

## **Effect of Interfacial Strength and Energy Absorption at the UHMW-PE Fiber/Epoxy Interface Using Atmospheric-Pressure, Low-Temperature Plasma**

Jacqueline H. Yim<sup>1</sup>, Denis Kissounko<sup>2</sup>, D. Daphne Pappas<sup>3</sup>, Alexander Fridman<sup>4</sup>, Giuseppe R. Palmese<sup>1</sup>

<sup>1</sup>Department of Chemical & Biological Engineering, Drexel University, Philadelphia, PA 19104

<sup>2</sup>Center for Composite Materials, University of Delaware, Newark, DE 19716

<sup>3</sup>US Army Research Laboratory, Aberdeen Proving Ground, MD 21005

<sup>4</sup>Drexel A.J. Drexel Plasma Institute, Drexel University, Philadelphia, PA 19104

The interface in fiber-reinforced composite materials plays a key role in imparting unique material properties such as toughening and energy absorption capabilities. The poor adhesive nature that exists in composites is largely attributed to the fiber's low surface energy and chemical inertness. In efforts to enhance the adhesion strength between organic fibers and resins, surface treatments have been explored and pursued. It has been widely accepted that the adhesion strength can be controlled by the degree of covalent bonding between the fibers and the resin. However, depending upon the utilization of the composite, such as in ballistic and structural applications, an optimal balance of adhesion strength and energy absorption properties is highly desired. Therefore, a practical methodology is needed where the tunability of the interface can be achieved. The model system used in this study is an ultra-high molecular weight polyethylene (UHMW-PE) fiber and epoxy system in which the fibers were subjected to a series of various plasma treatments. Through the use of these plasma treatments, we have shown that various reactive functional groups - hydroxyl, carboxyl, amine, and carbonyl groups can be imparted onto the surfaces of these fibers based on elemental analyses obtained from X-ray Photoelectron Spectroscopy (XPS). Based on treatment conditions – gas flow-rate, exposure time and plasma gas, it was found that the degree of functionality can be controlled where higher uptake of one particular chemical group over others can be achieved. The interfacial shear strength (IFSS) and energy absorption at the fiber/epoxy interface after plasma treatments were assessed using a single-fiber microdroplet shear test. Results show that the plasma treatments alone aid in the adhesion of the fiber to the epoxy as a six-fold increase of the shear strength was observed with a significant increase in the energy absorption as well.