 512), more than 12-14 bits optical modulation dynamic range (10,000:1), and millisecond response time in a compact and rigid package. Preferred technology is liquid crystal based SLM because it is rooted on the mature liquid crystal display (LCD) technology and fabrication process. The development of the IR SLMs is critical to the on-going missile interception programs in DoD. This effort seeks novel concept for the IR SLM device development meeting the desired performance goal. Significant technical challenges include reducing light loss, increasing modulation dynamic range, obtaining SLM uniformity, and shortening the response time. The output from this program would be fully functional SLMs in the three IR regions.

PHASE I: Develop concepts for the IR SLMs that can be used to modulate and scan IR laser or imaging beam in the NIR, MIR and LWIR bands. Conduct feasibility demonstrations to show that the SLMs can be successfully developed. Specifically address the issues of absorption loss, optical modulation dynamic range, response time, size, rigidness, and cost. Identify critical features relating to device design and operation performance. The proposed development effort should address modulation efficiency, dynamic range, resolution, spectrum coverage, light loss, response time, low voltage operation, package size, environment stability, and cost.

PHASE II: Develop and fully characterize the prototype SLM materials and devices. The prototypes shall be compatible with requirements of missile defense systems, in terms of optical modulation dynamic range and response time. Address a scalable fabrication process and device final cost.

PHASE III: Successful completion of Phase II will result in a fully functional demonstration optical SLM device that can be transitioned into system applications for missile interception.

PRIVATE SECTOR COMMERCIAL POTENTIAL: High performance IR SLMs would enhance the photonics instrument performance such as IR spectrometer, IR LADAR, IR CCD for night vision, and IR laser sources which could promote significant applications outside military scope in communication, night vision, weather science, material science, metrology, industrial process monitoring, and surveillance.

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KEYWORDS: spatial light modulator; motionless, multispectrum; IRFPA; long wave infrared (LWIR); sensor; laser, low-loss liquid crystal.

MDA04-T021 TITLE: Innovative Thermal Insulation Technologies

TECHNOLOGY AREAS: Materials/Processes, Weapons

ACQUISITION PROGRAM: BMDS-MDA/SS/SL

OBJECTIVE: Develop an innovative robust thermal insulation blanket to insulate cryogenic temperature-sensitive space systems and components

DESCRIPTION: Significant investments are made each year in the continued development of increasingly robust and sophisticated heating/cooling technologies for major defense acquisition programs. However, the effectiveness of thermal management systems are often directly related to the performance of insulating blankets utilized in their design. Accordingly, the commercial availability of passive thermal super-insulation materials is an essential step toward meeting MDA/DoD goals for cryogenic thermal management on space or missile defense systems. Sensitive cryogenic structures and their subsystems need to be protected from direct solar heating, earth's albedo, and internal heating, due to internal component radiation - Such systems need to operate in the hard-to-maintain cryogenic temperature region. For instance, the Space Tracking and Surveillance System (STSS) and Space-based Laser (SBL), scheduled for deployments in the 2012 time-frame and beyond, has requirements to protect sensitive optical components as well as other structural components and fluid storage tanks from excess heating due to exposure to the Sun and the Earth's albedo. Current insulation blankets are totally dominated by Multi Layer Insulation (MLI), which fall far short from being ideal due to being extremely labor intensive, ineffective at corners and sharp edges and when resealed, in addition to on-orbit durability issues. A robust capable thermal blanket, without MLI's shortcomings, has to be developed. Robust lightweight thermal insulation blankets will enable the STSS optical track telescope (optimal operations ~ 65* Kelvin) and the SBL, to minimize power consumption while maintaining critical temperature control of key components without exceeding launch vehicle lift capabilities. All proposing entities are encouraged to develop a working relationship with system integrators and supporting government offices for future demonstration efforts. A strategy to incorporate selected technologies in the STSS and SBIRS-High system is highly encouraged.

PHASE I: Evaluate/develop conceptual designs or techniques that provide significant thermal protection system improvements compared to current state-of-the-practice techniques. As part of Phase I, a program plan for risk mitigation strategies is required. A well-defined Phase II development and a demonstration plan need to be developed. A proof of concept subscale hardware demonstration is encouraged.

PHASE II: Demonstrate the feasibility of technology identified in Phase I. Tasks shall include, but not limited to, a detailed demonstration of key technical parameters, which can be accomplished at a subscale level, although a full-scale demonstration is encouraged if feasible. A detailed performance analysis of the technology is also required.

PHASE III: Apply the thermal insulation technology that is developed from this effort to DoD systems such as for TPS systems for STSS, SBL, spacecrafts, aircraft, and Reusable Launch Vehicles.

PRIVATE SECTOR COMMERCIAL POTENTIAL: There are numerous and far-ranging possibilities of commercial applications for an ultra-lightweight, durable, and reliable thermal super insulation system such as for commercial aircrafts, launch vehicles, or protective clothing.

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KEYWORDS: Thermal Control; Thermal Insulation; Light-Weight, Shock Resistance, Vibration Resistance, and G Tolerance Thermal Management System

MDA04-T022 TITLE: Strategic Monitoring of Spacecraft Mechanical Parts Assemblies

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: BMDS-MDA/SS/SL

OBJECTIVE: To develop the essential strategic monitoring technologies and techniques to monitor the health of spacecraft moving parts (i.e. bearings, gimbals) over a 15-20 year service life.

DESCRIPTION: Inadequate lubrication is the primary cause of problems and premature failure in spacecraft moving part systems. Lack of proper lubrication results in the inability to position properly and/or to stabilize the satellite in orbit, while adversely affecting the sensitive instrumentation of the satellite. In extreme/catastrophic failures the satellite can be rendered useless. Thus, a real-time strategy and assessment of the performance of moving parts, mechanical systems, and the accompanying lubricants, on a spacecraft/satellite is essential. This includes, but is not limited to the following systems: bearings, controlled momentum gyros, gimbals, flywheels, MEMS devices, and louvers for spacecraft thermal control. Repairing actual problems/failures that occur on a spacecraft is almost impossible due to the great distances that these assets orbit the earth at, and the large expenses associated with sending up an astronaut in space to accomplish a repair task. Also, as future satellites need to be lighter weight, previous practices of carrying entire backup/spare moving part systems into orbit, in the event of failure, will not be feasible. Thus, method(s) of being able to anticipate moving part/mechanical system failures before they occur, combined with the capability of proactively performing the necessary corrective action(s) to these systems is imperative. As future spacecraft / satellites will have in-service lifetimes of 15-20 yrs (from the current 5-7 yrs), it is even more important that any/all difficulties be identified and mitigated prior to failure.

PHASE I: Demonstrate the feasibility of a strategic space vehicle health monitoring system that will identify potential and/or imminent lubrication problems, analyze these parameters in real time, and provide direct input so that these problem are mitigated prior to failure (i.e. application of additionally required lubrication). Identify specific strategies and parameter(s) (i.e. torque, temperature, vibration sensing, etc) within a spacecraft mechanical system that would monitor the health of that system. Areas of interest would include: bearings, controlled momentum gyros, gimbals, flywheels, MEMS devices, and louvers for spacecraft thermal control. Mechanism(s)/model(s) for how this occurs will also be part of this task. Preliminary laboratory test results should be used to demonstrate the proof-of-concept for the proposed moving part(s) failure mechanism(s). The feasibility of potential in-service corrective actions to provide adequate in-service lubrication applications (both when to apply and the amount of lubrication necessary to alleviate the problem(s)) prior to failure should be demonstrated.

PHASE II: Further develop and test the proposed system defined in the Phase I effort for spacecraft mechanical parts health monitoring and mitigating actions. These tests should also include simulated space flight experimental testing. A thorough understanding of the failure mechanisms of the moving parts will emerge by the end of the Phase II effort, as well as the methodology to prevent catastrophic failure while in orbit. Space flight experimental opportunities will be identified to perform actual in-service space flight tests of mechanical systems for vehicular health monitoring as well as in-service corrective actions.

PHASE III: The proposed system would have application in many DoD space systems, including space platforms and military strategic satellites, and will be essential in maintaining proper and required working order of all mechanical moving part assemblies (i.e. bearings, gimbals) on all military space assets.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This system can be applied in any space satellite / vehicle in the commercial sector.

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KEYWORDS: spacecraft health monitoring, spacecraft moving parts, mechanical assemblies, space lubricants, failure mechanisms, space vehicle health monitoring

MDA04-T023 TITLE: Low-cost, multi-spectral frequency augmenter for exo-atmospheric ballistic missile targets

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: BMDS-MDA/TC

OBJECTIVE: Develop effective, low-cost materials or methods to actively manipulate spectral emissions at optical, infrared (IR) and radar frequencies of interest.

DESCRIPTION: Develop innovative material or coating technologies, such as MEMS, that permit MDA to easily and actively augment the spectral emissions of target bodies. The material solution must be able to vary the desired effect by command and/or pre-programmed methods, should be lightweight, and not interfere with other systems found in missile-related targets.

PHASE I: Evaluate material technologies that are capable of altering IR and radar emissions and assess suitability for the intended application.

PHASE II: Prototype and test the system for IR and radar performance against a variety of effects to determine performance and reflex time.

PHASE III: Produce a limited scale system that achieves sufficient IR and visual performance.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This system could be applied to numerous commercial and civil law enforcement activities; active matrix coatings for advertisement applications, emergency egress lighting systems such as fire doors; anti-collision IR and optical coatings for civil applications.

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KEYWORDS: Materials, Composite, Missile, Structure

MDA04-T024 TITLE: High-Strength Carbide-Based Materials for Solid Rocket Nozzles

TECHNOLOGY AREAS: Materials/Processes, Space Platforms

ACQUISITION PROGRAM: BMDS-MDA/TH/MP/SL

OBJECTIVE: Produce tantalum or hafnium carbide-based materials (monolithic, laminate, graded, or composite structures) for low-erosion rocket nozzle throats used in either high- or low-aluminized propellants.

DESCRIPTION: Missile defense systems have requirements for solid rockets that operate at much faster speeds and with bigger payloads than current systems. In order to meet this mission erosion resistant ceramic and ceramic matrix composite nozzles will be required to constrain propellants that operate at temperatures above 6000°F and at pressures greater than 2000psi. There are only a few ceramic materials (TaC, HfC, and HfN) that have a potential to survive these high temperatures and eroding environments. Solid rocket nozzle models suggest that a brittle material could possibly survive these extreme thermal shock conditions if the material had an axial tensile failure strain over 0.5% through the temperature range 0 to 4000°F. For monolithic materials this translates into room temperature strengths in excess of 200 ksi.

At least three material approaches have been identified that may result in components that can handle this level of fracture strain and associated fracture strength. The first approach would be to produce a dense material where the critical defect size scales with the grain size. Then, sub-micron grain sized material should possess sufficient tensile strength and strain capabilities to make it through a motor firing. However, producing dense sub-micron grain sized material is difficult but may be possible by either rapid sintering of two phased, nano-sized powders or multiple re-nucleations in a chemical vapor deposition (CVD) process. The second approach would be to produce laminated or graded structures having a dense carbide at the hot gas-phase interface, which grades to either a ductile metallic or a reinforced carbon foam at the cooler load-transfer surface. A third approach might be to fabricate a fiber-reinforced TaC or HfC composite. Here the interior surface of the nozzle would have be fully dense carbide material capable of protecting the fibers and their interface coating. In this ceramic matrix composite cases, the coefficient of thermal expansion (CTE) mismatch between the selected carbide and the fibers will have to be closely matched to prevent fiber or matrix cracking during processing. New processes, not realized by the author, may also be capable of producing material with these high fracture strain and stress values. However in all cases the proposer needs to present rational arguments as to why they feel their process will result in the desired material properties and performance.

Contamination control in all of the processing is a major concern for these types of materials. Low melting point impurities tend to segregate to the grain boundaries and result in poor high temperature strength and creep resistance. Extreme care must be taken to minimize impurity level or materials that have low creep resistance.

PHASE I: Offerers should provide in the proposal clear evidence and/or technically sound descriptions of their processes that illustrate why it will lead to a high tensile fracture stress and strain material at both room and elevated temperatures. They should also make some estimates of the time and cost of producing two-inch nozzle throats. In the Phase I effort, the offerers will be required to produce material and conduct at least ten tensile tests and ten bend test (five at room temperature and five at temperatures above on 3000°F). Material characterization should include at least phase identification, standard fractography, density and density gradient determination. Deliverables will include untested tensile sample and all of the tested samples.

PHASE II: Phase II will focus on the manufacturability, testing and scale-up of the process. Repeatability and reliability issues need to be addressed through process analysis, process control studies, and nondestructive evaluation (NDE). Plates, cylinders, and small nozzles throats will be produced so that a full regimen of mechanical test data and small nozzle test bed firings can be generated in order to feed data into existing performance models developed under the Integrated High-Performance Rocket Propulsion Technology (IHPRPT) Phase III Solid Rocket Motor program. Offerers are encouraged to team with a major material testing house and a major rocket manufacturer to conduct mechanical testing, performance simulation, and instrumented nozzle throat test firings using IHPRPT Phase III-type propellants. Deliverable items will be the data, simulations, interim and final reports, test samples, and a representative 2-inch diameter nozzle throat.

PHASE III: The Phase III effort will focus on the scaling up of the nozzle size from 2-inch throats to at least a 5-inch diameter nozzle throats. Again manufacturability and reliability will be a major issue. The nozzle throat geometries should be selected to retrofit into existing commercial and military rocket designs. Several instrumented land-based test firings should be conducted to qualify the final nozzle designs.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Private-sector applications of ceramic rocket nozzles include boost capabilities for space-based systems such as the space shuttle solid rocket motors and telecommunication satellites.

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KEYWORDS: Solid rocket nozzle throats, ceramic, and zero erosion.