Laser-Activated Zero-Loss Yield Battery

Team 22

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Technology Taxonomy Identifiers: #TX03.02.03 – Advanced Concepts for Energy Storage, #TX03.03.01 – Management and Control

Abstract

This proposal aims to develop a hybrid lithium-ion battery model, powered by laser technology, to achieve an energy density of ~300 Wh/kg and to increase the number of life cycles. Traditional lithium-ion batteries are limited by lower energy densities and shorter lifespans, which restrict their efficiency and application in high-demand scenarios. Our innovative approach involves charging the battery with short laser pulses, in the range of 1mJ per picosecond, resulting in higher energy density and extended battery life compared to conventional methods. By using a laser that supports frequency tuning, this method of charging will also produce reduced unwanted thermal energy, lessening the damage on the battery's health. Through these key characteristics, lasers will enable the hybrid lithium-ion battery to not only achieve significantly higher energy density but also extend its battery life, providing a powerful solution for energy storage systems.

1. Introduction

1.1 Current State of the Art

Typical current SOA 18x65mm batteries, in packs of 6830 cells at a time, are limited by an energy density of ~180 Wh/kg and ~800 life cycles before they degrade. Despite supporting rechargeability, modern methods lack a controlled and consistent charging method that does not lead to extreme decreases in energy density and material degradation. Most electric vehicles use this type of lithium-ion battery. For further reference, a typical lithium-ion battery pack in an electric vehicle weighs 1,200 lbs (544.3 kg), making up over 25% of the vehicle's weight. With such a substantial percentage of the vehicle housing the battery, the improved weight-to-energy ratio of the hybrid lithium-ion battery would greatly enhance the vehicle's mileage and performance.

Furthermore, as a result of excess electron scattering, a significant amount of thermal energy buildup can occur during the electric to chemical energy conversion process in traditional batteries. As the external voltage causes electrons to scatter, the produced thermal energy accelerates damage of the battery over the course of extended use and time. However, the accumulation of heat can be greatly mitigated through changes in laser frequencies.

1.2 Improvements for the current SOA

Laser beams offer a consistent and easily controlled stream of energy, allowing us to mitigate damage on the battery caused by abrupt and rapid charging. By introducing a laser as a power source for the battery, as opposed to applying an external voltage on the battery, it is possible to reduce the excess heat in the battery pack while shooting the laser beam onto a photovoltaic cell. By matching the laser's energy output with the energy needed to excite the lithium-ions only, electron scattering will be minimized. As a result, damage from thermal energy would also be minimized. The team's idea would increase the lifespan of the battery, reducing the need to replace it often and indirectly increasing the energy density through efficient charging. Furthermore, by achieving an energy density of 300 Wh/kg, the overall battery pack's weight-to-energy ratio can be reduced by roughly half, allowing technologies utilizing these batteries to be lighter.

1.3 Previous Experiments on Laser Power and Battery Charging

According to Stanford University's Science and Engineering Department, Stanford researchers have developed a method of charging lithium-ion batteries without compromising the longevity of the battery. Instead of focusing on delivering charge uniformly, the aforementioned battery charging method manages the rate of electrical current flowing to an individual cell in the battery, preventing the rapid wear that happens during a fast charging cycle. This approach ensures that the energy in each cell is balanced, resulting in low heat strain once the battery reaches the desired state of charge. Similarly, the team's proposal also involves a method of managing the rate at which energy is transferred to the battery, mitigating thermal damage in a similar way.

2. Objective

The team's objective is to create a hybrid lithium-ion battery of energy density 300 Wh/kg capable of being efficiently charged by short high power laser beam bursts. By increasing the energy density to such an amount, the SOA battery pack weight can be reduced to roughly half the original weight. This will be an adaptation of non-NASA concepts for NASA application. The team will regularly consult with SME Christopher Barty during the design process for the battery attachment that is responsible for converting laser energy into electrical energy. He will also be heavily involved in ensuring the safety and stability of the battery itself.

3. Technology Merit and Work Plan

3.1 Concept and Applications

Through short but consistently spaced high-energy laser pulses, the team will leverage light amplification by stimulated emission and the photoelectric effect to efficiently charge a lithium ion battery while mitigating damage to material health and increasing energy density. The increased energy density of our battery allows for the possibility to reduce its size whilst maintaining the same overall battery energy capacity. Rather than a long continuous beam of power, short laser bursts minimize time whilst keeping energy constant, allowing for higher peak instantaneous power and therefore higher laser charging efficiency. With a solar panel-like attachment, such as photovoltaic cells, the team's method of energy conversion from laser to electrical energy can be tuned to the system's optimal absorption wavelength, indirectly increasing the battery's energy density. This fine-tuning is possible by varying the laser diode current and temperature, and coarse adjustment of the diffusion angle.

In regards to the energy density, our method of increasing it would directly reduce the weight of the battery pack by packing more energy into the same size battery pack. For example, a 544.3 kg battery pack has an energy density of 180 Wh/kg. By packing twice the amount of energy into the pack, say 360 Wh/kg, the team will reduce the total weight by half of the original.

With such a high concentration of energy, laser beams can cause overcharging and electrolyte evaporation due to extreme heat buildup. Similar to modern batteries, the team will implement protection-circuits that monitor the battery's voltage and current, cutting off charge once max capacity is reached and preventing decomposition of the electrolyte due to overcharging. Furthermore, using extremely short bursts of energy from the laser rather than a continuous beam gives us precise control over the temperature of the battery, allowing us to keep the temperature below the evaporation temperature of important electrolyte liquids and gels, mitigating that risk. Working with high energy concentration laser beams for prolonged periods of time can lead to reduced lifespan, capacity loss, and fire hazards if the battery overheats. Using short rather than continuous bursts of energy helps the team minimize and monitor the battery's temperature, mitigating this limitation. To further mitigate thermal limitations, the laser beam will be tuned to the precise frequency needed to excite lithium-ion batteries. This approach reduces electron scattering, a major source of heat generation. By minimizing scattering, team 22 can significantly decrease heat production, thereby enhancing battery efficiency and longevity.

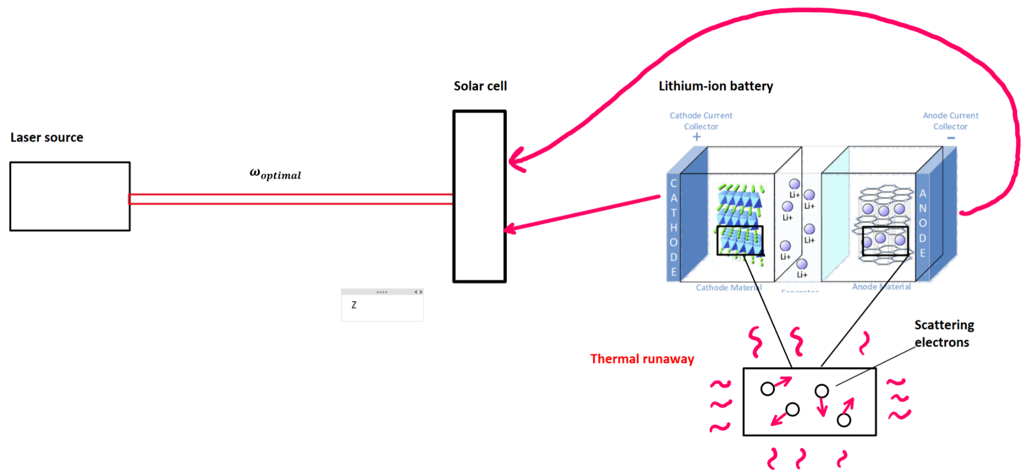

Fig. 1 Diagram of battery being charged with laser source. We aim to decrease the thermal runaway that arises with traditional charging methods.

3.3 Metrics

Battery (single cell)	**Lithium-Ion Battery**	**Laser-Activated Zero-Loss Yield Battery**
Energy Density	~180 wh/kg, 18x65mm	~300 Wh/kg, 26x65mm
Weight	.085-.095 kg	<= .09 kg
Power Density	~ 205.6 W/kg	>= 205.6 W/kg
Sustainability	Around ~800 to 1000 cycles	Target ~1200+ cycles
Charging time	1-1.5 h at 1A (Amp)	<= 1h at 1A
Energy Conversion Efficiency	15%-20%	40%

3.4 Minimum Performance Metrics

Energy Density	At least 300 Wh/kg
Weight	.085-.095 kg
Power Density	205.6 W/kg.
Cycle Life	Target 1000+ Cycles
Charging Time	2.5 h at 1A
Energy Conversion Efficiency	20%

3.5 Overview of Work Plan

The team's work plan consists of four stages: Initial design and prototype, testing and optimization, miniaturization, and final testing and integration. Key variables guiding the team's development plans include energy and power density, energy and power efficiency, laser pulse duration, distance between the receiver and transmitter, lithium-ion battery response, and the time it reaches full charge. Monitoring these variables will help determine thermal limits and manage the overhead limitations of the battery's exposure to the laser.

3.6 Differentiation from Similar Efforts

The most well-known technology capable of charging using light beams are solar panels. Since sunlight encompasses a broad spectrum of wavelengths, many of which do not align perfectly with the solar cell's optimal frequency for energy conversion, prior efforts to use solar cells have been highly inefficient, ranging around 15% to 20% conversion efficiency. In contrast, the team's proposal allows us to directly fine-tune the laser beam to match the solar cell's optimal frequency for energy conversion, thereby maximizing efficiency, reducing losses in energy from the battery, and improving overall performance. Prior research results by Fraunhofer ISE have shown that solar cells are capable of up to 47.6% conversion efficiency when light frequencies match the cells' absorption characteristics. Whilst it may be difficult to meet this constraint using sunlight, laser frequencies can be easily configured to consistently meet the frequency requirement for maximum solar cell performance. Combining the laser's high energy concentration and the solar cell's conversion efficiency will result in a highly efficient, energy dense, and rechargeable battery with a long life cycle.

At the same time, by leveraging the photoelectric effect, it is possible to fine-tune the laser to match the energy needed to excite the lithium-ions in the battery, solely targeting the ions rather than the electrons. This method will reduce the amount of heat generated by scattering electrons, therefore increasing the battery's health and life term.

4. Project Management

Enabling traceability and repeatability in the team's decision making, team 22 will be using trade studies to conduct the decision making process. Since the success of the proposal is directly proportional to the team's battery's metrics, trade studies allow for quick and accurate quantitative comparisons between proposed methods, increasing team efficiency and enabling detailed documentation of the team's progress and findings. Trade studies encourage a clear understanding of the team's proposal's value system, keeping everyone on the same page about the work's objective and providing a template to guide the design process. Once proposals are approved, the engineering team will move forward with rigorous testing protocols, which include thermal tests, environmental stress screening, altitude simulations, and load testing. Any additional tests required due to new insights will be integrated and documented alongside the design decisions, ensuring a reliable reasoning that supports the integrity of the engineering process and facilitates further refinements. Through these efforts team 22 aims to deliver an efficient and sustainable solution that meets all technical requirements while maintaining high standards of efficiency and clarity.

4.1 Project Schedule

Phase 1: Initial Design and Prototype Development (0-3 months)

- This phase involves creating conceptual designs, simulations, and theoretical calculations to ensure the functionality of the prototype and identify any immediate issues or design flaws. Choosing appropriate materials for the battery electrodes and electrolytes to withstand the laser-induced charging process is critical to the success of the team's proposal. For this reason, this phase will also involve assembling a preliminary prototype incorporating the selected components and evaluating the basic functionality of the laser charging mechanism.

Phase 2: Testing and Optimization (4-6 months)

- This phase focuses on performance tests and refinement of: charge/discharge cycles, energy efficiency, thermal stability, overheating, short-circuiting, and other potential hazards to adhere to safety standards. Conduction of initial tests to measure the efficiency of energy conversion from laser to electrical energy falls within this category. In addition, the protection circuits and thermal performance of the system will also be documented to prevent accidental overcharging and thermal runaway.

Phase 3: Miniaturization (7-9 months)

- This phase focuses on maximizing integration efficiency between the battery's components without compromising performance and safety. A possible plan of action during this phase would be to integrate advanced thermal management solutions, such as heat sinks or phase-change materials, to effectively dissipate heat in a smaller form factor. Experimentation with the battery's housing could also assist in reducing the battery's size.

Phase 4: Final Testing and Integration (10-12 months)

- This phase involves a wider range of experiments, including environmental and extended testing. Following these tests, the final performance metrics will be documented. By this point, the battery's reliability and safety, as determined by all relevant industry standards and regulatory requirements, will be ensured, making the battery ready for commercial use.

Milestones and Deliverables:

1. Completion of initial prototype (3 months)
2. Achievement of targeted energy density in testing (6 months)
3. Miniaturization of design for reduced weight (9 months)
4. Final product validation (12 months)

Resources:

Part of the $10k funding will be put towards a high energy density Titanium-Sapphire laser or Diode pumped solid state laser, which can fine tune frequency to fulfill the team's needs. Acquiring photoactive materials for efficient laser energy conversion, high-capacity anode and cathode materials like silicon and NMC, solid-state and gel polymer electrolytes for enhanced safety and conductivity, and thermal management materials will be another substantial part of the budget. Remaining funds will be allocated to laser diodes and optical components necessary for the laser charging system.

Items for Budget Allocation	Components	Funds Allocated
Laser and Optical Components	Titanium Sapphire or Diode pumped solid state laser, lenses,beams,schafer,optical fiber and more.	**$5,400**
Battery Materials	Silicone based anodes and commercial graphite	**$2,600**
Thermal Management and Testing	Phase Change Material in compound of Battery.	**$580**
Prototyping and Environmental Tests	Includes all material need for all software, mechanical, electrical, load, and stress of battery,	**$1000**
Tools and Extras	Includes all safety equipment needed.	**$420**

Items for Budget Allocation	Components	Funds Allocated
	Replacement Materials and substitutions on testing equipment, lab supplies, and shipping.	

5. Teaming and Roles

5.1 Core Team Members

Samantha Cantu Olea (PI) - Physics expertise with basic knowledge of laser beam interactions and energy transfer theory, leading overall project direction.
Nancy Ta, Nathan Pham, Seline Venzon, Jhaydine Banda, Heli Kadakia etc. - Engineering and computer science team members contributing to the integration of laser and energy processes in the prototype and maximizing the energy output via testing.
Christopher Barty (SME) - Advisor on the laser technology and optical physics aspect, expected to provide guidance on achieving high energy density safely and practically via laser applications.

5.2 Time Commitment

Each team member's role aligns with their specialty: Physicists focus on the theory of laser and energy processes and thresholds, while engineers work on the design, integration, and application of these principles in the prototype. The time commitment of team members is expected to be 10-15 hours per week, while the PI and key engineers may spend up to 20 hours during critical phases.

6. Appendix

6.1 Quad Chart

Laser-Activated Zero-Loss Yield Battery
PI: Samantha Cantu Olea, Team #22

Goal / Objective

Current energy generating/storage methods rely on lithium ion batteries which:

1. Make up ~60% of spacecraft payload weight
2. Do not meet the energy density requirements to enable feasible electric aviation
3. Limit the range of miles of travel possible.

Our team proposes a laser-beam-powered battery that can meet the high specific energy density requirements and reduce the weight of the energy system payload on electric spacecraft that rely on lithium-ion battery . Current Lithium-ion batteries are charged by an external voltage, which is limited on board. By implementing a laser-beam source powered by an external light source and exploiting the photoelectric effect, charging batteries with a laser would be key in generating high amounts of energy due to the tightly focused light. This also allows for more space to accommodate for additional energy storage devices due to the compactness of laser systems. In addition, more compact energy generation systems will lead to lower cost.

The final deliverable of the $10k funding would enable development of a hybrid lithium-ion battery model, charged by short laser pulses, that will meet an energy density of ~300 Wh/kg to meet the requirements for electric aviation-based missions.

This concept qualifies as an NTR.

Through the process of laser amplification by stimulated emission, the emitted photons can be used to charge the battery. This method will pack as many emitted photons as possible on lithium-ion batteries, providing a higher energy density and lower packaging weight overall. The laser amplification process emits a cascade of photons after meeting the energy threshold, resulting in high amounts of photons that will be converted to a voltage to be applied to the battery.

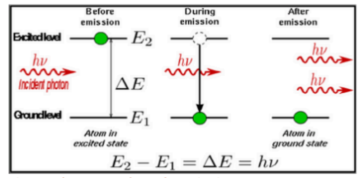

Fig. 1 The stimulated emission process.

Source:
https://www.researchgate.net/figure/Figure-1-2-The-stimulated-emission-process-23_fig2_343083923

Team Overview

Nathan Pham - UC Santa Cruz, Computer Engineering
Jhaydine Bandola - UC Davis, Computer Science
Nutthawat Panyangnoi - San Jose State University, Computer Engineering
Luke McCormick - Folsom Lake College, Computer Science
Heli Kadakia - UC Santa Cruz, Computer Engineering
Samantha Cantu Olea - UC Irvine, Physics
Seline Venzon - Folsom Lake College, Computer Engineering
Nancy Ta - De Anza College, Computer Engineering
Andrew Gamboa, De Anza, Aerospace Engineering

SMEs:

Huolin Xin, Professor of Physics & Astronomy at UC Irvine, research in lithium-ion batteries and condensed matter physics

Christopher Barty, Distinguished Professor of Physics & Astronomy at UC Irvine, Lead Faculty at the Beckman Laser Institute

Using the fundamental concepts such as laser amplification and the photoelectric effect our team will leverage access to university laboratories in lasers and lithium-ion batteries to test the capabilities of our prototype. This includes evaluating the thermal limits of the battery's exposure to the laser.

#TX03.03.01 #TX03.02.03

Metrics and Key Performance Parameters

Battery (single cell)	Lithium-Ion Battery	Laser-Activated Zero-Loss Yield Battery
Energy Density	~180 wh/kg, 18x65mm	~300 Wh/kg, 26x65mm
Sustainability	Around ~800 to 1000 cycles	Target ~1200+ cycles
Charging time	1-1.5 h at 1A (Amp)	<= 1h at 1A
Energy Conversion Efficiency	15%-20%	40%

Current SOA batteries lack a controlled and consistent charging method that does not lead to extreme decreases in energy density and material degradation. The primary metric to demonstrate improvement will be the lifespan and health of the battery.

Source:
https://www.laserax.com/blog/laser-powers
https://www.nasa.gov/smallsat-institute/sst-soa/power-subsystems/

7. References

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[5] "Lithium-Ion Battery Structure and the Reduced-Order Model ..." ResearchGate. Accessed November 14, 2024. https://www.researchgate.net/figure/Lithium-Ion-Battery-Structure-and-the-Reduced-Order-Model-Assumption-Adopted-from-8_fig6_264427594.

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2024-11-13</td></tr>
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Laser-Activated Zero-Loss Yield Battery</td></tr>
<tr><td colspan="4">2.INNOVATOR(S) (For each innovator provide: Name, Title, Work Address, Work Phone Number, and Work E-mail Address. If multiple innovators, number each to match Box 5.)
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Jhaydine Bandola, Software Engineer, 1 Shields Ave, Davis, CA, 95616, (415) 889-9842, jybandola@ucdavis.edu</td></tr>
<tr><td colspan="4">3.INNOVATOR'S EMPLOYER WHEN INNOVATION WAS MADE--PLACE OF PERFORMANCE (For each innovator provide: Name, Department/Division and Address of Employer. If multiple innovators, number each to match Box 5.)
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University of California, Santa Cruz, 1156 High St, Santa Cruz, CA, 95064, , 80NSSC19M0186
De Anza College, 21250 Stevens Creek Blvd, Cupertino, CA, 95014, , 80NSSC19M0186
De Anza College, 21250 Stevens Creek Blvd, Cupertino, CA, 95014, , 80NSSC19M0186
Folsom Lake College, 10 College Pkwy, Folsom, CA, 95630, , 80NSSC19M0186
Folsom Lake College, 10 College Pkwy, Folsom, CA, 95630, , 80NSSC19M0186
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San Jose State University, 1 Washington Sq, San Jose, CA, 95192, , 80NSSC19M0186
University of California, Davis, 1 Shields Ave, Davis, CA, 95616, , 80NSSC19M0186</td></tr>
<tr><td colspan="4">4. CURRENT EMPLOYER INFORMATION (Address(es) where Innovator is currently employed. If multiple innovators, number each to match Box 5)
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10 College Pkwy, Folsom, CA, 95630
10 College Pkwy, Folsom, CA, 95630
260 Aldrich Hall Ste 2, Irvine, CA, 92697
1 Washington Sq, San Jose, CA, 95192
1 Shields Ave, Davis, CA, 95616</td></tr>
</table>

5. EMPLOYER STATUS *(choose one for each innovator)*	6. CONTRACT/GRANT INFORMATION	
Innovator #1: CU Innovator #2: CU Innovator #3: CU Innovator #4: CU GE = Government CU = College or University NP = Non-Profit Organization SB = Small Business Firm LE = Large Entity	Innovator #1 Grant/Cooperative Agreement No. 80NSSC19M0186 Prime Contract No. Subcontract No. Innovator #3 Grant/Cooperative Agreement No. 80NSSC19M0186 Prime Contract No. Subcontract No.	Innovator #2 Grant/Cooperative Agreement No. 80NSSC19M0186 Prime Contract No. Subcontract No. Innovator #4 Grant/Cooperative Agreement No. 80NSSC19M0186 Prime Contract No. Subcontract No.
	6a. Is this innovator an inventor on this technology? *An Inventor is defined as: An individual who creatively contributed in the making of the invention such as: helped conceive an element or step of the invention or helped conceive any new improvements on an element or step of the invention.* Innovator #1: yes Innovator #2: yes Innovator #3: yes Innovator #4: yes	6b. For each Innovator, select all roles that apply: Innovator #1 [X] POC [X] Software Author [X] Innovator [X] Contributor [ ] Open Source Contributor Innovator #2 [ ] POC [ ] Software Author [X] Innovator [X] Contributor [ ] Open Source Contributor Innovator #3 [ ] POC [ ] Software Author [X] Innovator [X] Contributor [ ] Open Source Contributor Innovator #4 [X] POC [X] Software Author [X] Innovator [X] Contributor [ ] Open Source Contributor

7.CONTRACTOR/GRANTEE NEW TECHNOLOGY REPRESENTATIVE (POC) and ADDITIONAL REVIEWERS (*Provide Name, E-mail, Company, Contract and role*)

Name	Email Address	Company	Contract Number	Role

8. BRIEF ABSTRACT (Describe your technology.)

This proposal aims to develop a hybrid lithium-ion battery model, powered by laser technology, to achieve an energy density of ~300 Wh/kg and to increase the number of life cycles. Charged by short laser pulses, in the range of 1mJ per picosecond, this battery will have higher energy density and increased battery life, compared to traditional lithium-ion batteries, allowing for extremely high-efficiency charging of lithium-ion batteries. By using a laser that supports frequency tuning, this method of charging will also produce reduced unwanted thermal energy, lessening the damage on the battery's health. Through these key characteristics, lasers will enable the hybrid lithium-ion battery to not only achieve significantly higher energy density but also extend its battery life, providing a powerful solution for energy storage systems.

9. DESCRIPTION OF THE PROBLEM OR OBJECTIVE THAT MOTIVATED THE INNOVATION'S DEVELOPMENT (*General description of problem/objective or unique problem characteristics.*)

Typical current SOA 18x65mm batteries, in packs of 6830 cells at a time, are limited by an energy density of ~180 Wh/kg and ~800 life cycles before they degrade. Despite supporting rechargeability, modern methods lack a controlled and consistent charging method that does not lead to extreme decreases in energy density and material degradation. Most electric vehicles use this type of lithium-ion battery. For further reference, a typical lithium-ion battery pack in an electric vehicle weighs 1,200 lbs (544.3 kg), making up over 25% of the vehicle's weight. With such a substantial percentage of the vehicle housing the battery, the improved weight-to-energy ratio of the hybrid lithium-ion battery would greatly enhance the vehicle's mileage and performance. Furthermore, as a result of excess electron scattering, a significant amount of thermal energy buildup can occur during the electric to chemical energy conversion process in traditional batteries. As the external voltage causes electrons to scatter, the produced thermal energy accelerates damage of the battery over the course of extended use and time. However, the accumulation of heat can be greatly mitigated through changes in laser frequencies.

10. TECHNICALLY COMPLETE DESCRIPTION OF INNOVATION (*Purpose and description of innovation/software and explanation of mode of operation referring to drawings, sketches, photographs, graphs, flow charts, and/or parts or ingredient lists illustrating the components; functional operation; alternate embodiments of the innovation/software and supportive theory.*)

The team will utilize short, consistently spaced high-energy laser pulses to efficiently charge a lithium-ion battery. This method leverages light amplification by stimulated emission and the photoelectric effect, which helps mitigate material degradation and increase energy density. Instead of using a continuous power beam, short laser bursts minimize charging time while maintaining constant energy, resulting in higher peak instantaneous power and improved laser charging efficiency. By incorporating a solar panel-like attachment, such as photovoltaic cells, the energy conversion from laser to electrical energy can be optimized to the system's absorption wavelength. This optimization is achieved by adjusting the laser diode current, temperature, and diffusion angle. To prevent overcharging and electrolyte evaporation due to extreme heat buildup, the team will implement protection circuits that monitor the battery's voltage and current, cutting off the charge once maximum capacity is reached. Using extremely short laser bursts instead of a continuous beam allows precise temperature control, keeping it below the evaporation point of critical electrolyte components.

11. UNIQUE OR NOVEL FEATURES (*Provide brief details focused on what component(s) or method step(s) differentiate(s) the new technology from other similar technologies (aka the "secret sauce"). Include as attachments any presentations, images, flowcharts, etc. that help identify the unique component(s) or method step(s). If there are no unique component(s) and method step(s) (e.g. NTR submitted only for software release), state "None."*)

The most well-known technology capable of charging using light beams are solar panels. Since sunlight encompasses a broad spectrum of wavelengths, many of which do not align perfectly with the solar cell's optimal frequency for energy conversion, prior efforts to use solar cells have been highly inefficient, ranging around 15% to 20% conversion efficiency. In contrast, the team's proposal allows us to directly fine-tune the laser beam to match the solar cell's optimal frequency for energy conversion, thereby maximizing efficiency, reducing losses in energy from the battery, and improving overall performance. Prior research results by Fraunhofer ISE have shown that solar cells are capable of up to 47.6% conversion efficiency when light frequencies match the cells' absorption characteristics. Whilst it may be difficult to meet this constraint using sunlight, laser frequencies can be easily configured to consistently meet the frequency requirement for maximum solar cell performance. Combining the laser's high energy concentration and the solar cell's conversion efficiency will result in a highly efficient, energy dense, and rechargeable battery with a long life cycle. At the same time, by leveraging the photoelectric effect, it is possible to fine-tune the laser to match the energy needed to excite the lithium-ions in the battery, solely targeting the ions rather than the electrons. This method will reduce the amount of heat generated by scattering electrons, therefore increasing the battery's health and life term.

12. COMMERCIALIZATION POTENTIAL (*Identify other applications for this technology beyond the specific NASA use. What type of industries would be most applicable for this technology? Are there related commercial products that you're aware of that would benefit from this technology? List any companies that you've contacted, or think may be interested in using this technology.*)

Due to its high energy density and conversion efficiency, laser charged batteries can significantly reduce charging times compared to traditional methods, making it highly attractive for consumer electronics and electric vehicles. The versatility and widespread use of regular lithium ion batteries will make implementation of this new technology smooth and seamless. Possible applications include battery-powered vehicles, portable electronics, and any other rising technologies requiring long-term use of quick-charge batteries. Furthermore, with the issue of sustainability rising, utilizing renewable energy sources and reducing the need for frequent battery replacements would contribute to a reduction in electronic waste and lower carbon emissions.

13. DEGREE OF TECHNOLOGY SIGNIFICANCE (Which best expresses the degree of technological significance of this innovation?)

[X] Modification to Existing Technology [ ] Substantial Advancement in the Art [ ] Major Breakthrough

14. QUESTIONS FOR SOFTWARE ONLY

a. Does this technology include custom software, developed wholly or in part under NASA funding? [X] YES [ ] NO

b. Is this technology primarily a software product or computer program technology (versus primarily a hardware technology)? [ ] YES [X] NO

c.Could the software be used or adapted for other applications outside of your project? [ ] YES [X] NO

d. Does the software contain any embedded, third-party code? [ ] YES [ ] NO
If yes, list each third-party code by title and version, under what license they were obtained, and either cut and paste the license below or provide the URL for the license to the downloaded version of the third-party code:

e. Does the software call any third-party code when it runs? [ ] YES [ ] NO
If yes, list each third-party code by title and version, under what license they were obtained, and either cut and paste the license below or provide the URL for the license to the downloaded version of the third-party code:

f. Can the software be distributed without third-party code? [ ] YES [ ] NO

g. Copyright registered? [ ] YES [ ] NO [ ] Unknown
If yes, then by whom?

h. Are there any programmatic restrictions or other sensitivities that impact release/distribution of the software (e.g., contains Government sensitive information/command and control/spaceflight software, etc.)? [ ] YES [ ] NO [ ] Unknown
If yes, explain

i. State of Development (for software only)

[ ] Concept Only [ ] Requirement Phase [ ] Design Phase [ ] Code Completed [ ] Code Testing Complete [ ] Used in Current Work

15.STATE OF DEVELOPMENT (*For software only, complete State of Development in question 14i*.)

[X] Concept Only [X] Design [ ] Prototype [ ] Modification [ ] Production Model [ ] Used in Current World

16. ADDITIONAL DOCUMENTATION (*Include copies or list below any pertinent documentation which aids in the understanding or application of the innovation (e.g., articles, contractor reports, engineering specs, assembly/manufacturing drawings, parts or ingredients list, operating manuals, test data, assembly/manufacturing procedures, etc.*).)

TITLE	PAGE	DATE

17. Does the invention or software being reported contain any restrictive notices or other indication that it includes proprietary/restricted information of a non-Government entity? (copyright, proprietary, applicable licenses, Limited Rights/Restricted Rights, SBIR rights, etc.)?

[ ] YES [X] NO

If yes, indicate type(s):

18. Are there any publications or public disclosures to report for this technology?

[ ] YES [X] NO

If yes, list each public disclosure, including planned disclosures. (Include Title of Disclosure, Type of Disclosure, Disclosure By and Date of Disclosure, Location of Disclosure, Link to Document and Additional Information):

19. Has any intellectual property protection (patents or copyright) been sought for this technology?

[ ] YES [X] NO

If yes, list each public disclosure, including planned disclosures. (Include Title of Disclosure, Type of Disclosure, Disclosure By and Date of Disclosure, Location of Disclosure, Link to Document and Additional Information):

20.Does this technology have any related technologies (past or current New Technology Reports)?

If yes, list Case Number and Titles below:

Case Number Title

21. Funding Mission Directorate:

Space Technology

Project Name:
[ ] Unknown; the project this technology has been developed under is unknown
[X] Not applicable; this technology is not associated with a funded project

22.Contribution of Innovators (*if jointly developed, provide the contribution of each innovator*)

23. SIGNATURES OF INNOVATOR(S), WITNESS(ES), AND NASA APPROVAL

TYPED NAME AND SIGNATURE *(Innovator #1)*	DATE	TYPED NAME AND SIGNATURE *(Innovator #2)*	DATE
TYPED NAME AND SIGNATURE *(Innovator #3)*	DATE	TYPED NAME AND SIGNATURE *(Innovator #4)*	DATE
TYPED NAME AND SIGNATURE *(Innovator #5)*	DATE	TYPED NAME AND SIGNATURE *(Innovator #6)*	DATE

NASA APPROVED	TYPED NAME	SIGNATURE	DATE