Deployment of Thermoplastic and Thermosetting Technologies To Improve the Durability of Solar Sails

Keuchel, Destynn (School: Hawken School)

Solar sails are most effective closer to the sun, where propulsion is aided by high photon density. As solar sails need to be large and light to utilize the very slight pressure of the photons, and are intended to stay in space for a long time, their durability is essential. The typical solar sail material (PEN) is seamed together to achieve the desired size, further increasing its fragility. In my previous work, a high-strength fiber was integrated within a seam to resist tear propagation. Since deployment in high-temperature environments requires heat resistance, the feasibility of applying a thermoset powder onto thermoplastic webs was investigated. Due to the difficulty to consistently deploy the thermoset powder in the small area of a seam, two methods of induced electrostatic attraction, shake and spray, were developed. Aluminum foil and metallized PEN were laminated using various adhesive webs, and the effects of reinforcing fibers, thermoset powders, and powder-coating methods, on the thickness, tear resistance, and heat resistance of the samples were studied. Optical microscopy of selected webs was also examined. Adding the reinforcing fiber increased the tear resistance, while adding the powder using the shake method increased the heat resistance of all samples tested, some reaching beyond 224 °C, the temperature limit of the oven. In conclusion, a fiber-reinforced web, thermoset powder-coated using the shake method, would provide a seam with the best combination of tear and heat resistance. A solar sail seamed with these technologies could be deployed with higher structural and thermal stability.

Awards Won:
Air Force Research Laboratory on behalf of the United States Air Force: Glass trophy and USAF medal for each recipient
Air Force Research Laboratory on behalf of the United States Air Force: First Award of $750 in each Regeneron ISEF Category