Office of The Secretary of Defense (OSD)
Deputy Director of Defense Research & Engineering
Deputy Under Secretary of Defense (Science & Technology)
Small Business Technology Transfer Research (STTR)
FY 2010B Program Description

Introduction

The Deputy Under Secretary of Defense (Science & Technology) STTR Program is sponsoring five topics in this solicitation, in the following technology focus areas: Nanomanufacturing and Rocket Propulsion.

The Army, Air Force and Navy are participating in the OSD program on this solicitation. The service laboratories act as our OSD Agent in the management and execution of the contracts with small businesses. The service laboratories, often referred to as a DoD Component acting on behalf of the OSD, invite small business firms to submit proposals under this Small Business Technology Transfer Research (STTR) Program solicitation. In order to participate in the OSD STTR Program this year, all potential proposers should register on the DoD SBIR/STTR Web site as soon as you can, and should follow the instruction for electronic submittal of proposals. It is required that all bidders submit their proposal cover sheet, company commercialization report and their firm's technical and cost proposal form electronically through the DoD SBIR/STTR Proposal Submission Website at https://www.dodsbir.net/submission. If you experience problems submitting your proposal, call the help desk (toll free) at 1-866-724-7457. You must include a Company Commercialization Report as part of each proposal you submit; however, it does not count against the proposal page limit. Please note that improper handling of this form may result in the proposal being substantially delayed. Information provided may have a direct impact on the review of the proposal. The DoD SBIR/STTR Proposal Submission Website allows your company to come in any time (prior to the proposal submission deadline) to edit your Cover Sheets, Technical and Cost Proposal and Company Commercialization Report.

We WILL NOT accept any proposals that are not submitted through the on-line submission site. The submission site does not limit the overall file size for each electronic proposal, there is only a 25-page limit. However, file uploads may take a great deal of time depending on your file size and your internet server connection speed. If you wish to upload a very large file, it is highly recommended that you submit prior to the deadline submittal date, as the last day is heavily trafficked. You are responsible for performing a virus check on each technical proposal file to be uploaded electronically. The detection of a virus on any submission may be cause for the rejection of the proposal. We will not accept e-mail submissions.

Firms with strong research and development capabilities in science or engineering in any of the topic areas described in this section and with the ability to commercialize the results are encouraged to participate. Subject to availability of funds, the DUSD(S&T) STTR Program will support high quality research and development proposals of innovative concepts to solve the listed defense-related scientific or engineering problems, especially those concepts that also have high potential for commercialization in the private sector. Objectives of the DUSD(S&T) STTR Program include stimulating technological innovation, strengthening the role of small business in meeting DoD research and development needs, fostering and encouraging participation by minority and disadvantaged persons in technological innovation, and increasing the commercial application of DoD-supported research and development results. The guidelines presented in the solicitation incorporate and exploit the flexibility of the SBA

Policy Directive to encourage proposals based on scientific and technical approaches most likely to yield results important to DoD and the private sector.

Description of the OSD STTR Three Phase Program

Phase I is to determine, insofar as possible, the scientific or technical merit and feasibility of ideas submitted under the STTR Program and will typically be one half-person year effort over a period not to exceed six months, with a dollar value up to $100,000. We plan to fund 3 Phase I contracts, on average, and downselect to one Phase II contract per topic. This is assuming that the proposals are sufficient in quality to fund this many. Proposals are evaluated using the Phase I evaluation criteria, in accordance with paragraph 4.2 of the DoD Solicitation Preface. Proposals should concentrate on that research and development which will significantly contribute to proving the scientific and technical feasibility of the proposed effort, the successful completion of which is a prerequisite for further DoD support in Phase II. The measure of Phase I success includes technical performance toward the topic objectives and evaluations of the extent to which Phase II results would have the potential to yield a product or process of continuing importance to DoD and the private sector, in accordance with Section 4.3.

Subsequent Phase II awards will be made to firms on the basis of results from the Phase I effort and the scientific and technical merit of the Phase II proposal in addressing the goals and objectives described in the topic. Phase II awards will typically cover 2 to 5 person-years of effort over a period generally not to exceed 24 months (subject to negotiation). Phase II is the principal research and development effort and is expected to produce a well defined deliverable prototype or process. A more comprehensive proposal will be required for Phase II.

Under Phase III, the DoD may award non-STTR funded follow-on contracts for products or processes, which meet the component mission needs. This solicitation is designed, in part, to encourage the conversion of federally sponsored research and development innovation into private sector applications. The small business is expected to use non-federal capital to pursue private sector applications of the research and development.

This solicitation is for Phase I proposals only. Any proposal submitted under prior STTR solicitations will not be considered under this solicitation; however, offerors who were not awarded a contract in response to a particular topic under prior STTR solicitations are free to update or modify and submit the same or modified proposal if it is responsive to any of the topics listed in this section.

For Phase II, no separate solicitation will be issued and no unsolicited proposals will be accepted. Only those firms that were awarded Phase I contracts, and have successfully completed their Phase I efforts, may be invited to submit a Phase II proposal. Invitations to submit Phase II proposals will be released at or before the end of the Phase I period of performance. The decision to invite a Phase II proposal will be made based upon the success of the Phase I contract to meet the technical goals of the topic, as well as the overall merit based upon the criteria in section 4.3. DoD is not obligated to make any awards under Phase I, II, or III. DoD is not responsible for any money expended by the proposer before award of any contract. For specifics regarding the evaluation and award of Phase I or II contracts, please read the front section of this solicitation very carefully. Every Phase II proposal will be reviewed for overall merit based upon the criteria in section 4.3 of this solicitation, repeated below:

a. The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.
b. The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.

c. The potential for commercial (defense and private sector) application and the benefits expected to accrue from this commercialization.

In addition, the OSD STTR Program has a Phase II Plus Program, which provides matching STTR funds to expand an existing Phase II contract that attracts investment funds from a DoD acquisition program, a non-SBIR/non-STTR government program or Private sector investments. Phase II Plus allows for an existing Phase II OSD STTR contract to be extended for up to one and a half year per Phase II Plus application, to perform additional research and development. Phase II Plus matching funds will be provided on a one-for-one basis up to a maximum $500,000 of STTR funds. All Phase II Plus awards are subject to acceptance, review, and selection of candidate projects, are subject to availability of funding, and successful negotiation and award of a Phase II Plus contract modification. The funds provided by the DoD acquisition program or a non-SBIR/non-STTR government program must be obligated on the OSD Phase II contract as a modification prior to or concurrent with the OSD STTR funds. Private sector funds must be deemed an "outside investor" which may include such entities as another company, or an investor. It does not include the owners or family members, or affiliates of the small business (13 CFR 121.103).

The Fast Track provisions in section 4.0 of this solicitation apply as follows. Under the Fast Track policy, STTR projects that attract matching cash from an outside investor for their Phase II effort have an opportunity to receive interim funding between Phases I and II, to be evaluated for Phase II under an expedited process, and to be selected for Phase II award provided they meet or exceed the technical thresholds and have met their Phase I technical goals, as discussed in Section 4.5. Under the Fast Track Program, a company submits a Fast Track application, including statement of work and cost estimate, within 120 to 180 days of the award of a Phase I contract (see the Fast Track Application Form on www.dodsbir.net/submission). Also submitted at this time is a commitment of third party funding for Phase II. Subsequently, the company must submit its Phase I Final Report and its Phase II proposal no later than 210 days after the effective date of Phase I, and must certify, within 45 days of being selected for Phase II award, that all matching funds have been transferred to the company. For projects that qualify for the Fast Track (as discussed in Section 4.5), DoD will evaluate the Phase II proposals in an expedited manner in accordance with the above criteria, and may select these proposals for Phase II award provided: (1) they meet or exceed selection criteria (a) and (b) above and (2) the project has substantially met its Phase I technical goals (and assuming budgetary and other programmatic factors are met, as discussed in Section 4.1). Fast Track proposals, having attracted matching cash from an outside investor, presumptively meet criterion (c). However, selection and award of a Fast Track proposal is not mandated and DoD retains the discretion not to select or fund any Fast Track proposal.

Follow-On Funding

In addition to supporting scientific and engineering research and development, another important goal of the program is conversion of DoD-supported research and development into commercial products. Proposers are encouraged to obtain a contingent commitment for private follow-on funding prior to Phase II where it is felt that the research and development has commercial potential in the private sector. Proposers who feel that their research and development have the potential to meet private sector market needs, in addition to meeting DoD objectives, are encouraged to obtain non-federal follow-on funding for Phase III to pursue private sector development. The commitment should be obtained during the course of Phase I performance. This commitment may be contingent upon the DoD supported development meeting some specific technical objectives in Phase II which if met, would justify non-federal funding to pursue further development for commercial purposes in Phase III. The recipient will be permitted to obtain commercial rights to any invention made in either Phase I or Phase II, subject to the patent policies stated elsewhere in this solicitation.

Contact with DoD

General informational questions pertaining to proposal instructions contained in this solicitation should be directed to the topic authors and point of contact identified in the topic description section. Proposals should be electronically submitted. Oral communications with DoD personnel regarding the technical content of this solicitation during the pre-solicitation phase are allowed, however, proposal evaluation is conducted only on the written submittal. Oral communications during the pre-solicitation period should be considered informal, and will not be factored into the selection for award of contracts. Oral communications subsequent to the pre-solicitation period, during the Phase I proposal preparation periods are prohibited for reasons of competitive fairness; however, to obtain answers to technical questions during the formal Solicitation period, please visit http://www.dodsbir.net/sitis. Refer to the front section of the solicitation for the exact dates.

Proposal Submission

Proposals shall be submitted in response to a specific topic identified in the following topic description sections. The topics listed are the only topics for which proposals will be accepted. Scientific and technical information assistance may be requested by using the SBIR/STTR Interactive Technical Information System (SITIS).

It is required that all bidders submit their proposal cover sheet, company commercialization report and their firm's technical and cost proposal form electronically through the DoD SBIR/STTR Proposal Submission Website at http://www.dodsbir.net/submission. If you experience problems submitting your proposal, call the help desk (toll free) at 866-724-7457. You must include a Company Commercialization Report as part of each proposal you submit; however, it does not count against the proposal page limit. Please note that improper handling of this form may result in the proposal being substantially delayed. Information provided may have a direct impact on the review of the proposal. The proposal submission Web site allows your company to come in any time (prior to the proposal submission deadline) to edit your Cover Sheets, Technical and Cost Proposal and Company Commercialization Report. We **WILL NOT accept any proposals which are not submitted through the on-line submission site.** The submission site does not limit the overall file size for each electronic proposal, only the number of pages are limited. However, file uploads may take a great deal of time depending on your file size and your internet server connection speed. You are responsible for performing a virus check on each technical proposal file to be uploaded electronically. The detection of a virus on any submission may be cause for the rejection of the proposal. We will not accept e-mail submissions.

The following pages contain a summary of the technology focus areas, followed by the topics.

NANOMANUFACTURING SMALL BUSINESS TECHNOLOGY TRANSFER INITIATIVE

The Office of the Secretary of Defense is interested in innovative, collaborative research in the broad area of nanomanufacturing, which is defined as increasing knowledge, understanding, and manipulative capability associated with matter and phenomena at the nanoscale (1–100 nm) with a focus on the practical control of useful physical, chemical, or mechanical properties. Research may include efforts dealing with materials synthesis, processing, fabrication, or design of nanoscale materials or structures; modeling and simulation of structures and properties at the nanoscale; or tools and instrumentation for characterization and manipulation at the nanoscale. The product of the research should lead to enhanced understanding, knowledge, model materials/structures or other outcome that can enhance current fabrication or manufacturing processes or establish a foundation for new processes or fabricable product.

Research is being solicited in the following five topic areas:

- Intelligent adaptive systems through bottom-up microstructural control and synthesis: The objective of the research is the investigation of the feasibility of molecular assembly to develop microstructures composed of both active and passive elements optimized by a new set of design rules derived from hierarchical principles to create macroscale high strength materials that change their microstructures in response to a variety of loading conditions and/or external signals.
- Design Automation Software for DNA-Based Nano-Sensor Architectures: The objective of the research is the development and demonstration of a DNA design automation software package that allows for the specification of large and complex DNA-based nano-sensor architectures and the successful computation of the optimized DNA sequence-sets required for the reliable self-assembly of the pre-defined DNA structures.
- Nanomanufactured catalytic arrays on patterned addressable substrates for advanced electronic device applications.: The objective of the research is the development of nanomanufacturing approaches and tools to deposit large scale and dense arrays of intermetallic catalytic particles of controlled geometries on addressable pre-patterned substrates (metallic, semiconducting and insulating). This platform will serve as the base for a large number of products dealing with the exploitation of the carbon nanotube properties (in particular ultra-capacitors). This platform will also help with other scientific investigations addressing issues of growth and control of the of carbon nanotube properties. A second objective is to develop different types of ultracapacitors based on the above platform (different sizes, with different electrode geometries, with different dielectric materials and different metal substrates).
- Roll to roll nanoimprinting: The objective of the research is to obtain very fine scale structures for photonic applications patterned by nanoimprinting on flexible substrates in a roll-to-roll process. Such structures may be patterned to have unique optical properties through the arrangement of two or more materials arranged in a regular geometric pattern with sub-wavelength dimensions. These structures have been referred to as photonic crystals, plasmonic crystals and metamaterials. Small feature size requiring techniques such as direct write electron/ion beam lithography have generally restricted fabrication to small samples. This research aims to develop affordable techniques for fabrication of large areas of such materials for photonic applications.
- Flexible Micro- and Nano-Patterning Tools for Photonics: The objective of the research is to develop low cost, highly flexible micro- and nano-patterning tools, systems, and methods with excellent durability for multilevel nanophotonic devices and/or dense photonic and optoelectronic components. Nanoimprinting appears to provide an opportunity not only to create resist patterns, as in lithography, but to also imprint functional device structures in various polymers, which can lead to a wide range of applications in electronics, photonics, data storage, and biotechnology.

OSD STTR 10.B Topic Index

The Rocket Propulsion topic is:

The Nanomanufacturing Technology topics are:

OSD STTR 10.B Topic Descriptions

OSD10-T001 TITLE: Turbulent Combustion Interaction Models for LES Simulations of High Speed Flow

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop an accurate modeling tool that can be used for high speed propulsion system certification and with an emphasis on investigating the impacts of fine scale turbulent motions.

DESCRIPTION: Proposed future AF high speed propulsion systems will be physically too large to conduct the required R&D at full scale within the nations existing ground test infrastructure prior to flight evaluation. In order to utilize sub-scale ground testing to mature a concept to an acceptable technology readiness level for flight certification, high fidelity analytical and modeling methods will be required to bridge the gap between sub-scale-based development and full-scale flight test with acceptable risk. Such modeling tools must have a strong theoretical and physical basis. The improved efficiency of the reduced chemical kinetics modeling and advances in computational capabilities may make hybrid Reynolds Averaged Navier-Stokes (RANS) / large eddy simulation (LES) and LES practical in the required time frame.

A key component for LES is the sub-grid turbulence model and the interactions with combustion kinetics. For high speed high Reynolds number combustion flow, the interaction scales for turbulence and chemical kinetics would differ significantly from low speed flows where chemical time and space scales are much smaller than the flow scales. Hydrocarbon combustion kinetics and turbulence both encompass several orders of magnitude in time scales. In high speed flows, these scales can have significant overlap, and with reduced combustion models the short time scales are often ignored or removed. The goal of this research is to develop better models for turbulent mixing and for turbulent combustion interaction in high speed flows. The models could include innovative numerical methods or combustion rate and turbulence model interactions. The incorporation of reduced kinetics models on the formulation should also be achievable without decreasing simulation fidelity. Detailed simulations of sub-grid turbulence could be performed using direct numerical simulation (DNS) on low Reynolds number canonical flows including chemical kinetics. These simulations could be applied to the development and calibration of sub-grid turbulence models and sub-grid turbulent combustion interaction. However, care must be taken to include turbulent and combustion scale overlap consistent with high speed combustion flows. Extra emphasis will be given to efforts which clearly define experiments and diagnostics that would provide fundamental data for evaluating the models developed. These data should be applicable to high speed combustion where turbulent and kinetic time scales have significant overlap.

PHASE I: Identify innovative methods for incorporating the interaction of combustion kinetics and turbulent scales in high speed flows. Provide preliminary verification and validation approaches to support the activity. Identify the experimental data sets that will be used for validation.

PHASE II: Develop and verify software modules implementing the new models consistent with a system or component level flow simulation tool. Demonstrate the level of accuracy improvement and additional simulation cost in applying the methods. Incorporate these models into current state-of-the-art CFD modeling tools useful for high speed combustion simulations.

PHASE III DUAL USE COMMERCIALIZATION:
Military Application: Military benefits include improved standoff missile capabilities for rapid response by reducing design time, cost, and risk contributing to global strike capability in manned systems.
Commercial Application: Commercial benefits include reduced time, risk, and cost for developing a propulsion capability for commercial space flight.

REFERENCES:
1. Oelelein, J.C., Scherer, R.W., Barlow R.S., “Toward Validation of Large Eddy Simulation for Turbulent Combustion,” AIAA Journal, Vol. 44, No. 3, March 2006.

2. Mongia, H.C., “Recent Progress in Comprehensive Modeling of Gas Turbine Combustion,” AIAA 2008-1445, Jan 2008.

3. Keistler, P.G., Hassan, H.A., Xiao, X., “Role of Chemistry/Turbulence Interaction in 3-D Supersonic Combustion,” AIAA 2008-89, Jan 2008.

4. Gaffney, R. L., Jr., White, J. A., Girimaji, S. S. and Drummond, J. P., “Modeling Temperature and Species Fluctuations in Turbulent, Reacting Flow,” Modeling Temperature and Species Fluctuations in Turbulent, Reacting Flow, Computing Systems in Engineering Vol. 5, No. 2, pp. 117-133, 1994.

5. Boles, J., Edwards, J., Choi, J., and Baurle, R., “Simulations of High-Speed Internal Flows using LES/RANS Models,” AIAA-2009-1324, 47th AIAA Aerospace Sciences Meeting, Orlando, Florida, Jan. 5-8, 2009.

KEYWORDS: hypersonic, scramjet, turbulent mixing, combustion, supersonic combustion, RANS, LES, DNS

OSD10-T002 TITLE: Intelligent adaptive systems through bottom-up microstructural control and synthesis

TECHNOLOGY AREAS: Materials/Processes

OBJECTIVE: Investigate the feasibility of molecular assembly to develop microstructures composed of both active and passive elements optimized by a new set of design rules derived from hierarchical principles to create macroscale high strength materials that change their microstructures in response to a variety of loading conditions and/or external signals.

DESCRIPTION: Structures with radically improved performance and novel functionality have not been realized because they often require material property sets that are competing such as yield strength and ductility, hardness and density, and stiffness and toughness. They lack adaptability to cope with widely varying loading regimes (e.g. combat versus non-combat applications). The capability to realize structures that would surmount these barriers have been demonstrated separately by nature or in weak polymers-based systems, by advanced modeling results, and by experiments that span the nano to the micro scales. However, to achieve intelligent adaptive systems using high strength man-made materials will require the development of new hierarchical design principles and synthesis methods.

Often, material synthesis methods are based on random processes rather than structured approaches across multiple scales as seen in nature, resulting in limited success. The design and synthesis of materials from the bottom-up, to create hierarchical structures in which the conventional concepts of structure and material are merged will provide a fundamentally new direction for materials development that would change the way new structures are developed in the decades to come. Further, the integration of materials design with active feedback processes (sensing, signaling, and control systems) will provide an innovative approach to enhance the performance of materials under changing environmental conditions, that is, to create a new generation of active and tunable material that can adapt and respond to adverse and often disparate loading conditions. Adaptable hierarchical materials will be enabled through the emergence of new techniques of self-assembly and material characterization, along with multiscale and multiphysics topological optimization that can “evolve” the optimal material hierarchy without a preconceived notion for the “optimum” microstructure.

PHASE I: Develop multi-physics, multi-scale modeling, experimental characterization and synthesis methods that are needed to optimize the inelastic response of a high strength (>300 MPa) adaptable hierarchical structures composed of active and passive engineering materials subjected to at least two significantly different loading regimes. Demonstrate new synthesis methods with molecular precision to produce a minimum of three hierarchical levels that can produce a volume of material with minimum dimensions of 1mm × 1mm × 1mm. Develop plan to scale up the process to produce meter-scale dimensions.

PHASE II: Scale-up the synthesis process proposed in Phase I to produce hierarchical material with minimum dimensions of 10cm X 10cm X 1cm. Experimentally measure yield strength and ductility ratios and compare them to traditional composites composed of the same constituents. Generate experimental data to fine tune modeling and optimization procedures.

PHASE III: DUAL USE APPLICATIONS: After achieving the milestones outlined in Phase II the synthesis process should be further scaled-up for large scale manufacturing. Optimization and modeling techniques should be integrated into commercial design codes and used to develop materials for both DoD and Civilian platforms such as rotorcraft, aircraft, and ground vehicles. Efforts should be made to commercialize technology that focuses on components that undergo a full spectrum of loading conditions including fatigue, creep, and high rate loading.

REFERENCES:

1. Progress in Materials Science 52 (2007) 1263–1334

2. Int. J. Materials and Structural Integrity, Vol. 3, Nos. 2/3, 2009

3. ACSNano, VOL. 3, NO. 8, 2207–2216, 2009

KEYWORDS: hierarchical structures, self-assemble, optimization, responsive materials

OSD10-T003 TITLE: Design Automation Software for DNA-Based Nano-Sensor Architectures

TECHNOLOGY AREAS: Materials/Processes, Sensors

OBJECTIVE: Develop and demonstrate a DNA design automation software package that allows for the specification of large and complex DNA-based nano-sensor architectures and the successful computation of the optimized DNA sequence-sets required for the reliable self-assembly of the pre-defined DNA structures.

DESCRIPTION: The field of DNA-based nanotechnology has grown rapidly in recent years, with capabilities advancing from the design and generation of structures to the design and generation of functional nano-sensor materials [1]. To promote this existing technology base to commercial-level bio-molecular sensing applications will require the development of software/hardware platforms capable of addressing current computational bottlenecks and the generation of simulation tools for successfully defining the electro/optical modes of reporting the sensor status. More specifically, the computational complexity of determining DNA sequence sets capable of self-assembly into target structural designs has been an ongoing obstacle to nano-engineering with DNA [2]. The permutation space of candidate sequence sets over a DNA nanostructure with n base pairs is O(4n) and evaluating only simple (non-hairpin) segments for possible non-specific bindings over a single candidate sequence set is O(n3). Consequently, currently available DNA design software does not attempt to address the added complexity associated with the practical necessity of accommodating pseudo-knots (sequences which fold back and hybridize themselves) [3,4]. In the case of Rothemund's origami approach, the folding is accomplished automatically by the fixed sequence of the M13 virus [5]. However, in direct contrast to origami structures, the design of more generalized composite nanostructures utilizing multiple motifs functionalized for sensing applications requires sequence optimization that addresses pseudo-knots and other computationally challenging design constraints. Recent advances in highly distributed computing systems that can outperform traditional supercomputers on related biologically-based problems [6] and the development of evolutionary search algorithms specifically designed to treat these type of problems [7] now provide a basis for performing optimizations over sequence design spaces previously thought to be intractable. When design automation software for prescribing the self-assembly of such DNA nanostructures becomes available that can efficiently leverage such massively distributed computational systems for sequence optimization, it will dramatically accelerate the development of new and novel types of DNA architectures which will be useful for defining functionalized nano-sensors.

At the present time, a comprehensive development tool for realizing very complex DNA-based nanostructures and architectures does not exist. The envisioned DNA design automation application must adequately address several requirements.

Specifically, the application must: (1) provide basic infrastructure for information passing; (2) determine optimal sequence sets according to first principles constraints (imposed by topology, molecular thermodynamics and self-assembly kinetics); (3) accommodate designs with up to 30,000 bases and arbitrarily complex pseudo-knots; (4) provide a graphical user interface which allows specification of nanostructure designs, including strand position and topology, designation of the location of non-DNA species in the design, designation of fixed bases versus variable bases (those to be calculated); and (5) address the important problem of localized target melting temperatures, which dictate the desired order of self-assembly. When design automation software of this prescription is developed it will allow for the creation of novel biomolecular architectures that are amenable for incorporating nanoscale sensing functionality. More specifically, this software will accelerate the development of complex DNA nanoscaffolds which are compatible with molecular sensing elements that are driven by interactions with specific chemical and biological targets. Hence, this architectural software will be a significant enabler when combined with existing first-principle molecular-dynamics/chemical-reactions modeling capabilities in that it can be expected to fuel the evolution of new capabilities for the detection and identification of threat agents. Furthermore, new discoveries and technologies will emerge that will have important relevance to defense and security requirements for the continuous monitoring the environment for biological and molecular species of interest.

PHASE I: The Phase I effort should produce a detailed requirements document for a design automation tool that captures the essential design cases for the software application workflow – from DNA-based design specification to design optimization via distributed computing to inspection of results and management of user workspace. A description of the core thermodynamics and sequence optimization algorithms should also be provided. Based on these requirements, a distributed, design tool architecture should be proposed that satisfies the usability and computational complexity challenges of the envisioned application. Phase I efforts that also include a corresponding proof-of-concept software demonstration are strongly preferred.

PHASE II: The Phase II effort should target a prototype software application that honors the top-level requirements identified in Phase I and that allows complex nanostructure designs to be specified, then automatically populated with optimized sequences. The research and development work should include experimental verification that the resultant sequence sets self-assemble into the targeted designs with high fidelity and yield. The relevance to defense and security applications should be demonstrated through simulation of a bio-molecular nano-sensing structure response to a bio-species of interest.

PHASE III: DUAL USE APPLICATIONS: Once an effective prototype software system is achieved, the system will be amenable to the design of numerous architectures for biological sensing and characterization. Specifically the software will be a key enabler of sensors having relevance to scientific studies of biological materials, to the detection and identification of biological threats, to medical diagnostics and therapeutics of biological induced diseases, and to the monitoring of commercial consumables for biological contamination.

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[3] R. Dirks, J. Bois, J. Schaeffer, E. Winfree, N. Pierce, Thermodynamic analysis of interacting nucleic acid strands, SIAM REVIEW, Vol: 49 Issue: 1: 65-88, Mar 2007.

[4] A. Condon and H. Jabbari. Computational prediction of nucleic acid secondary structure: Methods, applications and challenges, Theoretical Computer Science, 2008.

[5] P.W.K. Rothemund, "Folding DNA to create nanoscale shapes and patterns", Nature (440) 297–302, 2006.

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computation on large-scale computational grids, Proceedings of the 2008 GECCO conference companion on Genetic and evolutionary computation, pp. 2227-2232, Jul 2008.

KEYWORDS: Design Automation Software, DNA Nanotechnology, Nano-Sensor, Biological Detection, Environmental Monitoring

OSD10-T004 TITLE: Nanomanufactured catalytic arrays on patterned addressable substrates for advanced electronic device applications

TECHNOLOGY AREAS: Materials/Processes, Weapons

OBJECTIVE: To develop nanomanufacturing approaches and tools to deposit large scale and dense arrays of intermetallic catalytic particles of controlled geometries on addressable pre-patterned substrates (metallic, semiconducting and insulating). This platform will serve as the base for a large number of products dealing with the exploitation of the carbon nanotube properties (in particular ultra-capacitors). This platform will also help with other scientific investigations addressing issues of growth and control of the of CNT properties. The second objective is to develop different types of ultracapacitors based on the above platform (different sizes, with different electrode geometries, with different dielectric materials and different metal substrates).

DESCRIPTION: Nanotechnology, and specifically of carbon nanotube (CNT) science and technology, has been growing exponentially since Iijima's paper on CNTs in 1991. A large number of products and devices (composites materials, advanced coatings, conductive paints and elastomers, capacitors, semiconductors and transistors) have been demonstrated in a laboratory environment since then. Random powders, mats, and entangled forest of CNTs have been grown by many groups around the country. Despite the large progress in many areas of science and technology using CNTs, there is still a need for new tools and approaches for manufacturing advanced nanotechnology products with controlled properties. Dense periodic arrays of catalytic nanoparticles of controlled geometry on pre-patterned addressable substrates is a technology area that could provide quick results in terms of advanced devices. Some of the challenges to overcome include: identifying adequate substrate materials for patterning/metallization with nanoscale line resolution that are compatible with the temperature and chemistry of conventional CVD CNT forest growth; manipulation (production – separation – classification - placement) of intermetallic nanoparticles of precise geometry at specific locations in a pre-patterned substrate; uniform growth of high quality (vertical CNTs with low defect count) multiwalled CNTs with low base contact resistances; dense coating/infusing of dielectric material with high breakdown potentials and no shorts and others challenges.

PHASE I: During the Phase I the contractor will develop tools and approaches to produce substrates with dense arrays of catalytic particles with controlled geometries. He will demonstrate the capability to fabricate at least three different dense arrays with average particle size of 10, 20 and 40 nanometer respectively (with comparable interspace) and to grow multiwall carbon nanotubes (MWNT) from said substrates. Finally, he will develop tools and approaches to fabricate capacitors with different ratings (capacitance and discharge rate) using those MWNT arrays. The target scale of the devices during the Phase I will be in the millimeter range. Addressability issues will be developed during the phase II effort.

PHASE II: During the Phase II, the contractor will further optimize the tools and processes demonstrated earlier and he will further the technology by demonstrating ability to manipulate smaller catalyst particles. He will also demonstrate the ability to address a small number of rows of catalytic particles with the ultimate goal of making new MWNT capacitor architectures. Also, during the Phase II the contractor will scale up his tools and approaches to centimeter length scales of the substrate with addressable pattern geometries.

PHASE III: The contractor, in collaboration with the Navy monitoring team, will seek a potential military application and/or demonstration during Phase III.

COMMERCIAL POTENTIAL/DUAL-USE APPLICATIONS: The commercial power and energy industry could benefit significantly from these tools. Other industries that could benefit from this technology are the electronic, the computer industry and the telecommunication industries. Substrates with addressable arrays of catalytic particles could be a commercial product on its own of great interest to universities and laboratories.

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KEYWORDS: Nanomanufacturing, Carbon Nanotubes, Devices, Capacitors

OSD10-T005 TITLE: Roll to Roll Nanoimprinting

TECHNOLOGY AREAS: Materials/Processes, Electronics

OBJECTIVE: Demonstrate very fine scale structures for photonic applications patterned by nanoimprinting on flexible substrates in a roll-to-roll process.

DESCRIPTION: Unique optical properties can be obtained in structures formed of two or more materials arranged in a regular geometric pattern with sub-wavelength dimensions. These structures have been referred to as photonic crystals, plasmonic crystals and metamaterials. Small feature size requiring techniques such as direct write electron/ion beam lithography have generally restricted fabrication to small samples. This research aims to develop affordable techniques for fabrication of large areas of such materials for photonic applications.

Broad and diverse approaches and applications in photonics and nanophotonics are sought. One particular area might be printing/placing of nanomembranes or even printing patterns on nanomembranes roll to roll. Printing patterns on nanomembranes that are already placed on a rolled-up flexible support is a challenge and might require development of associated automated pick and placement strategies. The work could address pixelated and integrated nano-optical devices to improve integration with the compact, low-cost image sensors or the development of plasmonic solar cells.

PHASE I: Demonstrate the feasibility of sub-wavelength patterning of metals and/or dielectrics using roll-to-roll processing. Non-limiting examples of processes are printing, imprinting, or patterning resists for etching or lift-off. Design and fabricate a sample large enough to demonstrate the feasibility of the process and eventual product.

PHASE II: Design, fabricate and test photonic device(s) made by roll-to-roll processing. Deliver details of the fabrication process and a sample at least 0.1 square meter of area with test results for devices on the sample. Clearly identify an application which would benefit from this fabrication strategy.

COMMERCIAL/DUAL-USE APPLICATIONS: Novel photonic devices and affordable processing approaches are equally valuable in the commercial active device arena as in military application and the potential for flexibility and cost-savings through roll processing provide great commercial potential for the expected research product.

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KEYWORDS: nanotechnology, photonics, integration, nanoimprint, roll to roll, sub-wavelength patterning, nanophotonics, large-area, high-throughput, nanostamping, manufacturing, flexible, flexible substrates, nanomembranes, patterning tools, nanofabrication, low cost

OSD10-T006 TITLE: Flexible Micro- and Nano-Patterning Tools for Photonics

TECHNOLOGY AREAS: Materials/Processes, Electronics

OBJECTIVE: To develop low cost, highly flexible micro- and nano-patterning tools, systems, and methods with excellent durability for multilevel nanophotonic devices and/or dense photonic and optoelectronic components

DESCRIPTION: The ability to fabricate structures from micro- to nano- scale with high precision on a wide variety of materials is of crucial importance to the advancement of micro- and nano- technology and sciences. The semiconductor industry has been pushing high-precision nanoscale lithography to manufacture ever-smaller transistors and higher-density integrated circuits (ICs). Critical issues, such as resolution, reliability, speed, and overlay accuracy, all need to be addressed in order to develop new lithography methodologies for such demanding, industrially relevant processes. On the other hand, less stringent conditions are found in many other areas, for example, photonics, micro- and nano-fluidics, chip-based sensors, and most biological applications. Several alternative approaches towards nanostructure fabrication have been exploited in the past 15 years, without resorting to expensive tools such as those used in deep-UV projection lithography and electron-beam lithography. These techniques include microcontact printing (or soft lithography), nanoimprint lithography (NIL), scanning-probe-based techniques (e.g., atomic force microscope lithography), and dip-pen lithography. Of these techniques, Nanoimprinting can not only create resist patterns, as in lithography, but can also imprint functional device structures in various polymers, which can lead to a wide range of applications in electronics, photonics, data storage, and biotechnology.

However, there are still several serious concerns upon nanoimprinting which limit its applications. The major drawbacks for nanoimprint lithography are overlay, defects, template patterning and template wear. Additionally, nanoimprint lithography relies on displacing polymer materials for creating the desired features. This could lead to systematic effects over long distances. For example, a large, dense array of protrusions will displace significantly more polymer than an isolated protrusion which becomes more and more serious as the feature size varying from nanometer to micrometer. Thus it is highly desirable to develop a low cost, flexible nano-pattern transferring technology with high durability, and capability of molding feature size from sub-100nm to 100ìm and above. The nano-pattern transferring technology should have the potential to form 3-D photonic and electronic structures as well.

PHASE I: In the Phase I effort, a complete design of the nano-patterning tools should be formulated, and the fabrication procedures should be developed for at least one device implementation. It is expected that the flexible nano-patterning tool should have high durability as well as the capability of forming feature size from sub-100nm to 100micrometer.

PHASE II: Based on the results of Phase I, full characterization of the nano-patterning methods should be addressed. Technology issues such as yield, defect density, wafer size, and throughput rate need to be resolved. In the Phase II effort, 3-D patterning of nano- and micro-structures is highly preferred. The nano-patterning tools should demonstrate the capability of transferring patterns to both flexible and rigid substrate with replication rates greater than 104. Novel approaches such as recent developments in plasmonic lithography may be considered.

PHASE III: This Phase III work will demonstrate scalability and repeatability of the nano-patterning tools. Industrial production of commercial photonic and electronic devices with the nano-patterning tools should be conducted.

COMMERCIAL/DUAL-USE APPLICATIONS: Novel microelectronic and photonic devices and novel processing approaches are equally valuable in the commercial electronic active device arena as in military application and the potential for flexibility and cost-savings provide great commercial potential for the expected research product.

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KEYWORDS: nanotechnology, photonics, photonic integrated circuits, integration, nanoimprint, plasmonic lithography, nanophotonics, large-area, high-throughput, manufacturing, flexible, patterning tools, 3D lithography, nano-fabrication, soft-lithography, low cost