. **Innovation[X] 2021-2022 Proposal Application**
The School of Innovation and Innovation Partners are calling for proposals for the next round of our Innovation[X] Program, which provides grants that allow multidisciplinary teams of faculty, undergraduates, graduate students, and postdocs to work together to address complex real-world challenges.

Faculty may apply for grants of up to **$20,000** to facilitate year-long projects. The number of grants to be awarded will depend on funding and application levels. Funding begins September 1, 2021.

Additionally, we have partnered with the Mays Innovation Research Center to fund a set of proposals to study the process of innovation itself. Successful proposals for this subset will pursue topics such as, barriers to or preconditions for innovation, the effects of law and policy on innovation, the behavior or psychological requirements for innovation, innovation and health, the social impacts of innovation, international comparisons of innovation, or novel measurements of innovation.

Proposals are due by 11:59 PM on our **newly extended** deadline of **February 22, 2021** and must be submitted using this online form.

NOTE - Only one team leader/faculty member needs to submit a proposal for a given project.

Reminder of Requirements:

- Teams must consist of an interdisciplinary set of faculty members, and must include two (2) faculty members from different colleges/schools.
- Teams must include a multidisciplinary team of 10-20 students, both undergraduate and graduate, from across the university.
- At least 8-10 of these students must be undergraduates.
- The team must include students from at least two (2) different colleges/schools.
- Students must participate in the project for both Fall 2021 and Spring 2022 semesters, with limited exceptions.
- Proposals should demonstrate a team-based approach to a complex problem and include meaningful deliverables.

Please contact Assistant Director Emily Finbow at innovationx@tamu.edu or 979-862-6071 with questions.

. For which tracks would you like your proposal to be considered?

- ○ Track A - Traditional Innovation[X] Project
- ○ Track B - Special Track - "Process of Innovation" Innovation[X] Project
- ◉ Both Track A and Track B

. Project Title

Perovskite Quantum Dot Solar Cells with Enhanced Efficiency and Stability

. *Please provide the following information for the Primary Point of Contact for the Project (Project Leader)*

. Prefix

Dr.

. First Name

Zi Jing

. Last Name

Wong

. Email Address

zijing@tamu.edu

. Phone Number

9798453289

. Gender Identity

- (●) Man
- ( ) Woman
- ( ) Trans Man
- ( ) Trans Woman
- ( ) Genderqueer
- ( ) Non-Binary/Gender non-conforming
- ( ) Not listed above, please specify
- ( ) Prefer not to respond

.
Ethnic and Racial Identity

- ( ) Hispanic/Latino/a/x
- ( ) American Indian or Alaska Native
- (●) Asian/Pacific Islander/Desi-American
- ( ) Black/African American

- White
- Bi-racial / Multi-Racial (please specify):
- Not listed (please specify):
- Prefer not to respond

. *Project Information*

. Please provide brief background/context for the issue this project seeks to address. (2,000 character maximum)

Global warming and climate change negatively impact our health and lifestyle, and threaten the very existence of species on earth. This calls for a transition from polluting fossil fuels to green energy sources like solar renewable energy. Today's photovoltaic systems mostly utilize high-purity silicon to convert sunlight to electricity, but their high costs limit widespread application and global adoption of the technology. The recent discovery of defect-tolerant perovskite materials presents a much cheaper alternative for solar energy harvesting owing to their low material costs and easy manufacturing processes. However, perovskite materials are less stable in ambient environment, where their performances degrade rapidly with heat, moisture and ultraviolet (UV) light in real-world operation. In addition, perovskite solar cells (PSCs) generally have lower power conversion efficiencies (PCE) due to their non-ideal optical bandgaps that pose a limit to the solar spectrum absorbed. There is thus a strong demand for a transformative approach to improve the stability and efficiency of PSCs to drive the new photovoltaic market and promote clean energy and environmental sustainability.

. What are the goals for this project? (5,000 character maximum)

Our team proposes to develop new perovskite quantum dot solar cells with enhanced power conversion efficiency and stability. The specific goals and innovations are: 1. Efficiency enhancement using multilayer perovskite quantum dots: Quantum dots are extremely small nanoparticles whose optical and electronic properties vary with its size due to the quantum confinement effect. By using stacks of perovskite quantum dot films with different optical bandgap and color absorption, we can expand the absorbed solar spectrum. Furthermore, a gradient energy band alignment can be engineered to produce efficient charge generation and carrier extraction, which can lead to a dramatic increase in power conversion efficiency. We will synthesize different perovskite quantum dots and deposit them in a layer-by-layer fashion to fabricate a multilayer solar cell device. UV-visible absorption and photoluminescence measurement will be carried out to characterize the properties of the perovskite quantum dots, while the PCE will be measured using a solar simulator and a current-voltage test system. 2. Stability enhancement using perovskites with lattice-matched colloidal quantum dots: The instability of inorganic perovskite materials is mainly due to moisture- and temperature-induced crystal structure (phase) change, which renders them transparent and useless for light absorption. By incorporating colloidal quantum dots that are lattice-matched to the light-absorbing perovskite phase, we can lock the desired phase and suppress the formation of the transparent phase. Perovskites also passivate the colloidal quantum dots and prevent their agglomeration and the attack from oxygen, which further improve the device stability. We will carefully control the stoichiometry and weight ratio of the perovskites and colloidal quantum dots to attain the matching lattice constant, before integrating them in a standard solar cell device architecture. High-resolution X-ray diffraction and transmission electron microscopy will be used to measure the composition, crystal structure and lattice spacing of the hybrid film. The improvement in the PSC's long-term stability will be verified by performing a light soaking test over an extended period of time.

. What are anticipated outcomes from this project? (e.g., publications, website, app, data collection for further research/grant) (2,000 characters maximum)

We anticipate four major outcomes: 1. Publications: We expect to publish two papers in high-impact journals with separate claims of efficiency and stability improvement, respectively, using the developed perovskite quantum dot solar cell technology. 2. Preliminary results for federal funding: We will leverage the proof of concept results achieved in this project to apply for a larger collaborative grant to demonstrate a large-scale perovskite quantum dot solar module with state-of-the-art PCE and stability. 3. Student education and teamwork building: Undergraduate and graduate students will get to learn, brainstorm, and work together with each other and with the postdoc and faculty, as the scope of work is closely linked and requires different fields of knowledge. 4. Society impact and reputation: The success of this project will establish TAMU as one of the leaders in renewable energy research and march an important step towards resolving the threat of global warming and climate change.

. Is this proposed project an extension of existing work or a new endeavor? (1,200 character maximum)

This project is a new endeavor. The proposed work to develop multilayer and lattice-matched perovskite quantum dot solar cells to increase both stability and efficiency is the first of its kind in the field. This project also marks the beginning of a new collaboration: (i) Horizontal integration between different departments and colleges across multiple disciplines, such as chemistry, material science, optoelectronics and nanotechnology; and (ii) Vertical integration between undergraduate students, graduate students, postdoc and faculty to jointly tackle the interconnected scope of work.

. Is Institutional Review Board (IRB) approval required for this project?

No

. *Team Participants*

. Please list all Team Leaders below (including yourself), including Prefix, Name, Title, and Department/School.

Dr. Zi Jing Wong, Assistant Professor, Department of Aerospace Engineering, College of Engineering. Dr. Dong Hee Son, Professor, Department of Chemistry, College of Science.

. Do any of the team leaders listed above have plans for a sabbatical or other extended leave away from campus during the 2021-22 academic year? Note: Selecting “yes” will not automatically disqualify a team, but rather will indicate that we need to have a discussion with your team about the nature of the planned leave in relation to the project.

No

. Please list all Team Contributors below, including Name, Title, and Department/School. *Please exclude anyone you already listed as a Team Leader.*

Dr, Chengzhi Qin, Postdoctoral researcher, Department of Aerospace Engineering, College of Engineering.

. Do you plan to assign someone other than a faculty leader as a “project manager” for your team (i.e., a graduate student, postdoc, staff person)?

- (●) Yes
- ( ) No
- ( ) Not sure yet

. What would be the ideal composition of team members for this project? What majors, disciplines, skills, backgrounds, or perspectives would you like to have on the team? (2,000 characters maximum)

Ideally, we would like to have students from both College of Science and College of Engineering joining the team. The synthesis and characterization work of perovskites and quantum dots have a relatively low entry requirement, so any undergraduate students with basic training in chemistry and physics should be able to handle the job, which apply to almost all students from engineering, chemistry, and physics departments. On the other hand, solar cell experiments require a deeper understanding of optics, electronics, material chemistry and device physics. Therefore, graduate students and postdoc majoring in electrical engineering, materials science and engineering, aerospace engineering, chemistry, and physics are preferred, as well as those with relevant experience and skill sets aligning with our research topic.

. Will your team also include any external organizations or individuals as either partners, clients, study subjects, beneficiaries of the work, etc.?

No

. *Travel*

. Does your proposal include travel for students beyond Bryan/College Station?

- ○ Yes
- ◉ No
- ○ Not sure yet

. Where would the team travel?

N/A

. When do you anticipate that this travel would take place? (e.g., Fall 2021, Spring 2022, some other academic break, TBD)

N/A

. Do you expect that all students selected for the team would be able to travel, or just a select number?

N/A

. *Collaboration with Students*

. Ideally, how many undergraduate students would you select to participate on this team? (Numeric responses only, please)

10

. Ideally, how many graduate students would you select to participate on this team?

6

. Ideally, how many professional or doctoral students would you select to participate on this team?

4

. How will you facilitate collaborative inquiry on the team? How often and in what format will the team meet? How will you divide tasks? How you will ensure effective management of the project (e.g., appoint a student as a project manager, assign that role to a faculty leader, etc.)? (2,500 character maximum)

Undergraduate students will synthesize and characterize the different types of perovskite and colloidal quantum dots, while graduate students will integrate the materials with carrier transport layers and electrodes to fabricate solar cells and measure the device performance. These works are tightly linked, so undergraduate and graduate students have to actively communicate, discuss and work closely together to overcome different challenges. Faculty team leaders will supervise the project and provide technical guidance: Dr. Son (CHEM, expert in quantum dots and nanocrystals) will advise on the perovskite and quantum dots synthesis and characterization, while Dr. Wong (AERO and MSEN, expert in optoelectronic devices) will advise on the device integration and solar cell measurement. A postdoc will also be appointed as a project manager to help run the project and provide instant feedback to the team. In addition to the highly cooperative research work, all team members will attend a weekly meeting to have an interactive discussion on the project. Undergraduate and graduate students will present what they did in the past week, highlight the key achievements and major bottlenecks (if any). Faculty team leaders will lead the discussion and all members will contribute to idea exchange and brainstorming for problem solutions. At the end of each semester, every student will submit a report summarizing his/her work.

. What might students gain from their participation (e.g., conducting research directly with subjects, contributing to publications, using language skills)? What unique and differentiated learning opportunities would be available for graduate students? (2,500 character maximum)

All students participating in this project will gain: 1. Hands-on research experience: Students will not only learn cutting-edge perovskite solar cell research knowledge, they will get to try different chemicals and fabrication processes and carry out advanced characterization techniques. 2. High-impact publications: Our new approach to develop perovskite quantum dot solar cell for enhanced efficiency and stability will result in two separate publications in prestigious journals, and all participating students will be in the author list. 3. Soft skills: Through the interactive research work and meetings, huge improvement in the students' communication and interpersonal skills are expected. In addition, we aim to instill integrity, work ethnic and professionalism among the students. 4. Energy and environmental awareness: Students will be constantly exposed to the importance of energy and sustainability, and how they can contribute on a personal level to increase the harvesting of renewable energy resources. This will promote environmental awareness among the students and nurture them into future leaders in energy research and policymaking. In addition to the above, graduate students will also learn how to manage, teach and guide undergraduate students and serve as their mentors. This experience will shape the graduate students' leadership and pave the way for their future success in academia and industry.

. *Timeline and Budget*

. Identify the timeline for the project, including start, completion and major project milestones.

NOTE - You may use the text box or upload a table or file in the next question.

September 2021 – Project initiation, literature review and laboratory safety training. October 2021 – Sample fabrication and characterization. November 2021 – Sample fabrication and solar cells' efficiency test. December 2021 – Solar cells' efficiency test, report and paper writing. January 2022 – Sample fabrication and laboratory safety training for new members. February 2022 – Sample fabrication and characterization. March 2022 – Sample fabrication and solar cells' stability test. April 2022 – Sample fabrication and solar cells' stability test. May 2022 – Report and paper writing, project completion.

. Timeline Upload (if needed)

. Total Budget Request (numeric response only, please). As a reminder, the maximum amount that can be requested is **$20,000.**

20000

. You may upload a budget table here encompassing the categories below, or you may complete the fields below through this form as applicable.

For each item listed below or on your budget table upload, please enter both dollar amount and any relevant notes/justification.

. GRADUATE OR RESEARCH ASSISTANTSHIP (PHD) *(Suggested range: $15-18/hour; note: RAships for students in graduate school should include costs for tuition remission and fees)*

$14,568 [This covers the graduate student salary, fringe benefits and tuition fee for two PhD students, based on a 1.0 person-month effort each. The monthly salary rate for a graduate student is $2,000, and the fringe and insurance charge for each student is $998. The incurred resident tuition fees for College of Science is $1,728 and for College of Engineering is $2,844. These two PhD students will help supervise and guide the undergraduate students for experiments at the Department of Aerospace Engineering and the Department of Chemistry, respectively.]

. RESEARCH ASSISTANTSHIP *(Suggested range: $12-15/hour)*

. INSTRUCTION (Teaching) - PHD STUDENT

. POST-DOCTORAL OR STAFF EFFORT

. UNDERGRADUATE STUDENT STIPEND OR WORK STUDY *(Suggested range: $11-14/hour)*

. INSTRUCTIONAL, RESEARCH OR OFFICE SUPPLIES

$5,432 [We will purchase chemicals, glassware, consumables and laboratory tools for the students to perform the experiments.]

. COMPUTERS AND MINOR EQUIPMENT

. TRAVEL - DOMESTIC

. TRAVEL - INTERNATIONAL

. CONTRACT WORK

. MEETINGS - BUSINESS

. OTHER - MISC.

. Please briefly note below any other sources of project funds. *(Projects that match or leverage additional funds are strongly encouraged. Please note any such funds, awarded or proposed, here so that we understand the comprehensive outlay for the project.)*

"Perovskite Solar Cells for Space Applications" (proposed to NASA)

. Please name a Unit/Business Manager who could administer funds for project, if requested. Include their name, email address, and phone number:

Julie Allen, jballen@tamu.edu, 979-845-1600

Location Data

Location: (3.1607055664062, 101.70599365234)

Source: GeoIP Estimation