Summary of Comments

Proposal 10-01-07T Electricity, Ranked # 1

Bonding of Metal-Plastic Composites for Lightweight, Fuel Efficient Vehicles

Robert Hicks, UCLA

PROJECT OBJECTIVE:

- Proposes to determine the feasibility of using atmospheric pressure capacitive discharge plasmas to increase the bond strength of metal-plastic composites for fuel efficient vehicles.

FUNDING RECOMMENDATION:

- Recommended for funding.

PUBLIC INTEREST BENEFITS:

- The proposed technology has the potential to provide a cost-effective option for resolving fuel-efficiency demands by California automotive consumers.
- The proposed technology has the potential to produce a vehicle body that is 50% lighter, but with the same appearance and durability as a body made from steel, thereby decreasing steel output and decreasing electricity consumption from iron and steel manufacturers.

STRENGTHS:

- Well-qualified PI and team with a strong publishing history and review.
- Successful application of this process can yield a 50% reduction in vehicle body weight at a cost no greater than 1.5 times that of standard sheet metal.

WEAKNESSES:

- No significant weaknesses noted.

CLARIFICATIONS / CONDITIONS:

- None.

California Energy Commission Energy Innovations Small Grant (EISG) Transportation Program **GRANT APPLICATION COVER PAGE**	**FORM A**

a. Project Title: **Bonding of Metal-Plastic Composites for Lightweight, Fuel Efficient Vehicles**
(not to exceed 10 words) **Project Subject Area:** (*Indicate the one that most applies)*

☒ Vehicle Technologies ☐ Transportation Systems

b. Applicant Category:

☐ Individual ☒ Academic Institution
☐ Small Business ☐ Non-Profit

d. Grant Funding Requested: $ $89,920 ☒ Hardware $95K ☐ Modeling $50K

e. Proposed Project Duration: 12 months *(maximum duration 12 months)*

f. Principal Investigator/Project Manager: *(serves as single point of contact for all communications)*

Name: Robert F. Hicks	Address: Robert F. Hicks UCLA Chemical Engineering Department 5532-J Boelter Hall Los Angeles, CA 90095
Phone: (310) 206-6865 Fax: (310)206-4107	
Email: rhicks@ucla.edu	
Organization: University of California-Los Angeles	
Position/Title: Professor	

g. Proprietary/Confidential Information:

☒ NO – Proposal does not contain proprietary information, unrestricted distribution authorized.

☐ YES - Proposal contains proprietary information, restrict distribution and disclosure.*(clearly mark and label those sections that are proprietary on all copies)*

h. Application Status *(include only prior submissions on same concept)*

☒ First Submission ☐ Second Submission ☐ Third Submission

Provide the proposal number(s) assigned to prior submission(s):_____

i. Indicate the Solicitation Number Listed on the Solicitation Notice: **10-01T Electricity**
j. Indicate the Solicitation Number Printed on the Application Manual Used: **10-01T Electricity**
(the solicitation numbers listed in items i and j must match)

k. Principal Investigator/Project Manager Certification: To the best of my knowledge, I certify that the information contained in this grant application package is true, and discloses all requested information.

Principal Investigator/Project Manager Signature:_____ **Date**:_____

Reserved for EISG Program Administrator Use		
Solicitation	Date Received	Proposal Number Assigned
10-01T E		

Project Summary
Bonding of Metal-Plastic Composites for Lightweight, Fuel Efficient Vehicles
Prof. Robert F. Hicks, Principal Investigator, UCLA

The use of lightweight composite materials in automobiles allows for greatly increased fuel efficiency, and reduced energy consumption during raw material production. A 2006 report by the United States Energy Information Administration places the electricity consumption of the iron and steel industry at 51.2 billion kWh annually. An auto industry rule of thumb says that every 10% reduction in vehicle weight yields a 5% increase in fuel economy. By bonding ultrathin sheet metal to polymer composites, one can produce a vehicle body that is 50% lighter, but with the same appearance and durability as a body made from steel. In 1960 automobiles contained an average of 18 pounds of polymers per vehicle. This has increased to 335 pounds in 2004 to comprise 8% of total vehicle weight.[14] This is often restricted to low-performance commodity parts but it is desired to use metal-polymer composites in a greater number of structural elements. The biggest problem with achieving a suitable composite material is the low strength of the adhesive bond between the metal-polymer laminate, particularly if high-temperature, high strength thermoplastics are used. This reduction in steel output is accompanied by a reduction in the electrical demand made by steel processing facilities.

We propose to develop a new, low-cost process for bonding together metal polymer composites. This process uses in-line atmospheric pressure plasma to rapidly scan the material surfaces and activate them prior to adhesive bonding. The plasma creates a more chemically active surface with which the adhesive will readily react. It has already been demonstrated that adhesion between polyetheretherketone (PEEK) can be increased up to 6 times with atmospheric plasma activation. In this project, a process will be developed for the rapid, low-cost treatment of thin sheet steel and thermoplastic composites (e.g., PEEK) prior to bonding and curing. The bonded laminates will be subjected to mechanical testing, including ASTM lap shear measurements, as well as impact and deformation tests. We will demonstrate that metal-polymer composite materials can be created which survive ASTM testing 100% of the time and demonstrate 100% cohesive failure at 5000 psi. In addition, the chemical and physical properties of the surfaces will be characterized before and after plasma treatment. Surfaces will be analyzed through water contact angle measurements, x-ray photoemission spectroscopy (XPS) and infrared (IR) spectroscopy. Through this project, we will demonstrate that a 50% reduction in the vehicle body weight can be achieved without any degradation in the structural properties of the material. We will confirm that a strongly bonded metal-polymer composite can be produced at a cost no greater than 1.5 times that of standard sheet metal.

Statement of Work
Bonding of Metal-Plastic Composites for Lightweight, Fuel Efficient Vehicles
Prof. Robert F. Hicks, Principal Investigator, UCLA

Project Goal: The goal of this project is to determine the feasibility of using atmospheric pressure capacitive discharge plasmas to increase the bond strength of metal-plastic composites for fuel efficient vehicles.

Project Tasks	Performance / Cost Objectives
1) Finalize test plan a. Obtain EISG PA approval of test plan.	1) Complete within first month after project start date. Acquire substrates and materials for the experiments.
2) Conduct pretreatment testing a. Conduct AFM testing b. Conduct contact angle testing c. Conduct composition testing	2) Demonstrate reduced water contact angles (WCA) of metal and composite surfaces to below 20°. 3) Show that <20° WCA may be achieved at surface scan rates >1.0 cm/s.
3) Conduct adhesive bond testing a. Conduct mechanical shear and pull testing of metal-polymer structures	4) Demonstrate 100% cohesive failure of the bond, and a minimum lap shear force for failure of 5000 lbs per in^2.
4) Conduct ASTM mechanical testing a. Conduct static testing b. Conduct impact testing	5) Demonstrate that metal-plastic composites meet or exceed static and dynamic impact performance equal to sheet steel 1.5 mm thick. Submit a metal-polymer composite sample to EISG.
5) Perform weight reduction analysis	6) Confirm from the project findings that composite materials can achieve the same mechanical performance as sheet steel with a minimum 50% reduction in weight.
6) Perform manufacturing cost analysis	7) Confirm from the project findings that metal-polymer composites can be produced at a cost no greater than 1.5 times that of sheet metal.

Reporting Requirements:
Submit Progress Reports and Final Report in accordance with the proposed Project Schedule/Deliverables Chart.