

**SBIR Topic Number:**  
AF05-005

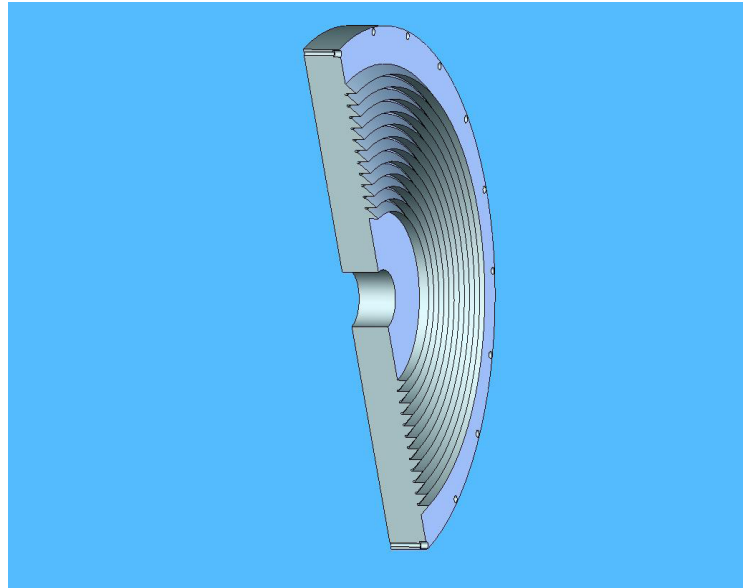
**SBIR Title:**  
Refractory Coatings  
on Mechanically  
Resilient Insulators

**Contract Number:**  
FA9451-06-C-0090

**SBIR Company Name:**  
Acree Technologies  
Incorporated  
Concord, CA

**Technical Project Office:**  
AFRL Directed Energy  
Directorate, Kirtland  
AFB, NM

This Air Force SBIR/STTR Innovation Story is an example of Air Force supported SBIR/STTR technology that met topic requirements and has outstanding potential for Air Force and DoD.



**Coated Plastic High-Voltage Insulator.**

## Refractory Coatings for High-Voltage Polymer Insulators

- This project demonstrated the effectiveness of using ceramic coatings on plastic high-voltage insulators to increase their surface breakdown voltage and improve their recovery after a breakdown event
- Acree Technologies explored methods to benefit from the resiliency and ease of fabrication of plastic insulators which still have the toughness and resistance to surface flashover damage of a ceramic by coating the plastic insulator with a ceramic surface treatment
- Using this technology, high voltage insulators reap the benefit of inexpensive fabrication costs and ease-of-use of plastic insulators while having electrical performance equivalent to more expensive ceramic insulators
- Acree Technologies delivered a coated plastic insulator to the Air Force for use in a high-power pulse power device

09-0264

**A**

DISTRIBUTION A:  
Approved for public  
release; distribution  
unlimited.

## Air Force Requirement

The purpose of this project was to demonstrate the effectiveness of using ceramic coatings on plastic high-voltage insulators to increase their surface breakdown voltage and improve their recovery after a breakdown event. High power microwave tubes, coaxial plasma guns, plasma thrusters and intense radiation sources all use large, complex shaped plastic insulators. The disadvantage of plastic insulators is that they tend to fail after repeated surface breakdown events, leading to a lowering of the voltage at which the next breakdown occurs. On the other hand, ceramic materials are less susceptible to damage and tracking and tend to recover better than plastics.

## SBIR Technology

Under this SBIR project, Acree Technologies explored methods to benefit from the resiliency and ease of fabrication of plastic insulators which still have the toughness and resistance to surface flashover damage of a ceramic by coating the plastic insulator with a ceramic surface treatment.

Surface flashover occurs when the electrical field across the face of an insulator exceeds a given value which depends in a complex way on the material, pre-conditioning of the surface, insulator shape, and material history. In many applications plastic insulators are used to hold off high voltages. The advantage of plastic over ceramic insulators is that they are easier and cheaper to construct, particularly for large complex shapes, and they are resilient and more durable. The resiliency of plastic insulators is particularly important in vacuum applications where the insulator may form an integral part of the vacuum seal and may be subjected to compressive stresses as the chamber is pumped down.

Studies have shown that the surface breakdown voltage of high-density polyethylene (HDPE) is significantly increased and does not fall off with repeated flashover events when a ceramic coating is deposited on the surface. Two ceramic coatings were selected for this project for three reasons: 1) previous breakdown results taken in our lab and elsewhere have demonstrated that SiO<sub>x</sub> improves flashover characteristics of high-density polyethylene; 2) both Silicon-based glasses and Al<sub>2</sub>O<sub>3</sub> are well established, proven insulator materials with good flashover characteristics and recovery; and 3) these materials (as well as other metal-based oxides) can be deposited with low intrinsic film stress and excellent adhesion to polymers.

This project consisted of depositing the ceramic coatings on small HDPE coupons and performing electrical breakdown tests of the surface flashover characteristics using a 10 kV test stand. Uncoated samples were tested as controls. Additional testing was also performed for selected samples using a 50 kV test stand. The samples for the 50 kV breakdown tests were cylindrical in shape. The dimensions of the electrodes and samples and the values of the circuit components were carefully selected to give current, charge and energy densities equivalent to those of high-power pulsed power devices during breakdown.

## Potential Air Force Application

The results showed that the coated samples out-performed the uncoated HDPE control samples. The uncoated samples sustained significant surface damage and tracking whereas the coated samples did not. In addition, the coated samples were able to withstand greater field strengths before breakdown compared to the uncoated HDPE. The SiO<sub>x</sub> and Al<sub>2</sub>O<sub>3</sub> coatings each performed about the same and were able to hold-off > 100 kV/cm.

Coating inexpensive, easy-to-fabricate, high-voltage insulators with a ceramic coating significantly improves the performance of the component. Using this technology, high voltage insulators reap the benefit of inexpensive fabrication costs and ease-of-use of plastic insulators while having electrical performance equivalent to more expensive ceramic insulators.

## Company Impact

Acree Technologies delivered a coated plastic insulator to the Air Force for use in a high-power pulse power device. The coated insulator should increase the life of the pulse power component while allowing the performance of the pulse powered device to increase.

This SBIR-developed technology allows for the potential commercialization of ceramic coated insulators for private industry and also allows higher-performing, more sophisticated pulse power devices to be constructed.



# SBIR/STTR

Air Force SBIR Program  
AFRL/XP  
1864 4th Street  
Wright-Patterson AFB OH 45433

AF SBIR/STTR Program Manager: Augustine Vu  
Website: [www.sbirsttrmall.com](http://www.sbirsttrmall.com)  
Comm: (800) 222-0336  
Fax: (937) 255-2219  
e-mail: [afrl.xppn.dl.sbir.hq@wpafb.af.mil](mailto:afrl.xppn.dl.sbir.hq@wpafb.af.mil)

