AIR FORCE
PROPOSAL PREPARATION INSTRUCTIONS

The responsibility for the implementation and management of the Air Force STTR Program is with the Air Force Research Lab, Wright-Patterson Air Force Base, Ohio. The Air Force STTR Program Manager is Steve Guilfoos, (800)222-0336. All Phase I and Phase II STTR proposals **MUST** be submitted to the following administrative organization.

Air Force Office of Scientific Research AFOSR/NI
4040 N. Fairfax Dr., Ste 500
Arlington, VA 22203-1613
Attn: Dr. Victoria Franques
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The Pre-Solicitation Announcement (PSA), listing the full descriptions of the topics and the author of each, is issued electronically after being announced in the Commerce Business Daily. Contact AFOSR directly for information on future PSAs. Open discussions concerning technical questions pertaining to the topics can be held with topic authors (as listed in the PSA) until the solicitation formally opens. Once the solicitation opens the only way to ask pertinent technical questions about a topic with the topic author is through the DTIC SBIR Interactive Technical Information System (SITIS). For a full description of this system and the other technical information assistance available from DTIC, please refer to Section 1.5c of this solicitation.

Unless otherwise stated in the topic, Phase I will show the concept feasibility and Phase II will produce a prototype or at least show a proof-of-principle.

Phase I period of performance is typically 1 year not to exceed $100,000.

Phase II period of performance is typically 2 years not to exceed $500,000. The solicitation closing dates and times are firm.

Air Force Fast Track

Detailed instructions on the Air Force Fast Track and Phase II proposals will be given out by the awarding Air Force directorate along with the Phase I contracts. The Air Force encourages businesses to consider Fast Track application when they can attract outside funding and the technology is mature enough to be ready for application following successful completion of the Phase II contract. Further information on the STTR Fast Track can be found in Section 4.5 of this solicitation.

Commercial Potential Evidence

An offeror needs to document their Phase I or II proposal's commercial potential as follows: 1) the small business concern's record of commercializing STTR or other research, particularly as reflected in its Company Commercialization Report (www.DoDsbir.net/companycommercialization; 2) the existence of second phase funding commitments from private sector or non-SBIR funding sources; 3) the existence of third phase follow-on commitments for the subject of the research and 4) the presence of other indicators of commercial potential of the idea, including the small business' commercialization strategy.

Submission of Final Reports

All final reports will be submitted to the sponsoring agency. Companies **will not** submit final reports directly to DTIC.

Proposal Submission Instructions

Your proposal will be ACCEPTED if you meet all of the following criteria. Failure to meet any one of the criteria will result in your proposal being REJECTED.

1. You must use the electronic format described in the Electronic Submission described below. The Air Force will not accept any proposals that do not have electronic forms of the Proposal Cover Sheet (formerly," Appendix A and B "). The electronic forms submitted must match the paper copies submitted via mail/express delivery.

2. A copy of the Company Commercialization Report (formerly Appendix E) with summary page must be submitted with all proposals (See Section 3.4n of the solicitation). Even if you have no Phase I or Phase II information to report, you must submit a Company Commercialization Report. Your proposal will not be penalized in the evaluation process if your company never had any STTR Phase I's or II's in the past. Both the electronic submission of the Proposal Cover Sheet and the paper copies of your proposal must be received on or before the solicitation deadline unless it was sent by U.S. Postal Service Express Mail Next Day Service-Post Office to Addressee, not later than 5:00 p.m. at the place of mailing two working days prior to the date specified for receipt of proposals. The term "working days" excludes weekends and U.S. Federal holidays. The Air Force will not accept late proposals, or incomplete proposals. If you have any questions or problems with submission of your proposal allow yourself enough time to contact the Air Force and get an answer to your question. Submit the Electronic Proposal Cover Sheet and Company Commercialization Report early, as computer traffic increases, computer speed slows down. **Do not wait until the last minute**. The Air Force will not be responsible for late proposals caused by computer systems or servers being " down " or inaccessible. The Air Force will not be held responsible for late delivery of proposals, be advised that an Overnight delivery may not reach the appropriate desk within one day.

Electronic Submission of Proposal Cover Sheet and Commercialization Report

Submit your Proposal Cover Sheet (formerly Appendix A and B) and the Company Commercialization Report (formerly Appendix E) to the Air Force using the DoD online submission at http://www.dodsbir.net/submission and as discussed in section 3.4b and 3.4n of this solicitation. This site allows your company to come in any time (prior to the closing of the solicitation) to edit or print out your appendices. The Air Force will not accept any forms from past solicitation books or any electronic download version except those from the DoD SBIR Website as valid proposal submission forms. Detailed instructions can be found by selecting the Help button on this site once you have registered. If you have any questions or problems with the electronic submission contact the DoD SBIR Helpdesk at 1-800-382-4634. Once you have prepared, printed, and signed the Proposal Cover Sheet, mail it along with one original and three copies of your entire proposal (the copies should include three copies of the signed Proposal Cover Sheets) to the Air Force Office of Scientific Research (AFOSR).

PROPOSAL SUBMISSION INSTRUCTIONS

For administrative questions or questions about mailing proposals, contact Victoria Franques at (703) 696-7313. For contract questions, call Richard Pihl at (703)696-9728.

Mail proposals to:
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FY01 AIR FORCE STTR TOPICS

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH, ARLINGTON VA

AF01T002 Terahertz Quantum Well Emitters and Detectors

AF01T003 Crested Quantum Tunneling Barriers for Advanced Data Storage Systems

AF01T004 Micromachined Deformable Mirrors for Beam Control and Imaging Applications

AF01T005 Reactants and Combustion Processes for Neutralization of Chemical and Biological Agents

AF01T006 High Stiffness Passive Damping Concepts Using Materials or Innovative Mechanisms

AF01T007 Development of Advanced Crystalline Garnet Materials and Fibers

AF01T008 High Temperature, High Bandwidth, Pressure Transducer

AF01T009 High Frequency Electromagnetic Propagation / Scattering Codes

AF01T010 Machine Learning for Record Linkage

AF01T011 Closed-Loop Flow Control for External Aerodynamics

AF01T012 Advanced Hearing Protection

AF01T013 Polymer Based Photovoltaic for Space Applications

AF01T014 Biomimetic Inspired Fibers, Materials, and Properties

AF01T015 Affordable Airframe Life Extension: Designer Corrosion Suppression Technologies

AF01T018 Develop Turnable Adhesive Coatings (Release on Command) for Corrosion Prevention in Aging Aircraft

AF01T002 TITLE: Terahertz Quantum Well Emitters and Detectors

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Development of solid state terahertz quantum device structures for operation in the range between 0.3 Thz to 10 Thz that are suitable for coherent sources and detectors for use in space-based and short range terrestial communications, atmospheric sensing, and near object analysis.

DESCRIPTION: The terahertz frequency range (0.3 – 10 THz) is one of the last frontiers in the electromagnetic spectrum. The lower microwave and millimeter wave frequency regions have been and continue to be exploited for numerous wireless communication and radar applications, whereas the optical and infrared frequencies are being used for high bandwidth data transmission and some niche applications, including night vision. However, terahertz applications have been slow to develop, mainly due to the lack of miniature, reliable sources, detectors and related passive components. The region offers the potential for a number of applications including space-based and short-range terrestrial or near earth communications, atmospheric sensing, collision avoidance for aircraft and ground vehicles, and near object observation and spectroscopy. To realize this potential the appropriate sources and detectors need to be developed.Innovative approaches are needed leading to the development, fabrication, and operation of coherent quantum well terahertz sources. Desired are approaches in quantum wells and tunneling devices, as well as other novel quantum structure approaches. The goals of this effort are devices and device concepts that will deliver coherent radiation at potentially milliwatt power level, ultimately coupled efficiently in THz circuits, guided wave structures and antennas. Work is needed in detectors to greatly improve the sensitivity, speed, and bandwidth. Specifically desired are efforts in semiconductor-based quantum well structures and the subsequent development of a useable detector that is narrow band, widely tunable, and yet highly sensitive. Approaches toward compact system modules addressing both generation and detection are also of interest.

PHASE I: Clearly demonstrate the feasibility of the proposed approach. Define the quantum well device that will deliver up to milliwatts of coherent radiation at specified frequencies in the THz regime, and/or define the quantum well detector or detector structure detailing optimal geometry, bandwidth limitations, tunability, and current-carrying capacity. The definition of the device/ system-module needs to include principal of operation, material, processing, associated circuit or guided wave structure, and regime of operation.

PHASE II: Build upon Phase 1 work and demonstration of system components and implementation of a prototype. Perform appropriate analysis and modeling, grow the material or structure, fabricate the device and test its performance.

PHASE III DUAL USE APPLICATIONS: Terahertz photonics have selected potential applications. Covert communication on the battlefield or in space, chemical agent detection, atmospheric environment sensing, near object detection, material imaging will benefit from new technology in this part of the electromagnetic spectrum.

REFERENCES:
1. "Photon-assisted tunneling in a resonant tunneling diode: Stimulated emission and absorption in the THz range," Hermann Drexler, Jeff Scott, S.J.Allen Jr, K.L. Campman and A.C. Gossard; Applied Physics Letters, Volume 67, 4102 (1995)
2. "Inverse Bloch Oscillator: Strong Terahertz-Photocurrent Resonances at the Bloch Frequency"; K. Unterrainer, B.J. Keay, M.C. Wanke, S.J. Allen, D. Leonard, G. Medeiros-Ribeiro, U. Bhattacharya, and M.J.W. Rodwell; Physical Review Letters, Vol. 76, 2973-6 (1996).
3. "Transition from classical to quantum response in semiconductor superlattices at THz frequencies" , S. Zeuner, B.J. Keay, S.J. Allen, K.D. Maranowski and A.C. Gossard, U. Bhattacharya and M.J.W. Rodwell; Physical Review-B Rapid Communications, B53, R1717 (1996).
4. Terahertz links on the web: http://www.bell-labs.com/user/igal/thzlinks.htm 5. C. Waschke, H. G. Roskos, R. Schwedler, K. Leo, H. Kurz, and K. Koehler, Phys. Rev. Lett. 70, 3319 (1993).

KEYWORDS: Terahertz devices, terahertz emitters, terahertz detectors, terahertz sources, submilimeter, spaced-based communications, atmosheric sensing, quantum well, quantum device imaging

AF01T003 TITLE: Crested Quantum Tunneling Barriers for Advanced Data Storage Systems

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Establish the basis for advanced digital memory and data storage systems with density beyond 1 terabit/cm2 and sub-10-ns read/write/erase time.

DESCRIPTION: Ultradense storage of large blocks of digital data, with the possibility of their fast, byte-addressable retrieval is a pivotal issue as the Air Force defines its future C4I war-fighting role. Battlefield management, especially if supplemented by simulation, also will require enormous data storage that is accessible by computers in real time, ideally in a few nanoseconds. Currently, hardware for ultra-dense, fast memory storage does not exist. Moreover, the rapid progress toward such systems by the electronics industry is slowing. In particular, dynamic random access memories are inherently non-scalable, and their density will very likely saturate at the level of several Gb/cm2 [1]. On the other hand, non-volatile, floating-gate memories are scalable, but their application in most systems is limited by long write/erase times, typically above 1 microsecond [2]. Finally, mainstream magnetic data storage systems are rapidly approaching an apparent fundamental density limit, somewhere in the low 100s of Mb/cm2. Proposed “crested” multilayer tunnel barriers [3] provide a remarkable opportunity to overcome the density-to-speed trade-offs of current data storage technologies. These barriers may permit the combination of an acceptable electric-charge retention time (beyond 10 years) with a sub-10-ns recharging time, and thus enable scalable and fast non-volatile memories (NOVORAM) [4] and electrostatic data storage systems (ESTOR) [3] with potential density well beyond 1 Tb/cm2. In the future, crested barriers also may make ultra-dense, terabit-scale single-electron memories possible [5]. However, implementation of crested barriers requires fabrication of high-quality multi-layers of wide-bandgap semiconductors (e.g., AlxGa1-xN) which have not yet been demonstrated, since it requires advanced film deposition techniques (e.g., MOCVD, etc.).

PHASE I: Develop the technology for deposition of 10-nm-scale crested tunnel barriers based on wide-bandgap semiconductors or other suitable materials. Demonstrate the effect of acceleration on Fowler-Nordheim tunneling due to barrier shaping.

PHASE II: Fabricate and test prototype semiconductor memory cells using crested barriers, with write/erase time below 10 ns. Explore retention time of these cells and their endurance under electric stress, and prove their scalability. Demonstrate a prototype electrostatic data storage system and explore its speed performance.

PHASE III DUAL USE APPLICATIONS: The development of fast, ultra-dense semiconductor memories and data storage systems for the most challenging DoD missions, will provide a basis for their commercial introduction into the rapidly growing digital data storage market, including personal computers, corporate and internet servers.

REFERENCES:
1. A. K. Sharma, Semiconductor Memories, IEEE Press, New York, 1997.
2. W. D. Brown and J. E. Brewer, eds. Nonvolatile Semiconductor Memory Technology, IEEE Press, Piscataway, NY, 1998.
3. A. N. Korotkov and K. K. Likharev, IEDM'99 Tech. Dig., pp. 223.
4. J. Brewer, ed., Special Issue on Nonvolatile Memory, IEEE Cir. & Dev. Mag., July 2000.
5. K. K. Likharev, Proc. of IEEE, vol. 87, pp. 606-632, Apr. 1999.

KEYWORDS: Micromachining, Deformable mirror, Adaptive optics, Abberation, Laser wavefront control.

AF01T004 TITLE: Micromachined Deformable Mirrors for Beam Control and Imaging Applications

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop scaleable, low-cost, deformable mirrors, for application to laser wavefront control and active aberration compensation for imaging and communication through the atmosphere, and for other dynamic aberrating media.

DESCRIPTION: Adaptive optical systems are a potential avenue for enhancing Air Force and DOD imaging, communications, and laser systems performance. Examples include space-to-ground and ground-to-ground communications, enhanced battlefield imaging, laser-based missile defense systems, laser illumination of a target through the atmosphere, smart-missile target identification, enhanced laser amplifier energy extraction, enhanced non-linear optics conversion via laser intensity profile control, and remote imaging and sensing. At the present time, there are no commercial deformable mirrors with sufficient engineering control, low-cost, and adequate response times to address the needs of the military community. The requirements for deformable mirrors, including disposability in some applications, make micromachining an attractive option for fabrication. Useful deformable mirrors must have good surface quality, to avoid loss of the incident radiation due to scatter and misdirection. Their architecture should address wire-packing problems currently facing the scaling of surface micromachined architectures. Deformable mirror surfaces should be capable of accepting dielectric coatings to enhance their reflectivity and increase their laser damage threshold. Novel actuator concepts are sought, to achieve useful actuator densities and cycling lifetimes.

PHASE I: Study micromachined mirror concepts, and demonstrate feasibility for low cost, high quality deformable mirrors. Design and show feasibility of suitable wavefront test procedures for the deformable mirrors to be studied.

PHASE II: Design and demonstrate micromachined deformable mirrors using the concepts studied in phase I. Fabricate and study scientific and engineering prototypes to understand their behavior and characteristics, and to elucidate potential processes to produce, assemble and test them. Develop optical diagnostic instrumentation capable of characterizing deformable mirrors after assembly, using the concepts demonstrated in Phase I.

PHASE III DUAL USE APPLICATIONS: The deformable mirrors developed under this topic will have value to commercial manufacturers of lasers and nonlinear optical systems used in displays, projection equipment, astronomical adaptive telescopes, photolithographic systems, surveillance and laser machining equipment. Small systems meeting the topic requirements would have many commercial and military customers.

REFERENCES:

(1) J. D. Mansell and R. L. Byer. "Silicon Micromachined Deformable Mirror". April 1998. SPIE vol. 3353.

(2) T. G. Bifano, J. Perreault, R. Krishnamoorthy-Mali, and M. N. Horenstein. "Microelectromechanical deformable mirrors". IEEE Journal of Selected Topics in Quantum Electronics, 5, 83-9, (1999).

KEYWORDS: Micromachining, Deformable mirror, Adaptive optics, Abberation, Laser wavefront control.

AF01T005 TITLE: Reactants and Combustion Processes for Neutralization of Chemical and Biological Agents

TECHNOLOGY AREAS: Chemical/Biological Defense

OBJECTIVE: Synthesize and formulate improved chemical systems that produce vigorous reactants and sustain high temperatures in order to neutralize toxic chemical and biological agents. The improved chemical systems must consume these agents rapidly by combustion and fast reaction without dispersing them by causing an explosion.

DESCRIPTION: The neutralization and destruction of chemical- and biological agents introduce unique research challenges. In most cases, such agents cannot be destroyed by conventional explosives because the hazards of dispersing materials that are not fully neutralized. The need exists for new energetic materials and formulations that behave more like propellants than explosives. Such materials would react to produce large amounts of highly reactive, primary combustion products that would mix and react with the toxic agents. Combustion and sustained heating then would be the primary modes of destruction and neutralization. Literature is available on industrial incineration of the same agents and their simulates. The primary difference is that the industrial type incineration is accomplished under controlled conditions, whereas this topic seeks approaches for the neutralization in hostile, uncontrolled environments. The hazardous and diverse nature of the reactants makes the destruction difficult to characterize experimentally. Thus, laboratory experiments that simulate the ignition, flame spreading, mixing, etc processes are essential. For research purposes, it will be necessary to avoid experiments that introduce extraordinary hazards. Bacterial spores are among the most resistant forms of life. Hazardous chemical agents are often organic compounds containing organic heteroatoms. Therefore, research on the production type incineration of such agents provides the precedent for using chemical agent simulates (such as triethyl phosphate C6H15O4P) and nonhazardous materials with thermal decomposition properties similar to spores. To achieve these goals more efficiently, specialized energetic materials are needed that introduce reactive combustion products. For example, ingredient ammonium perchlorate (AP), NH4ClO4, when burned with binders, produces high flame temperatures (>2500 K) and reactive products such as HCl, OH, etc. These reactive products further react with the surrounding atmosphere, disturbed environment, and targeted agents. Fluorine and its intermediate compounds are known to be more reactive than chlorine produced by conventional propellants. Systems that can produce large fractions of free fluorine are of particular interest. It is anticipated that the synthesis of the fluorinated compounds will require novel techniques that extend beyond the conventional NF2 chemistry.

PHASE I: A successful phase I effort will develop and assess a destruction concept based on either new energetic materials or nonconventional formations. The process controlling reaction steps and implementation schemes will be predicted. The initial questions concerning material synthesis or practicality and safety will be addressed. An experimental program of quantifying the effectiveness using simulants will be described.

PHASE II: A successful phase II effort will produce laboratory quantities of either a new material or nonconventional formulation that delivers reactive combustion products markedly superior to conventional propellant and reactant systems. Subscale experiments will be set up that quantify the ignition, mixing and flame spreading processes. The kinetics of the process controlling steps will be established. Appropriate flame models will be developed and used to correlate and explain the experimental findings. Analyses will develop the concept into a working prototype that can demonstrate the performance and effectiveness of the concept. Depending on the materials and concept, the use of DoD or industrial special test facilities can be proposed for measuring ignition and flame spread in a well instrumented, controlled, and safe environment. DoD facilities will be available at no cost to the contractor

PHASE III DUAL USE APPLICATIONS: The production potentials of the specialty materials and nonconventional formulations are large. The end-item will involve specialty packaging and custom delivery systems (i.e, airplane, missile, etc). Phase III funding probably requires involving an aerospace systems prime contractor to assess the market and to advise on the broader systems considerations. Stimulating the interest of an aerospace prime in the total system should be an integral part of the Phase II process. COMMERCIAL POTENTIAL: The demonstration of effective new energetic compounds and formulations could lead to production opportunities for military application. The underlying problem is not likely to go away. Dual use will involve the production of pyrotechnic devices and/or recipes for hazardous site protection and remediation in response to a toxic chemical or biological event.

REFERENCES:
"Evaluation of Demonstration Test Results of Alternative Technologies for Demilitarization of Assembled Chemical Weapons: A Supplemental Review," Committee on Review and Evaluation of Alternative Technologies for Demilitarization of Assembled Chemical Weapons, National Research Council, 52 pages, 2000.Starr, B., "Iraq Reveals a Startling Range of Toxin Agents," Jane's Defence Weekly, Nov. 11 1995, p.4Korobeinichev, O. P., Shvartsberg, V. M.; Chernov, A. A., "The destruction chemistry of organophosphorus compounds in flames-II: structure of a hydrogen-oxygen flame doped with trimethyl phosphate," Combustion And Flame, Vol: 118, Issue: 4, pp. 727-732.

KEYWORDS: Combustion, Toxic agent neutralization, chem/bio defense, remediation.

AF01T006 TITLE: High Stiffness Passive Damping Concepts Using Materials or Innovative Mechanisms

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Model, develop and demonstrate novel concepts for passive damping in high stiffness structures by utilizing the unique properties of smart materials or innovative mechanisms.

DESCRIPTION: A large amount of passive damping is often desirable in order to minimize vibration in various types of structures. Furthermore, it is often advantageous to distribute damping mechanisms throughout the structure rather than at joints or attachment points, especially when it is desired that the structure as a whole remain stiff. In conventional practice, viscoelastic passive damping layers may be affixed to a structural member such that they absorb energy as they are deformed. Such treatments, however, are highly dependent on temperature, and provide only minimal damping for very stiff structures. Damping concepts are desired that can provide large damping, on the order of 20%, while maintaining structural stiffness. Such concepts may make use of magnetostrictive materials, shape memory alloys (SMA) as a constraining layer, SMA ferromagnetic materials, particle damping, or other innovative active materials or mechanisms.

PHASE I: The scope of the Phase I effort will be to identify material systems and/or passive mechanisms with qualities that may be exploited for damping, while maintaining structural stiffness. Insensitivity or adaptability to temperature extremes is also desirable. Modeling and material characterization should be completed in this phase. Feasibility should be demonstrated.

PHASE II: The scope of the Phase II effort would be to construct a proof of concept demonstration of the technology developed in Phase I and characterize its performance over a range of temperatures and operating conditions. The results should be extrapolated to hypothesized performance in various applications.

PHASE III DUAL USE APPLICATIONS: Large precision deployable space structures will require large intrinsic damping while on orbit over an extreme temperature range. The structural members must also remain stiff to provide precision deployment and alignment.

REFERENCES:
(1) Friend, R. D. and Kinra, V. K. “Particle impact damping,” J. Sound and Vibration, 233(1), p. 93-118, 2000.(2) Carman, G.P. and Mitrovic, M., "Nonlinear Constitutive Relations for Magnetostrictive Materials with Application to 1-D

Problems," J. Intelligent Material Systems Structures, 6(5), p. 673-683, 1995.(3) van Humbeeck, J. and Liu, Y. “Shape memory alloys as damping materials,” Materials Science Forum, 327-328, p. 331-8, 2000.

KEYWORDS: Damping, Smart materials, High stiffness structure

AF01T007 TITLE: Development of Advanced Crystalline Garnet Materials and Fibers

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop fundamental understanding and processing procedures for economical manufacturing of strong, creep resistant crystalline yttria-alumina garnet oxide fibers for use in high temperature structural components in oxidizing conditions.

DESCRIPTION: The cubic rare earth oxide - aluminum oxide garnets are promising candidates for use in high temperature structural applications requiring strength and creep resistance in oxidizing conditions. These materials are the best candidates for use in novel Air Force engine designs that require refractory ceramic fibers. The proposed research will provide the basis for synthesis of polycrystalline and single crystal rare earth aluminate fibers formed by heat treatment of precursors. The research will establish the use dopants and additives to: (i) control grain growth kinetics, (ii) stabilize microstructure at high temperatures, and (iii) obtain single crystal fibers by thermal treatment of polycrystalline materials. The Phase I research will focus on the yttrium aluminum oxide family of materials with addition/substitution of cations with different ionic radii and coordination number, oxidation number, and reaction phase stability to control grain boundary mobility.

PHASE I: 1. Demonstration of the synthesis of polycrystalline fibers from yttrium oxide-aluminum oxide fiber materials containing substituted cations.2. Controlled thermal processing of fibers at temperatures from 0.75 to 0.95 times the melting point (1450-1900C) for periods up to 6 hours to achieve grain growth and microstructural evolution.3. Transmission electron microscopy and microchemical analysis of materials.4. Correlation of process-structure relationships to develop a roadmap for synthesis of high temperature structural oxide materials to be implemented in Phase II.

PHASE II: Produce and demonstrate a prototype of advanced materials and provide samples to the Air Force for evaluation.

PHASE III DUAL USE APPLICATIONS: Lightweight composites require advanced oxide fibers for structural applications in military applications such as airframe structures and advanced engine components. Civilian applications include use in composites for components of turbines used in power generation and engine components used in transportation, optical materials for transmission at infra-red wavelengths in opto-electronic devices, and hard, strong refractory ceramic materials for use in severe temperature environments.

REFERENCES:
1. “Ceramic Fibers and Coatings – Advanced Materials for the Twenty First Century,” National Materials Advisory Board, publication number NMAB-494, National Academy Press, Washington, DC, 1998.2. G.S. Corman, High Temperature Creep of Some Single Crystal Oxides,” Ceram. Eng. Sci. Proc., 12, 1745-66 (1991).3. K.R. Brown and D.A. Bonnell, “Segregation in Yttrium Aluminum Garnet: I Experimental Determination,” J. Am. Ceram. Soc., 82, 2423-30 (1999).

KEYWORDS: Creep resistant fibers, engine materials, oxygen-resistant

AF01T008 TITLE: High Temperature, High Bandwidth, Pressure Transducer

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop and demonstrate a high frequency response pressure transducer capable of operating at 1100 C or higher.

DESCRIPTION: Jet engine turbines operate in a high temperature environment with high frequency pressure and temperature variations caused by combustion instabilities, blade-row interactions, and unsteady aerodynamic phenomena. In addition, the turbine operates in a harsh environment with products of combustion present. In order to more completely understand the effects of pressure fluctuations on the operation and lifetime wear of a turbine, a device capable of making unsteady pressure measurements at up to 125 kHz, at temperatures of 2000 F (1100 C) or higher (up to 1400 C would be desirable) and pressures up to 750 psi (5170 kPa) absolute, with combined uncertainties of less than 1% of full scale is desired. It is envisioned that such a device could be based on a high temperature fiber optic lead coupled to either an optical etalon or a MEMS-based sensor. This will require research and development efforts involving the use of high temperature fiber optics or MEMS substrates, fabrication techniques, coating materials, and device design, calibration and stability characterization, etc. The resulting device would be a surface mounted pressure transducer for use on turbine vanes or casing walls and would provide a point measurement of the unsteady pressure fluctuation in the turbine at the surface of a vane or casing wall. These measurements would be useful both in test rig applications, and in lifetime wear characterization for operating engines. Ideally, this device would be insensitive to temperature variations, or would include a co-located temperature sensor of comparable operating range and frequency response in order to provide temperature corrections. All aspects of the device design and operation should be considered, including calibration, readout fibers or leadwires, corrosion resistance, electronics, and device mounting requirements. The total device must be compact and capable of surviving long duration operation in a turbine engine environment. The device should be minimally intrusive and capable of being flush-mounted on a stator or casing wall with minimal modification to the existing engine components. Ideally the system would be rugged enough to be capable of applications in flight. Device bandwidth, operational temperature, sensitivity, compactness, mounting requirements, calibration requirements, and ruggedness of the design will all be considered in evaluating candidate sensor concepts, and should be addressed in the proposed effort.

PHASE I: Conceptually design the pressure sensors and develop preliminary estimates of frequency response, accuracy and upper limits of temperature operating range. Test preliminary designs and demonstrate the survivability of the sensor components and/or materials by testing samples in lab-level demonstrations at elevated temperatures and pressures.

PHASE II: Build and test a working prototype of sensor proposed in Phase I. Characterize the frequency response, accuracy and resolution of the sensor. Test the prototype in a suitable test rig to demonstrate operation at elevated temperatures and pressures.

PHASE III DUAL USE APPLICATIONS: An improved pressure sensor capable of operation in a harsh, high temperature environment would be a useful device in the development of both internal combustion and gas turbine engines. Such a device would provide new experimental validation capabilities in laboratory setups and may also provide for lifetime monitoring of critical engine components in both military and civilian applications.

REFERENCES:
1. Propulsion Instrumentation Working Group, Dynamic Pressure Measurements Subteam requirements, http://www.oai.org/PIWG/tabl/table2.html.2. Rahnavardy, K., Arya, V., Wang, A., and Weiss, J.M., "Investigation and application of the frustrated-total-internal-reflection phenomenon in sapphire optical fibers," Applied Optics, Vol. 36, No. 10, pp. 2183-2187 (1997). 3. Chalker, P.R., and Johnston, C., "Thin Film Diamond Sensor Technology," Published in Diamond Thin Films, edited by John I.B. Wilson, Wilhelm Kulisch, Academie Verlag, 1996.

KEYWORDS: High Temperature, High Bandwidth, Sensor, Turbine,Temperature, Pressure, Fiberoptics

AF01T009 TITLE: High Frequency Electromagnetic Propagation/Scattering Codes

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: New approaches are sought for numerical implementations of high frequency (exceeding 3 GHz) approximations to Maxwell's equations.

DESCRIPTION: Because the numerical solution of the full Maxwell's equations are not in a particularly mature state the prediction of electromagnetic scattering attributes (radar cross sections, etc) of actual-size inventory (theirs and ours) is currently provided by high frequency (exceeding 3 GHz) approximations to Maxwell's equations such as Physical Optics (PO), Physical Theory of Diffraction (PTD) or Geometrical Theory of Diffraction (GTD). Numerical versions of these theories, the widely used code XPATCH being but one example, have various shortcomings and therefore the following improvements in numerical implementations are sought.(i) Correctly predict caustics and shadow boundaries and the wave fields (including creeping waves) which exist past such regions so that the predictions of the high frequency code are more accurate than PO/PTD/GTD in scenarios such as bistatic/multistatic radar distributions;(ii) Effectively incorporate higher order correction terms in the high frequency asymptotic expansion of Maxwell's equations;(iii) Since PO/PTD/GTD depend so crucially on an accurate geometrical description of the scattering object (particularly the normal vectors to the object's surface), produce an algorithm/subroutine which delivers to the main high frequency code the correct surface normals from an object's CAD file regardless of CAD file choices/sources;(iv) Provide a rigorous analysis of the numerical error (discretization-induced dispersion for example) accompanying the proferred implementations.

PHASE I: Compelling new approaches are solicited which provide some or all of the above improvements.

PHASE II: A user-friendly, commercially attractive code capable of handling CAD descriptions of airplane-sized objects.

PHASE III DUAL USE APPLICATIONS: An appropriate dual use application is the prediction of compatibility (minimization of interference) for commercial aircraft antennas including future GPS receivers allowing all-weather landings.

REFERENCES:
1. E. Fatemi et al, Jnl Comp Phys, Vol. 120, p. 145, (1995)
2. J. Steinhoff et al, Jnl Comp Physics, Vol. 157, p. 683, (2000)

KEYWORDS: High-Frequency Scattering, Computational Electromagnetics

AF01T010 TITLE: Machine Learning for Record Linkage

TECHNOLOGY AREAS: Information Systems Technology

OBJECTIVE: Develop an approach to rapidly and accurately linking records of related information from web-based information sources using machine learning techniques.

DESCRIPTION: The overwhelming amount of information now available through the internet has increased the need to combine or integrate the data retrieved from these sources in an intelligent and efficient manner. A problem that frequently arises is that even though the data in different sources is related, the objects in the sources are identified in different ways. For example an information agent that extracts and integrates data from various sources on countries needs to be able to recognize that the country that used to be called Zaire is now called the Democratic Republic of Congo, or that the country referred to as 'Denmark' may also be called 'Kingdom of Denmark'. The problem of identifying the same objects across multiple sources is pervasive and occurs anytime records are being linked across sources that were not designed to be used together. The problem occurs in the naming of people, places, organizations, institutions, governments, etc. Most work on record linkage is either done manually or by simple ad hoc rules. The automated approaches to determining mappings between sources take two forms. First, there is work on learning statistical models of the information being linked using techniques such as EM. This work is appropriate for matching very large sources, such as those dealt with by the U.S. Census Bureau [Winkler,1994] that involve hundreds of thousands of records. However, because there is often insufficient data, it cannot be effectively applied when dealing with smaller web-based information sources. Other related work [Cohen,1998] determines the mappings by using information retrieval techniques. The limitation of this approach is that an abbreviation such as "PRC" would not match "Peoples Republic of China." The challenge is to find an approach that minimizes the amount of information required from the user, but still learns the underlying structure of the sources to provide very high accuracy matches.

PHASE I: Develop a machine learning approach to linking records acrosssources and demonstrate the feasibility of the proposed approach.

PHASE II: Build and test a working prototype of the system proposed in Phase I and provide a detailed evaluation of the system.

PHASE III DUAL USE APPLICATIONS: Significant commercial potential given the importance of integrating the huge amount of data on World Wide Web for both commercial and military applications.

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KEYWORDS: Machine learning, Integration of Heterogeneous Data bases, Internet data mining, Internet linking

AF01T011 TITLE: Closed-Loop Flow Control for External Aerodynamics

TECHNOLOGY AREAS: Sensors, Electronics, and Battlespace Environment

OBJECTIVE: Demonstrate an integrated reactive aerodynamic flow control system that can control the pressure distribution and separation over a generic three-dimensional configuration for a range of subsonic and/or transonic flight conditions and vehicle orientations.

DESCRIPTION: Given recent successes in open-loop flow control, separation control, and virtual aerodynamic shaping (the use of aerodynamic flow control devices to significantly alter the flow field in lieu of modification of the physical shape of the body) is now an achievable goal. The use of sensors and actuators to intelligently control flow over aerodynamic surfaces offers the potential of enhanced flight capability for both autonomous and manned air vehicles. Laboratory experiments have demonstrated that flow control devices can yield reduced drag, increased lift, and control of unsteady aerodynamics. These effects could result in reduced fuel consumption, increased range/endurance, increased control authority, control without hinged surfaces, and enhanced maneuverability for future manned and unmanned air vehicles. The purpose of this program is to integrate feedback controller synthesis with aerodynamic flow control methods, which will be required to realize the full benefits of aerodynamic flow control.The integration of feedback control, including sensing some measure of the state of the flow field, is necessary for effectively and efficiently applying flow control actuation over a range of flight conditions and vehicle attitudes. A method for modeling the flow field and its reaction to control inputs must be developed that is amenable for control law design and evaluation. Given the high-order nature of the differential equations for aerodynamics and the complexity of separated flows, reduced order models will be required. The models can be developed using simulations and/or physical experiments. The necessity for a physical demonstration of the complete system on a representative, possibly sub-scale, air vehicle configuration must be considered.

PHASE I: Assess candidate actuators, sensors, control methodologies and air vehicle platforms for application. Develop approach for modeling aerodynamic flows, including the effects of actuation, sensors, actuators and control law implementation. Determine system benefits of adding feedback to flow control for chosen application. Develop an implementation and test plan for Phase II.

PHASE II: Continue development of aerodynamic flow control approach. Improve models and control law developed in Phase I. Perform a physical demonstration of the complete system on a representative air vehicle platform for a range of subsonic and/or transonic flight conditions and vehicle orientations.

PHASE III DUAL USE APPLICATIONS: Successful development of closed loop aerodynamic flow control will lead to applications for air, land and sea vehicles. Drag reduction will reduce fuel consumption. The control of forces and moments on the maneuvering vehicle will enhance control authority or enable control without the use of hinged surfaces.

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KEYWORDS: Flow control, Feedback control, Unsteady aerodynamics, External aerodynamics, Drag reduction, Separation control

AF01T012 TITLE: Advanced Hearing Protection

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: To develop safe and effective techniques for hearing protection in very high level noise environments.

DESCRIPTION: Power requirements and launching constraints currently require air crews to work in close proximity to aircraft engines that may produce sound pressure levels above 150dB. Several ground crew locations are at positions where the noise levels are 145-150 dB. Current hearing protection, passive plugs and muffs, provide approximately 30 dB of attenuation for the average user. In order to adequately protect the hearing of ground personnel, 50 dB of attenuation is required. Effective hearing protection must not only provide adequate attenuation, but also must be comfortable to wear and in some instances provide voice communication capability. However, a complete blocking of the noise arriving at the eardrum via the ear canal may be insufficient to protect hearing in 150 dB environments, because of bone conduction pathways: More acoustic energy may reach the cochlea via transmission paths through tissue and bone than via the external auditory canal. .

PHASE I: Investigate bone and tissue conduction pathways, i.e. flanking paths, to the cochlea and estimate/measure the magnitude of the effects on hearing thresholds. Quantify the magnitude of the bone and tissue conduction path for 150 dB overall sound pressure level 10 Hz-12.5 kHz noise fields. Test and evaluate active noise and active vibration reduction techniques with potential to reduce noise exposure/hearing loss in 150 dB noise fields. Develop methods/techniques to measure air-conducted and bone-conducted noise at the eardrum and/or cochlea and quantify the attenuation performance of hearing protection technologies which may be passive or active and may operate on air-conducted and/or bone/tissue-conducted noise.

PHASE II: Develop, demonstrate, and validate a laboratory prototype system for effective protection of human hearing in 150 dB noise level environments.

PHASE III DUAL USE APPLICATIONS: The techniques and technologies developed under this effort would be used in commercial aviation, in noisy medical procedures such as MRI, and in other high noise environments such as paint stripping, mining, or building construction.

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KEYWORDS: Acoustics, Bioacoustics, Noise attenuation, Hearing Protection, Noise-induced hearing loss.

AF01T013 TITLE: Polymer Based Photovoltaic for Space Applications

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: This STTR topic will seek to research flexible Polymer Based Photovoltaics that will provide lightweight power generation for Air Force space and terrestrial applications.

DESCRIPTION: Lightweight power generation is required for both advanced space systems and terrestial mobile airbase units for the United States Air Force. Polymer-based photovoltaics offer the potential for light-weight power generation from conformable films. The lightweight feature will be critically important in decreasing the cost of transport and deployment. The flexible feature will be important for efficient stowing prior to deployment as well as for efficient surface area utilization in advanced space concepts such as microsatellites and/or Tech Sat 21 and terrestrial shelters (i.e. mobile hangars and tents). Future durability and reliability in the harsh space and operational environment is an important parameter to consider for these applications. The goal of this research is to achieve flexible photovoltaic structures with an electrical power generation to weight ratio of over 200 Wop/kg at AM0 illumination (space applications) or a power efficiency of over 10% at AM1.5 illumination (terrestrial applications) by utilizing innovative broad spectrum capture concepts and/or improved quantum efficiency light conversion approaches.

PHASE I: Propose and demonstrate innovative material design approaches and concepts for generating efficienct polymer based photovoltaic cells on flexible substrates that would provide a substantial improvement in power generating capability on per weight basis.

PHASE II: Develop the proposed material technology and conduct appropriate testings to validate the appropriateness of the proposed material approaches and/or concepts to provide lightweight polymer based photovoltaic cells on flexible substrate for space power applications.

PHASE III DUAL USE APPLICATIONS: Lightweight flexible photovoltaic for terrestial applications.

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KEYWORDS: Flexible polymer based photovoltaic, lightweight power generation

AF01T014 TITLE: Biomimetic Inspired Fibers, Materials, and Properties

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Demonstrate the application, via mimicry, incorporation, adaptation, or replication, of biological silk fibers into the design and construct of novel, high tensile strength, high elasticity, and extremely light weight fibers, composites, and/or materials.

DESCRIPTION: Current studies on protein fibers, or silks, from spiders, Nephila clavipes, and silkworms, Bombyx mori, demonstrated enormously high tensile (or compressive) strength and percent elongation to failure (elasticity). Similar properties and characteristics can be enhanced in novel, ultra-lightweight films, composites, fibers, and polymers by incorporating these biologically inspired constituents. Technical challenges lie not in bulk manufacturing, but rather in producing in vitro protein fibers and films which retain the requisite in vivo properties. The applicability of novel polymeric extrusion processes to the improvement of silk fiber performance should included in the proposed study.The technological elements required to achieve the stated objective most likely exist; therefore, early efforts in this project should address appropriate sequencing, application, and processing of these elements. The materials should be regularly characterized so as to assess the impact of any changes. As the “correct” pathways are determined, the concept of scalability should be considered. Thus, a second step to this project should be incorporating the fiber into a composite, polymer, or other material.

PHASE I: Demonstrate, from pre-identified biological systems (e.g., the N. clavipes or B. mori), the ability to produce, in vitro, ultra-lightweight protein fibers AND films with high tensile strength and elasticity. Assess material properties and characterize the fibers and films. Then, develop a plan for scaling production of the protein fiber and film showing incorporation of either into a composite, polymer, etc. during Phase II.

PHASE II: Incorporate the Phase I biomimetic fibers into a composite, polymer, or other material. Characterize the material properties. Demonstrate that the fibers enhance the tensile strength and elasticity of the fiber-incorporated substance. Further, demonstrate scalability of the production and material processing of the fiber, film, and/or fiber-incorporated substance(s).

PHASE III DUAL USE APPLICATIONS: Ultra-lightweight, highly elastic materials (films, fibers, composites, etc.) with high tensile (compressive) strength would have several commercial and military customers. Applications would include medicine and pharmaceuticals, optics, coatings, automotive and aerospace components, electronics, clothing and apparel, etc.

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KEYWORDS: Biomimetics, Composites, Films, Polymers, Fibers, Materials, Novel materials, Emergent behaviors, Material processing, Material characterization

AF01T015 TITLE: Affordable Airframe Life Extension: Designer Corrosion Suppression Technologies

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: This STTR topic will seek research on corrosion prevention compounds that can be applied to aging aircraft to suppress corrosion and/or cracking and thereby extend the useful life of the airframe. The research will also include the investigation of properties of these materials relevant to space applications.

DESCRIPTION: The US Air Force fleet consists of a number of aircraft that are operating at or beyond their original design lifetimes. Corrosion has been found in many of these aircraft due to the breakdown of any original protective systems that were present at the time of manufacture. This corrosion attack can dramatically impact maintenance costs, operational risks, and aircraft readiness. Currently, corrosion prevention compounds (CPCs) are often applied to repaired areas during maintenance. These materials were generally not designed specifically for suppression of corrosion, but instead have been adapted to such use. The opportunity exists to apply rational design concepts to the development of corrosion and cracking prevention compounds for aerospace use. This topic will seek research that can lead to the development of compounds whose composition and structure are tuned to be highly effective in delaying the onset of corrosion and/or in the suppression of corrosion, especially that occurring in physically occluded regions on aircraft exposed to a wide range of environments. Compounds that can suppress the propagation of cracks are also of interest. Materials to be protected include AA2024-T3, AA7075-T6, AA7178-T6, and high-strength steel. Research to further understand the material degradation behavior in these environments with a clear connection to a material development effort in a later phase is acceptable.

PHASE I: Propose innovative chemical structures and/or chemical design concepts for corrosion suppression technologies for aerospace materials. Develop initial data demonstrating suppression design concepts on aerospace materials.

PHASE II: Develop the proposed suppression technology and conduct appropriate testing to validate the appropriateness of the proposed chemical structures and/or chemical design concepts for corrosion suppression of aerospace materials and progress toward commercial development of these chemical structures or concepts. Assess the effectiveness of the proposed corrosion suppression technology, identify applicable application processes and intervals.

PHASE III DUAL USE APPLICATIONS: Develop the proposed suppression technology and conduct appropriate testing to validate the appropriateness of the proposed chemical structures and/or chemical design concepts for corrosion suppression of aerospace materials and progress toward commercial development of these chemical structures or concepts. Assess the effectiveness of the proposed corrosion suppression technology, identify applicable application processes and intervals.

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KEYWORDS: Corrosion, corrosion prevention and/or suppression, aerospace aluminum alloys.

AF01T018 TITLE: Corrosion Prevention Coatings

TECHNOLOGY AREAS: Materials / Processes

OBJECTIVE: Develop Tunable Adhesion Coatings ("Release On Command) for Corrosion Prevention in Aging Aircraft

DESCRIPTION: Corrosion of metal structures is estimated to cost many billions of dollars annually. The most common methods of corrosion inhibition or prevention involve the application of heavy surface treatments (paints and primers) or conversion coatings using various metallics that use application and removal techniques that are strictly controlled and regulated due to toxicity and possible carcinogenic properties. Hybrid polymers, such as Ionic self-assembled monolayers (ISAMs), show promise as protective coating materials that offer opportunities for environmentally friendly "release on command" coating systems.The Air Force is seeking new coating systems that reduce the use of volatile organic compounds and hazardous material, such as hexavalent chromium, and offer unique "release on command" properties. The focus of this research is to meet the Air Force's top priority of corrosion protection, and environmental compliance for aging aircraft coating systems. Ionic self-assembled monolayers (ISAMs) are a recently developed , revolutionary technique that allows detailed structural control of materials at the molecular level combined with ease of manufacturing and low cost. A broad range of layer functionality is possible through incorporation of a wide range of inorganic nanoparticles to control of the electronic, conductive, optical, magnetic, thermal and mechanical properties. High performance polymers may allow excellent thermal stability, mechanical properties as well as processability. New coating processes based on ionic self-assembled monolayers and nanoparticles that 1) offer corrosion inhibition on metal alloys without the use of chromium, 2) neither contains nor generates hazardous materials, 3) offer the potential for "release on command" capabilities, and 4) have demonstrated practical application methods including spraying and non-electrolytic brushing are of interest.

PHASE I: A program in this area should address the requirements and goals described above, and provide a demonstration of the viability of the technology developed as proof of concept. Viability of the technology will be quantified in terms the breadth of needs addressed and demonstration of corrosion prevention. The phase one product for a successful effort is the formulation of the coating system, and testing and evaluation of this coating system on aluminum structures.

PHASE II: The product from Phase I would be developed through optimization and scale-up efforts to establish large-scale application and removal techniques of the corrosion inhibitor coating system. The product of this phase of the effort will need to be compatible with USAF current methods of aircraft inspection and maintenance.

PHASE III DUAL USE APPLICATIONS: The development of tunable adhesive coatings under this effort will have significant government and commercial applications. Protecting structures exposed to the environment is of key concern to any number of institutions, both in the private and government sector. The ability to controllably and cleanly apply and remove protective coatings will have significant impacts on the environmental and personnel costs of maintaining large assets. This technology will be especially beneficial to the aircraft and automobile industries.

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KEYWORDS: Corrosion, corrosion prvention, adhesion, aerospace aluminum alloys, aging aircrafts.