Defense Advanced Research Projects Agency (DARPA)
DoD 22.D Small Business Technology Transfer (STTR) Annual BAA
Proposal Submission Instructions

INTRODUCTION

DARPA's mission is to make strategic, early investments in science and technology that will have long-term positive impact on our national security. As part of this mission, DARPA makes high-risk, high-reward investments in science and technology that have the potential to disrupt current understanding and/or approaches. The pace of discovery in both science and technology is accelerating worldwide, resulting in new fields of study and the identification of scientific areas ripe for small business utilization through the SBIR and STTR programs. Small businesses are critical for developing technology to support national security. Proposers are encouraged to consider whether the R/R&D being proposed to DoD Components also has private sector potential, either for the proposed application or as a base for other applications. The topics below focus on technical domains important to DARPA's mission pursuing innovative research concepts that fall within one of its technology offices. More information about DARPA's technical domains and research topics of interest may be found at: http://www.darpa.mil/about-us/offices.

Proposers responding to a topic in this BAA must follow all general instructions provided in the Department of Defense (DoD) STTR Program BAA. DARPA requirements in addition to or deviating from the DoD Program BAA are provided in the instructions below.

Specific questions pertaining to the administration of the DARPA Program and these proposal preparation instructions should be directed to: DARPA Small Business Programs Office at SBIR_BAA@darpa.mil. DSIP Topic Q&A will NOT be available for these DARPA topics. Technical questions related to improving the understanding of a topic's requirements must be submitted to SBIR_BAA@darpa.mil by the deadline listed below.

The following dates apply to this DARPA Topic release:

January 25, 2022: Topics issued for pre-release
February 09, 2022: Topics open; DARPA begins accepting proposals via DSIP
March 09, 2022: Deadline for technical question submission
March 15, 2022: Deadline for receipt of proposals no later than **12:00 pm ET**

PHASE I PROPOSAL GUIDELINES

The Defense SBIR/STTR Innovation Portal (DSIP) is the official portal for DoD SBIR/STTR proposal submission. Proposers are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Detailed instructions regarding registration and proposal submission via DSIP are provided in Appendix A.

Current Release Award Structure by Topic

Topic Number	Phase I		
	Technical Volume	Award Amount	Period of Performance (PoP)
HR0011ST2022D-01	25 pages	$225,000	12 months

Technical Volume (Volume 2)
The technical volume is not to exceed 20 pages and must follow the formatting requirements provided in the DoD STTR 2022.D Program BAA. Phase I commercialization strategy shall not exceed 5 pages. This should be the last section of the Technical Volume and will not count against the 20-page limit.

Content of the Technical Volume
Proposers should refer to the DARPA Phase I Proposal Instructions, provided on the DARPA Small Business site (https://www.darpa.mil/work-with-us/for-small-businesses/participate-sbir-sttr-program).

Cost Volume (Volume 3)
Please see the chart above for award amounts listed by topic. Proposers are required to use the Phase I – Volume 3: Cost Proposal Template (Excel Spreadsheet) provided on the DARPA Small Business site (https://www.darpa.mil/work-with-us/for-small-businesses/participate-sbir-sttr-program).

Company Commercialization Report (CCR) (Volume 4)
Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD STTR Program BAA for full details on this requirement. Information contained in the CCR will not be considered by DARPA during proposal evaluations.

Supporting Documents (Volume 5)
In addition to the documents required by DoD, small businesses may also submit additional documentation to support the Technical Volume (Volume 2) and the Cost Volume (Volume 3) in Volume 5.

PHASE II PROPOSAL GUIDELINES

Phase II proposals may only be submitted by Phase I awardees. Should DARPA have funding available and decide to proceed with a Phase II, proposers awarded a Phase I contract will be eligible to submit a proposal for Phase II and will be contacted by the DARPA Small Business Programs Office at the appropriate time during their Phase I period of performance. Phase II proposals will be evaluated in accordance with the applicable DoD or DARPA SBIR/STTR BAA. Phase II selection(s) are at the sole discretion of the government and are subject to funding availability and Phase I performance.

Topic Number	Phase II				
	Tech Volume	Award Amount	Period of Performance (PoP)	Option Amount	Option PoP
HR0011ST2022D-01	45 pages	$1,000,000	24 months	$500,000	12 mos

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)

DARPA does not offer TABA funding.

EVALUATION AND SELECTION

All proposals will be evaluated in accordance with the evaluation criteria listed in the DoD STTR 2022.D BAA. DARPA will conduct an evaluation of each conforming proposal. Proposals that do not comply with the requirements detailed in this BAA and the research objective(s) of the corresponding topic are considered non-conforming and therefore are not evaluated nor considered for award.

Using the evaluation criteria, the Government will evaluate each proposal in its entirety, documenting the strengths and weaknesses relative to each evaluation criterion, and, based on these identified strengths and weaknesses, determine the proposal's overall selectability. Proposals will not be evaluated against each other during the evaluation process, but rather evaluated on their own individual merit to determine how well the proposal meets the criteria stated in this BAA and the corresponding topic.

Awards will be made to proposers whose proposals are determined to be the most advantageous to the Government, consistent with instructions and evaluation criteria specified in the DoD STTR 2022.D BAA and availability of funding. Given the limited funding available for each topic released, not all proposals considered selectable will be necessarily selected for funding.

For the purposes of this proposal evaluation process, a selectable proposal is defined as follows:

Selectable: A selectable proposal is a proposal that has been evaluated by the Government against the evaluation criteria listed in the BAA and topic, and the strengths of the overall proposal outweighs its weaknesses. Additionally, there are no accumulated weaknesses that would require extensive negotiations and/or a resubmitted proposal.

For the purposes of this proposal evaluation process, a non-selectable proposal is defined as follows:

Non-Selectable: A proposal is considered non-selectable when the proposal has been evaluated by the Government against the evaluation criteria listed in the BAA and topic, and the strengths of the overall proposal do not outweigh its weaknesses.

Proposing firms will be notified of selection or non-selection status for a Phase I award within 90 days of the closing date of the BAA. It is the policy of DARPA to treat all proposals as source selection information and to disclose their contents only for the purpose of evaluation. Restrictive notices notwithstanding, during the evaluation process, submissions may be handled by support contractors for administrative purposes and/or to assist with technical evaluation. All DARPA support contractors are expressly prohibited from performing DARPA-sponsored technical research and are bound by appropriate nondisclosure agreements. Input on technical aspects of the proposals may be solicited by DARPA from other Government and/or non-Government consultants/experts who are strictly bound by the appropriate non-disclosure requirements. No submissions will be returned. Upon completion of the evaluation and selection process, an electronic copy of each proposal received will be retained at DARPA.

Proposal titles, abstracts, anticipated benefits, and keywords of proposals that are selected for contract award will undergo a DARPA Policy and Security Review. Proposal titles, abstracts, anticipated benefits, and keywords are subject to revision and/or redaction by DARPA. Final approved versions of proposal titles, abstracts, anticipated benefits, and keywords may appear on the DoD SBIR/STTR awards website and/or the SBA's SBIR/STTR award website (https://www.sbir.gov/sbirsearch/award/all).

Refer to the DoD STTR 2022.D Program BAA for procedures to protest the Announcement.
As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests regarding the selection decision should be submitted to:

DARPA
Contracts Management Office (CMO)
675 N. Randolph Street
Arlington, VA 22203
E-mail: scott.ulrey@darpa.mil and sbir@darpa.mil

AWARD AND CONTRACT INFORMATION

1. General Award Information

Multiple awards are anticipated. DARPA may award FAR-based government contracts (Firm- Fixed Price or Cost-Plus Reimbursement) or Other Transactions for Prototypes agreement (under the authority of 10 U.S.C. § 2371b) subject to approval of the Contracting Officer. The amount of resources made available under each topic issued under this BAA will depend on the quality of the proposals received and the availability of funds.

The Government reserves the right to select for negotiation all, some, one, or none of the proposals received in response to this announcement and to make awards with or without communications with proposers. Additionally, the Government reserves the right to award all, some, one, or none of the options on the contract(s)/agreement(s) of the performers based on available funding and technical performance. If warranted, portions of resulting awards may be segregated into pre-priced options. Additionally, DARPA reserves the right to accept proposals in their entirety or to select only portions of proposals for award. In the event that DARPA desires to award only portions of a proposal, negotiations may be opened with that proposer. The Government reserves the right to fund proposals in phases with options for continued work, as applicable.

The Government reserves the right to request any additional, necessary documentation once it makes the award instrument determination. The Government reserves the right to remove a proposal from award consideration should the parties fail to reach agreement on award terms, conditions, and price within a reasonable time, and/or the proposer fails to provide requested additional information within three business days.

In all cases, the Government Contracting Officer reserves the right to select award instrument type, regardless of instrument type proposed, and to negotiate all instrument terms and conditions with selectees. DARPA will apply publication or other restrictions, as necessary, if it determines that the research resulting from the proposed effort will present a high likelihood of disclosing performance characteristics of military systems or manufacturing technologies that are unique and critical to defense. Any award resulting from such a determination will include a requirement for DARPA permission before publishing any information or results on the program. For more information on publication restrictions, see the DoD STTR 2022.D Program BAA.

Because of the desire to streamline the award negotiation and program execution process, proposals identified for negotiation will result in negotiating a type of instrument for award that is in the best interest of the Government. In the case of an OT for Prototype agreement under DARPA's authority to award OTs for prototype projects, 10 U.S.C. § 2371b, use of an OT provides significant opportunities for flexible execution to assist in meeting DARPA's aggressive SBIR/STTR program goals.

All proposers that wish to consider an OT award should carefully read the following:

The flexibility of the OT award instrument is beneficial to the program because the Performer will be able to apply its best practices as required to carry out the research project that may be outside of the Federal Acquisition Regulation (FAR) process-driven requirements. Streamlined practices will be used, such as milestone-driven performance, intended to reduce time and effort on award administration tasks and permit performers to focus on the research effort and rapid prototyping. Because of this ability, OTs provide the Agreements Officer the flexibility to create an award instrument that contains terms and conditions that promote commercial transition, reduce some administratively burdensome acquisition regulations, and meet SBIR/STTR program goals.

Proposers must only propose an OT agreement with fixed payable milestones. Fixed payable milestones are fixed payments based on successful completion of the milestone accomplishments agreed to in the milestone plan. Refer to the Other Transactions for Prototypes Fact Sheet and Other Transaction for Prototype Agreement, available at https://www.darpa.mil/work-with-us/for-small-businesses/participate-sbir-sttr-program. Specific milestones will be based upon the research objectives detailed in the SBO.

Please see https://www.darpa.mil/work-with-us/for-small-businesses/participate-sbir-sttr-program for more information on OTs.

2. Transition and Commercialization Support Program (TCSP)

DARPA will provide services to Phase II or DP2 awardees upon contract execution through the Transition and Commercialization Support Program (TCSP) at no cost to awardees. The TCSP goal is to maximize the potential for SBIR/STTR companies to move their technology beyond Phase II, and into other research and development programs for further maturity, or into solutions or products for DoD acquisition programs, other Federal programs, and/or the commercial market. Please visit https://www.darpa.mil/work-with-us/for-small-businesses/commercialization-continued for more information on DARPA TCSP.

3. Embedded Entrepreneurship Initiative

Awardees of SBIR funding pursuant to this BAA may be eligible to participate in the DARPA Embedded Entrepreneurship Initiative (EEI) during the Period of Performance. Invitation to participate in EEI is at the sole discretion of the Government based on evaluation of technical and commercial factors and subject to program balance and the availability of funding. EEI is a limited scope program offered by DARPA, at DARPA's discretion, to a small subset of awardees. The goal of DARPA's EEI is to increase the likelihood that DARPA-funded technologies take root in the U.S. and provide new capabilities for national defense. EEI supports DARPA's mission "to make pivotal investments in breakthrough technologies and capabilities for national security" by accelerating the transition of innovations out of the lab and into new capabilities for the Department of Defense (DoD). EEI investment supports development of a robust and deliberate Go-to-Market strategy for selling technology product to the government and commercial markets and positions DARPA awardees to attract U.S. investment. The following is for informational and planning purposes only and does not constitute solicitation of proposals to the EEI.

There are three elements to DARPA's EEI: (1) A Senior Commercialization Advisor (SCA) from DARPA who works with the Program Manager (PM) to examine the business case for the awardee's technology and uses commercial methodologies to identify steps toward achieving a successful transition of technology to the government and commercial markets; (2) Connections to potential industry and investor partners via EEI's Investor Working Groups; and (3) Additional funding on an awardee's contract for the awardee to hire an embedded entrepreneur to achieve specific milestones in a Go-to-Market strategy for transitioning the technology to products that serve both defense and commercial markets. This embedded entrepreneur's qualifications should include business experience within the target industries of interest, experience in commercializing early stage technology, and the ability to communicate and interact with technical and non-technical stakeholders. Funding for EEI is typically no more than $250,000 per awardee over the duration of the award. An awardee may apportion EEI funding to hire more than one embedded entrepreneur, if achieving the milestones requires different expertise that can be obtained without exceeding the awardee's total EEI funding. The EEI effort is intended to be conducted concurrent with the research program without extending the period of performance.

EEI Application Process:

After receiving an award under the solicitation, awardees interested in being considered for EEI should notify their DARPA Program Manager (PM) during the period of performance. Timing of such notification should ideally allow sufficient time for DARPA and the awardee to review the awardee's

initial transition plan, identify milestones to achieve under EEI, modify the award, and conduct the work required to achieve such milestones within the original award period of performance. These steps may take 9-18 months to complete, depending on the technology. If the DARPA PM determines that EEI could be of benefit to transition the technology to product(s) the Government needs, the PM will refer the performer to DARPA Commercial Strategy.

DARPA Commercial Strategy will then contact the performer, assess fitness for EEI, and in consultation with the DARPA technical office, determine whether to invite the performer to participate in the EEI. Factors that are considered in determining fitness for EEI include DoD/Government need for the technology; competitive approaches to enable a similar capability or product; risks and impact of the Government's being unable to access the technology from a sustainable source; Government and commercial markets for the technology; cost and affordability; manufacturability and scalability; supply chain requirements and barriers; regulatory requirements and timelines; Intellectual Property and Government Use Rights, and available funding.

Invitation to participate in EEI is at the sole discretion of DARPA and subject to program balance and the availability of funding. EEI participants' awards may be subsequently modified bilaterally to amend the Statement of Work to add negotiated EEI tasks, provide funding, and specify a milestone schedule which will include measurable steps necessary to build, refine, and execute a Go-to-Market technology transition plan aimed at delivering new capabilities for national defense. Milestone examples are available at: https://www.darpa.mil/work-with-us/contract-management.

Awardees under this solicitation are eligible to be considered for participation in EEI, but selection for award under this solicitation does not imply or guarantee participation in EEI.

For more information please refer to the EEI website https://eei.darpa.mil/.

ADDITIONAL INFORMATION

DARPA intends to use electronic mail for all correspondence regarding these topics. Questions related to the technical aspect of the research objectives and awards specifically related to a topic should be emailed to SBIR_BAA@darpa.mil. Please reference the topic number in the subject line. All questions must be in English and must include the name, email address, and the telephone number of a point of contact.

DARPA will attempt to answer questions in a timely manner; however, questions submitted within seven (7) calendar days of the proposal due date listed herein may not be answered. DARPA will post a consolidated Frequently Asked Questions (FAQ) document. To access the posting please visit: http://www.darpa.mil/work-with-us/opportunities. Under the topic number summary, there will be a link to the FAQ. The FAQ will be updated on an ongoing basis until one week prior to the proposal due date.

Technical support for the Defense SBIR/STTR Innovation Portal (DSIP) is available Monday through Friday, 9:00 a.m. – 5:00 p.m. ET. Requests for technical support must be emailed to DoDSBIRSupport@reisystems.com with a copy to SBIR_BAA@darpa.mil.

DARPA STTR 22.D Topic Index
Release 1

HR0011ST2022D-01	Biologically Driven High-Resolution Assembly of Flexible Light-Emitting Display

HR0011ST2022D-01 TITLE: Biologically Driven High-Resolution Assembly of Flexible Light-Emitting Display

OUSD (R&E) MODERNIZATION PRIORITY: Biotechnology, Microelectronics

TECHNOLOGY AREA(S): Electronics, Materials/Processes

OBJECTIVE: Develop a biology-based approach to assemble precisely structured arrays of pixels comprised of quantum dots for colorful, efficient, and flexible electroluminescent light-emitting displays

DESCRIPTION: Inorganic quantum dot (QD) nanoparticles exhibit uniquely tunable optoelectronic properties [1]. Their use in electroluminescent films will enhance capabilities of light-emitting diodes (QD-LEDs), which perform crucial functions in defense and personal electronic devices. QD-LED displays, such as those in computer monitors, will deliver more colorful, high-resolution images, operate at higher efficiencies, and enable flexible or bendable device configurations [2].

QD-LEDs are comprised of two-dimensional periodic pixel arrays with rapid response rates. Each full-color pixel consists of distinct QDs that assemble into red, green, and blue (RGB) constituent sub-pixels. Although QD-LEDs show promise, they require novel fabrication approaches to precisely pattern QD pixels and optimize performance. Spin-casting cannot pattern microscale multicolor pixels without cross-contaminating distinct light-emitting QDs. Top-down photolithography may leave behind photoresist processing residue that impedes charge transfer. Emerging methods, such as inkjet printing, are expensive and have not yet surpassed performance levels offered by LCD and OLED competing technologies [3]. Synthetic biology enables novel control over engineering of peptides and microbes. Their finely tuned interactions with QDs may enable the bottom-up assembly of high-resolution patterns with tunable electronic and photonic properties [4]. Previously, DNA or protein biopolymers have been used to assemble inorganic nanomaterials into functional electronic components [5]. DNA scaffolds have facilitated self-assembly and patterning of plasmonic materials and carbon nanotubes [6, 7]. Conductive biomolecules, such as mesoscale silk fibroin networks, may 1) organize inorganic nanoparticles into periodic two-dimensional arrays, and 2) facilitate electronic conductivity through optoelectronic material networks [8].

This topic seeks to demonstrate the feasibility of using customizable biopolymers to fabricate novel, flexible QD-LEDs that exhibit full RGB colors (emission wavelengths: red: 630 nm; green: 530 nm; blue: 450 nm). This effort aims to develop the necessary biological tools to pattern externally synthesized inorganic QDs into pixel arrays that function as electroluminescent light-emitting displays. Performers will utilize peptides, DNA scaffolds, and/or other biological tools to arrange QDs into arrays of microscale pixels (containing RGB sub-pixels). Performers will use QDs of their choosing (to include commercially available materials). This program encourages use of synthetic biology tools to optimize particle arrangement approaches. Importantly, this effort will directly contrast the bio-based strategy against state-of-the-art nanofabrication approaches that assemble functional QD-LEDs. This program will culminate in a demonstration of a functional QD-LED display at least 2.5 inches (6.35 cm) wide. A bio-driven approach will assemble QDs into its electroluminescent layer. Performers will demonstrate a conventional stacked film configuration of QD-LEDs: electrodes, electron and hole charge carrier transport layers, the luminescent QD layer, and an external protective coating. Performers will choose the materials and assembly methods that deliver the required final prototype functionality. The resulting device will demonstrate a high pixel resolution [> 3000 pixel per inch (ppi)] that will exhibit the full RGB color spectrum. Biologically- assembled electroluminescent QD-LEDs will operate with > 25% external quantum efficiencies (EQEs). The device will reliably operate in ambient environments for extended time periods while maintaining high luminosity. The final QD-LED will demonstrate repeated flexibility and bendability for foldable or curved light-emitting displays.

PHASE I: Develop a biologically-driven approach that assembles QDs into a pixelated two-dimensional film, which, with an externally applied electrical current, functions as a proof-of-concept electroluminescent QD-LED. Phase I prototype deliverable will emit monochromatic visible light (wavelength within the 450 – 700 nm range). The film should be at least 1 cm wide and can assume a rectangular or circular shape. The biopatterning technique will yield rectangular-shaped pixels with a 100 pixel-per-inch (ppi) resolution or greater, making each pixel 250 μm wide. Performers will need to fabricate necessary electrode and carrier injection layers that will complement the patterned QD pixels and enable electroluminescent operation of this proof-of-concept prototype. Physical elements used for biopatterning must be either compatible with (functionally integrated into) these layers, or fully removed from the film following completion of their intended QD assembly function, to prevent any detrimental interference with QDLED operation.

Schedule/Milestones/Deliverables

Phase I fixed milestones for this program should include:

- Month 2: Deliver a report that identifies the selected biological system(s), as well as the inorganic QDs, that will be integrated to form ordered pixels and arrays. Demonstrate biocompatibility of proposed biological systems with targeted QDs.
- Month 4: Demonstrate proof-of-concept ability to utilize the selected biological system(s) to organize QDs into films. Deliver a summary of complementary electrode and charge carrier materials, synthesis methods that will assemble them in conjunction with the QD films to exhibit electroluminescence, and experimentally-corroborated proof of compatibility of these device components with bio-patterned QD films.
- Month 6: Demonstrate the results and a detailed description of the employed methodology to use selected biological system(s) in order to arrange QDs in an array (of regularly spaced rectangles [pixels]) with an overall array length of ≥1 mm and a width of ≤250 μm of each pixel.
- Month 8: Document the ability to use biology to pattern a 2-dimensional array with equal pixel size and close-packed spacing between QDs in both x and y directions.
- Month 10: Develop and test a proof-of-concept multilayer assembly (electrodes, carrier charge layers, and luminescent QD film) that is electronically conductive, optically transparent, and utilizes the selected biological system(s) to organize/pattern a functional electroluminescent QD layer (activated with an applied electrical current).
- Month 12: Final Phase I Report that summarizes the overall approach and provides a description of the composition and operation of a proof-of-concept device architecture that uses a biological system to assemble QDs into a monochromatic, electroluminescent QD-LED. Its geometric configuration and mode of operation is expected to parallel that of conventional LED (such as an LED or OLED). Upon application of an external electrical current, the prototype will emit visible light perceptible to the naked eye. The LED will have a diagonal width of 1 cm or greater, with a luminescent layer comprised of rectangularly-shaped pixels, each with a side length ≤250 μm. The screen resolution for the Phase I prototype will be at least 100 pixels per inch (ppi). Test data should include device operational lifetime analysis (hours vs. luminosity and/or hours vs. quantum efficiency).

PHASE II: Phase II Base: Develop, test, and demonstrate a biology-driven approach to assemble QDs into a high-resolution, full-color, flexible electroluminescent light-emitting display. Performers are expected to expand beyond the capabilities of the proof-of-concept prototype demonstrated at the end of Phase I and develop a device that meets or exceeds performance found with commercially available LEDs, such as those in screens of personal electronics (target device performance is described below). Performers must benchmark their approach against comparable QD-LED fabrication methods used in

conventional manufacturing and demonstrate technical and commercial advantages of their bio-based approach.

The QD-LED demonstrated at the end of Phase II must employ the bio-based approach to organize tri-color quantum dot pixels exhibiting RGB colors into a two-dimensional electroluminescent display film. The QD-LED display prototype must be at least 1 inch (2.54 cm) wide and exhibit a resolution of 3000 pixel per inch (ppi) or higher (7200 x 7200 pixels comprising the 1-inch-wide display). The display must have a luminosity of 2000 cd/m2 or higher. The electroluminescent quantum dots patterned into the QD-LED must operate with an EQE of at least 20%. Resulting QD-LED prototype must emit light for at least 500 hours without decaying in luminosity by more than 5%. Packaging of the prototype must allow it to operate in real-life environments that are common for conventional electronics (i.e. outside of an inert gas-filled glovebox). The final fully-functional QD-LED prototype should be capable of repeated bending that expands the viewing angle to above 90 degrees.

Schedule/Milestones/Deliverables

Phase II Base fixed milestones for this program should include:

- Month 2: New Capabilities Report, which identifies additions and modifications that will be researched, developed, and customized for enhancement and optimization of the Phase I system to enable Phase II goals to be met.
- Month 4: Report on fabrication and testing of a proof-of-concept prototype electroluminescent QD-LED. The display should be comprised of bio-patterned QDs that operate with an EQE of 10% or higher, and a luminosity of 100 cd/m2 or higher.
- Month 6: Report that describes the state-of-the art manufacturing method that performers will use for comparison against their bio-based QD-LED assembly approach. The comparison must include experimental data that describes this approach's implementation and methodologies, as well as analysis of the method's costs and resulting QD-LED performance.
- Month 9: Experimentally demonstrate mechanical flexibility of the bio-based patterned QD layer and its ability to repeatably bend without breaking or affecting its electroluminescent performance. Demonstrate ability to modify bio-based QD patterning to control inter-pixel spacing to minimize image distortion during bending of QD-LED film.
- Month 12: Report on the feasibility of the bio-based patterning of an electroluminescent film comprised of pixels of two distinct colors (e.g. red and blue, green and red, or green and blue). Each pixel must be of identical size, and each color sub-pixel must be of identical size and luminosity. The pattern must retain regular periodicity throughout the display, which must be 1 cm or greater in width. The film that incorporates these pixels must exhibit these colors, and their combinations must be clearly visible to the naked eye of a human observer.
- Month 15: Report on the feasibility of the bio-based patterning of an electroluminescent film comprised of RBG pixels, with the same metrics for periodicity, pixel size, and observation capabilities as stated in month 12.
- Month 18: Demonstration of QD-LEDs that enable electroluminescent operation of RGB QD pixels with EQEs of at least 15%. Improve scalability of approach and deliver a light-emitting display with a width of at least 2 cm. Develop and demonstrate packaging of the display that enables its operation in ambient environments, to include oxygenated atmosphere, varying humidity levels, and room temperature. Assess operating lifetime of the display, including luminosity vs. timeline during constant operation, and achieve a minimum of 250 hours without decaying by more than 10%.
- Month 21: Report that comprehensively benchmarks the manufacturing method and performance of the bio-patterned QD-LED demonstrated in Month 18 against the SOA non-bio-based QD-LED synthesis approach. The report needs to directly compare the technical performance of the two methods, including luminescence, pixel resolution, external quantum efficiency, and

operating lifetime. Experimental comparison of the two prototypes must analyze identically sized bio-based QD-LED and non-bio-biased (SOA) QD-LED test coupons.

- Month 24: Final Phase II report that documents the fabrication and performance of the display, including structure of fully assembled functional QD-LEDs, biological assembly platforms, methods used to manufacture the display, the physical characteristics of the resulting device, and its performance testing results (including performance documented with photography/videography, as well as a description of methods and formulas used to calculate the key metrics that assess its performance). Report must include data that demonstrates the following: 1) bio-assembled electroluminescent display that clearly demonstrates fully visible RGB colors; 2) QDs in the display exhibit an EQE of at least 20%; 3) display width of 1 inch or greater; 4) luminosity of at least 2000 cd/m2; 5) lifetime assessment that demonstrates a luminosity decay of less than 5% after 500 hours of operation; 6) resolution of 3000 ppi or higher; 7) mechanical flexibility that enables a viewing angle of at least 90 degrees.

Phase II Option: The Phase II Option 12-month period aims to further scale up the size of the bio-patterned QD-LED prototype, improve its technological capabilities and versatility performance metrics, and advance its integration into DoD or commercial prototypes. Performers must develop capabilities to demonstrate high-resolution images and video on screens of QD-LEDs and scale-up dimensions of the technology to levels of targeted end products (such as those comparable to state-of-the-art mobile telephones or computer tablet screen) without a decrease in performance. Three prototypes will be delivered to the government for testing and analysis.

Schedule/Milestones/Deliverables

Phase II Option fixed milestones for this program should include:

- Month 2: Demonstrate the ability to exhibit a series of 5 still RGB images (with > 3000 ppi resolution) from data files on the screen of the display.
- Month 4: Demonstrated rapid color switching of QD color (turn pixel on/off) and color recycling with a fast refresh rate (of at least 2000 Hz) in the full-color QD-LED prototype.
- Month 6: Deliver three prototypes to U.S. government laboratories for testing and analysis.
- Month 9: Exhibit ability to scale up bio-based QD-LED to a width of 6.35 cm or more. Demonstrate ability of the prototype to repeatedly bend back and forth by 45 degrees or more for at least 100 cycles while operating without breaking.
- Month 12: Improve EQEs of QDs to 25%. Improve luminosity to over 10,000 cd/m2. Demonstrate continuous operation lifetimes of at least 2,000 hours with a luminosity decay of less than 5%. Demonstrate an ability to exhibit a 30-second full-color video file on the display (with > 3000 ppi resolution).

PHASE III DUAL USE APPLICATIONS: Electroluminescent QD-LED are highly desired for colorful, efficient, and flexible consumer electronics. Use of biologically-driven synthesis approaches that offer greater precision can enhance the performance capabilities of resulting devices over existing quantum dot technologies synthesized using conventional means. Precise patterning of inorganic nanoparticles using developed biological tools, such as microbes and biopolymers, may enable a wide variety of high-performance electronics that can be produced domestically using more environmentally friendly and less expensive methods. Non-defense applications of technologies developed under this program may include flexible displays for mobile phones and televisions, wearable personal electronics, smart textiles, antennas that receive microwaves or radio waves, circuitry components such as resistors and capacitors, and biomedical sensors and implants.

REFERENCES:

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3. [3] Song, J.-K., et al., Materials and devices for flexible and stretchable photodetectors and light-emitting diodes. Nano Research, 2021. 14 (9): p. 2919-2937.
4. [4] Shin, J., et al., Programming Escherichia coli to function as a digital display. Molecular Systems Biology, 2020. 16 (3): p. e9401.
5. [5] Sun, Q., et al., Highly Efficient Quantum-Dot Light-Emitting Diodes with DNA−CTMA as a Combined Hole-Transporting and Electron-Blocking Layer. ACS Nano, 2009. 3 (3): p. 737-743.
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7. [7] DeLuca, M., et al., Dynamic DNA nanotechnology: toward functional nanoscale devices. Nanoscale Horizons, 2020. 5 (2): p. 182-201.
8. [8] Fernández-Luna, V., et al., Biogenic fluorescent protein–silk fibroin phosphors for high performing light-emitting diodes. Materials Horizons, 2020. 7 (7): p. 1790-1800.

KEYWORDS: Light-emitting display, quantum dot, biological fabrication, synthetic biology, flexible electronics

Appendix A: DARPA PHASE I PROPOSAL INSTRUCTIONS

I. Introduction

A complete proposal submission consists of:

Volume 1: Proposal Cover Sheet
Volume 2: Technical Volume
Volume 3: Cost Volume
Volume 4: Company Commercialization Report
Volume 5: Supporting Documents
Volume 6: Fraud, Waste and Abuse Training

The Defense SBIR/STTR Innovation Portal (DSIP) provides a structure for building the proposal volumes and submitting a consolidated proposal package. If this is your first time submitting an SBIR or STTR proposal using DSIP, please review detailed training guides at https://www.dodsbirsttr.mil/submissions/learning-support/training-materials. It is the responsibility of the proposing firm to ensure that a complete proposal package is certified and submitted by the close date listed in the TOPIC to which they are responding.

To assist in proposal development, templates for Volume 2: Technical Volume and Volume 3: Cost Volume have been provided as attachments to the announcement posted at https://www.darpa.mil/work-with-us/for-small-businesses/participate-sbir-sttr-program. Use of these templates is mandatory.

II. Proprietary Information

Proposers that include in their proposals data that they do not want disclosed to the public for any purpose, or used by the Government except for evaluation purposes, shall follow instructions in the DoD SBIR 2022.4/STTR 2022.D BAA regarding marking propriety proposal information.

III. Phase I Proposal Instructions

a. Proposal Cover Sheet (Volume 1)

The Cover Sheet must include a brief technical abstract of no more than 3000 characters that describes the proposed R&D project with a discussion of anticipated benefits and potential commercial applications. **Do not include proprietary or classified information in the Proposal Cover Sheet**. If your proposal is selected for award, the technical abstract and discussion of anticipated benefits may be publicly released.

b. Format of Technical Volume (Volume 2)

1. Type of file: The Technical Volume must be a single Portable Document Format (PDF) file, including graphics. Perform a virus check before uploading the Technical Volume file. If a virus is detected, it may cause rejection of the proposal. **Do not lock or encrypt the uploaded file**. **Do not include or embed active graphics such as videos, moving pictures, or other similar media in the document.**

2. Length: The length of the technical volume will be specified by the corresponding

topic. The Government will not consider pages in excess of the page count limitations.

3. Layout: Number all pages of your proposal consecutively. Font size should not be smaller than 10-point on standard 8-1/2" x 11" paper with one-inch margins. The header on each page of the Technical Volume should contain your company name, topic number, and proposal number assigned by DSIP when the Cover Sheet was created. The header may be included in the one-inch margin. Please refer to the attachment titled Phase I Template – Volume 2: Technical Volume at https://www.darpa.mil/work-with-us/for-small-businesses/participate-sbir-sttr-program for additional details.

c. Content of the Technical Volume (Volume 2)

The Technical Volume should cover the following items in the order given below:

1. **Identification and Significance of the Problem or Opportunity.** Define the specific technical problem or opportunity addressed and its importance.

2. **Phase I Technical Objectives.** Enumerate the specific objectives of the Phase I work, including the questions the research and development effort will try to answer to determine the feasibility of the proposed approach.

3. **Phase I Statement of Work (including Subcontractors' Efforts)**

   a) Provide an explicit, detailed description of the Phase I approach. The Statement of Work should indicate what tasks are planned, how and where the work will be conducted, a schedule of major events, and the final product(s) to be delivered. The Phase I effort should attempt to determine the technical feasibility of the proposed concept. The methods planned to achieve each objective or task should be discussed explicitly and in detail. This section should be a substantial portion of the Technical Volume section.

   b) The topic may have been identified by the Program Manager as research or activities involving Human/Animal Subjects and/or Recombinant DNA. In the event that Phase I performance includes performance of these kinds of research or activities, please identify the applicable protocols and how those protocols will be followed during Phase I. Please note that funds cannot be released or used on any portion of the project involving human/animal subjects or recombinant DNA research or activities until all of the proper approvals have been obtained (see DoD SBIR 2022.4/STTR 2022.D BAA).

4. **Related Work**. Describe significant activities directly related to the proposed effort, including any conducted by the PI, the proposing firm, consultants, or others. Describe how these activities interface with the proposed project and discuss any planned coordination with outside sources. The technical volume must persuade reviewers of the proposer's awareness of the state-of-the-art in the specific topic. Describe previous work not directly related to the proposed effort but similar. Provide the following: (1) short description, (2) client for which work was performed (including individual to be contacted and phone number), and (3) date of completion.

5. **Relationship with Future Research or Research and Development**

   a) State the anticipated results of the proposed approach if the project is successful.

   b) Discuss the significance of the Phase I effort in providing a foundation for Phase II research or research and development effort.

   c) Identify the applicable clearances, certifications and approvals required to conduct Phase II testing and outline the plan for ensuring timely completion of said authorizations in support of Phase II research or research and development effort.

6. **Key Personnel**. Identify key personnel who will be involved in the Phase I effort including information on directly related education and experience. A concise technical resume of the PI, including a list of relevant publications (if any), must be included (Please do not include Privacy Act Information). All resumes will count toward the page limit for Volume 2, as specified in the topic.

7. **Foreign Citizens**. Identify any foreign citizens or individuals holding dual citizenship expected to be involved on this project as a direct employee, subcontractor, or consultant. For these individuals, please specify their country of origin, the type of visa or work permit under which they are performing and an explanation of their anticipated level of involvement on this project. Refer to DoD SBIR 2022.4/STTR 2022.D BAA for more information.

   Supplemental information provided in response to this paragraph will be protected in accordance with the Privacy Act (5 U.S.C. 552a), if applicable, and the Freedom of Information Act (5 U.S.C. 552(b)(6)).

8. **Facilities/Equipment**. Describe available instrumentation and physical facilities necessary to carry out the Phase I effort. Justify equipment purchases in this section and include detailed pricing information in the Cost Volume. State whether or not the facilities where the proposed work will be performed meet environmental laws and regulations of federal, state (name), and local Governments for, but not limited to, the following groupings: airborne emissions, waterborne effluents, external radiation levels, outdoor noise, solid and bulk waste disposal practices, and handling and storage of toxic and hazardous materials.

9. **Subcontractors/Consultants**. Subcontractor means any supplier, distributor, vendor, firm, academic institution, research center, or other person or entity that furnishes supplies or services pursuant to a subcontract, at any tier. Involvement of a university or other subcontractors or consultants in the project may be appropriate. If such involvement is intended, it should be identified and described according to the Cost Breakdown Structure at https://www.dodsbirsttr.mil/submissions/learning-support/firm-templates. Please refer to DoD SBIR 2022.4/STTR 2022.D BAA for detailed eligibility requirements as it pertains to the use of subcontractors/consultants.

10. **Prior, Current, or Pending Support of Similar Proposals or Awards**. If a proposal submitted in response to a corresponding topic is substantially the same as another proposal that was funded, is now being funded, or is pending with another Federal Agency, or another DoD Component or DARPA, you must reveal this on the Proposal Cover Sheet and provide the following information:

a) Name and address of the Federal Agency(s) or DoD Component to which a proposal was submitted, will be submitted, or from which an award is expected or has been received.
b) Date of proposal submission or date of award.
c) Title of proposal.
d) Name and title of the PI for each proposal submitted or award received.
e) Title, number, and date of BAA(s) or solicitation(s) under which the proposal was submitted, will be submitted, or under which award is expected or has been received.
f) If award was received, state contract number.
g) Specify the applicable topics for each proposal submitted or award received.

Note: If this does not apply, state in the proposal "No prior, current, or pending support for proposed work."

11. **Transition and Commercialization Strategy**. DARPA is equally interested in dual use commercialization of SBIR/STTR project results to the U.S. military, the private sector market, or both, and expects explicit discussion of key activities to achieve this result in the transition and commercialization strategy part of the proposal. Phase I is the time to plan for and begin transition and commercialization activities. The small business must convey an understanding of the market, competitive landscape, potential stakeholders and end-users, and preliminary transition path or paths to be established during the Phase I project. The Phase I transition and commercialization strategy shall not exceed 5 pages.

    It should be the last section of the technical volume and include the following elements:

    a) **A summary of transition and commercialization activities conducted during prior SBIR/STTR efforts if applicable, and the Technology Readiness Level (TRL) achieved.**
    b) **Problem or Need Statement.** Briefly describe the problem, need, or requirement, and its significance relevant to a Department of Defense application and/or a private sector application that the SBIR/STTR project results would address. Is there a broader societal need you are trying to address? Please describe.
    c) **Description of Product(s) and/or System Application(s).** Identify the commercial product(s) and/or DoD system(s), or system(s) under development, or potential new system(s). Identify the potential DoD end- users, Federal customers, and/or private sector customers who would likely use the technology.
    d) **Business Model(s)/Procurement Mechanism(s).** Discuss your current business model hypothesis for bringing the technology to market. Describe plans to license, partner, or self-produce your product. How do you plan to generate revenue? Describe the resources you expect will be needed to implement your business models. Discuss your plan and expected timeline to secure these resources. Understanding DARPA's goal of creating and sustaining a U.S. military advantage, describe how you intend to develop your product and supply chains to enable this differentiation.
    e) **Target Market**. Describe the market and addressable market for the innovation. Describe the customer sets you propose to target, their size, their growth rate, and their key reasons they would consider procuring the

technology. Discuss the business economics and market drivers in the target industry. Describe competing technologies existent today on the market as well as those being developed in the lab. How has the market opportunity been validated? Describe the competition. How do you expect the competitive landscape may change by the time your product/service enters the market?

f) **Funding Requirements.** Describe your company's funding history. How much external financing have you raised? Describe your plans for future funding sources (internal, loan, angel, venture capital, etc.).

g) **Transition and Commercialization Risks**. Describe the major technology, market and team risks associated with achieving successful transition and commercialization of the DARPA funded technology. DARPA is not afraid to take risks but we want to ensure that our awardees clearly understand the risks in front of them. What are the key risks in bringing your innovation to market? What are actions you plan to undertake to mitigate these risks?

h) **Expertise/Qualifications of Team/Company Readiness.** Describe the expertise and qualifications of your management, marketing/business development and technical team that will support the transition of the technology from the prototype to the commercial market and into government operational environments. Has this team previously taken similar products/services to market? If the present team does not have this needed expertise, how do you intend to obtain it? What is the financial history and health of your company (e.g., availability of cash, profitability, revenue growth, etc.)?

i) **Anticipated Transition and Commercialization Results.** Include a schedule showing the anticipated quantitative transition and commercialization results from the Phase II project at one year after the start of Phase II, at the completion of Phase II, and after the completion of Phase II (i.e., amount of additional investment, sales revenue, etc.). After Phase II award, the company is required to report actual sales and investment data in its Company Commercialization Report at least annually.

Advocacy Letters (OPTIONAL)* Feedback received from potential Commercial and/or DoD customers and other end-users regarding their interest in the technology to support their capability gaps. Advocacy letters that are faxed or e-mailed separately will NOT be accepted.

Letters of Intent/Commitment (OPTIONAL)* Relationships established, feedback received, support and commitment for the technology with one or more of the following: Commercial customer, DoD PM/PEO, a Defense Prime, or vendor/supplier to the Primes and/or other vendors/suppliers identified as having a potential role in the integration of the technology into fielded systems/products or those under development. Letters of Intent/Commitment that are faxed or e-mailed separately will NOT be accepted.

*Advocacy Letters and Letters of Intent/Commitment are optional, and should ONLY be submitted to substantiate any transition or commercialization claims made in the commercialization strategy. Please DO NOT submit these letters just for the sake of including them in your proposal. These letters DO NOT count against any page limit.

In accordance with section 3-209 of DOD 5500.7-R, Joint Ethics Regulation, letters from government personnel will NOT be considered during the evaluation process.

d. Format of Cost Volume (Volume 3)

Proposers are required to use the Phase I – Volume 3: Cost Proposal Template (Excel Spreadsheet) provided at https://www.darpa.mil/work-with-us/for-small-businesses/participate-sbir-sttr-program.

e. Content of the Cost Volume (Volume 3)

Some items in the Cost Breakdown Guidance below may not apply to the proposed project. If such is the case, there is no need to provide information on each and every item.

ALL proposed costs should be accompanied by documentation to substantiate how the cost was derived. For example, if you proposed travel cost to attend a project-related meeting or conference, and used a travel website to compare flight costs, include a screen shot of the comparison. Similarly, if you proposed to purchase materials or equipment, and used the internet to search for the best source, include your market research for those items. You do not necessarily have to propose the cheapest item or supplier, but you should explain your decision to choose one item or supplier over another. It's important to provide enough information to allow contracting personnel to understand how the proposer plans to use the requested funds.

If selected for award, failure to include the documentation with your proposal will delay contract negotiation, and the proposer will be asked to submit the necessary documentation to the Contracting Officer to substantiate costs (e.g., cost estimates for equipment, materials, and consultants or subcontractors). It is important to respond as quickly as possible to the Contracting Officer's request for documentation.

Cost Breakdown Guidance:

- List all key personnel by name as well as by number of hours dedicated to the project as direct labor.
- Special tooling and test equipment and material cost may be included. The inclusion of equipment and material will be carefully reviewed relative to need and appropriateness for the work proposed. The purchase of special tooling and test equipment must, in the opinion of the Contracting Officer, be advantageous to the Government and should be related directly to the specific topic. These may include such items as innovative instrumentation and/or automatic test equipment. Title to property furnished by the Government or acquired with Government funds will be vested with DARPA; unless it is determined that transfer of title to the contractor would be more cost effective than recovery of the equipment by the DARPA.
- Cost for travel funds must be justified and related to the needs of the project.
- Cost sharing is permitted for proposals under this announcement; however, cost sharing is not required nor will it be an evaluation factor in the consideration of a proposal.
- All subcontractor costs and consultant costs must be detailed at the same level as prime contractor costs in regard to labor, travel, equipment, etc. Provide detailed substantiation of subcontractor costs in your cost proposal. Enter this information in the Explanatory Material section of the on-line cost proposal form. The Supporting Documents Volume (Volume 5) may be used if additional space is needed.

For more information about cost proposals and accounting standards associated with contract

awards, see the DCAA publication titled "Audit Process Overview – Information for Contractors" available at http://www.dcaa.mil.

f. Company Commercialization Report (Volume 4)

The Company Commercialization Report (CCR) allows companies to report funding outcomes resulting from prior SBIR and STTR awards. The Company Commercialization Report (CCR) is required for Phase I and Direct to Phase II proposals. Please refer to the DoD STTR Program BAA for full details on this requirement. Information contained in the CCR will not be considered by DARPA during proposal evaluations.

g. Supporting Documents (Volume 5)

In addition to required DoD documentation and certifications, small businesses may also submit additional documentation to support the Technical Volume (Volume 2) and the Cost Volume (Volume 3) in Volume 5.

f. Fraud Waste and Abuse (Volume 6)

The Fraud, Waste and Abuse (FWA) training is required for Phase I and Direct to Phase II proposals. FWA training provides information on what represents FWA in the SBIR/STTR program, the most common mistakes that lead to FWA, as well as the penalties and ways to prevent FWA in your firm. This training material must be thoroughly reviewed once per year. Plan ahead and leave ample time to complete this training based on the proposal submission deadline. Knowingly and willfully making any false, fictitious, or fraudulent statements or representations may be a felony under the Federal Criminal False Statement Act (18 U.S.C. Sec 1001), punishable by a fine of up to $10,000, up to five years in prison, or both. Understanding the indicators and types of fraud, waste, and abuse that can occur is critical for the SBIR/STTR awardees' role in preventing the loss of research dollars.