

ATMOSPHERIC PLASMA AS A SURFACE TREATMENT TECHNIQUE FOR BONDING COMPOSITE MATERIALS

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ABSTRACT

There is a growing interest in the use of atmospheric plasma treatment techniques for the surface preparation of carbon fiber reinforced epoxy and polycyanurate composite hardware prior to bonding. In this paper, we will discuss the effects of atmospheric plasma treatment on the chemical and resultant mechanical properties of the treated composites. X-ray photoelectron spectroscopy (XPS) and lap shear strength (LSS) tests were performed to investigate the surface chemistry and the adhesive strengths of the treated composites. The results allow us to correlate improved adhesive strengths to formation of specific reactive surface functional groups.

1. INTRODUCTION

Adhesive bonding of composite structures is a critical aspect of modern spacecraft design, holding a number of advantages over mechanical fasteners. These include an ability to create uniform stress distributions, lower weight structures, and reductions in the cost of fabrication. However, with high performance adhesive joints there continues to be concerns related to consistency between builds. Currently there are no established nondestructive techniques suitable for determining bond strength. This has forced the aerospace industry to rely on process control to maintain reliable bond performance. A key component to the success of any bonding process is the application of an appropriate surface preparation technique. This is one that can effectively remove contamination (oils, release agents, particulates, etc) from the composite surface without damaging the physical structure of the laminate. Current production bond preparation techniques address this issue either by removing the contaminated surface with abrasion (grit blasting, sanding) or avoidance, using peel plies to create a fresh clean surface for bonding. While these approaches are well established there are inherent variability's in these techniques that can impact joint performance. These include the dependence of abrasion techniques on the bonding technician's skill at maintaining a consistent surface and removing the contaminated resin without compromising the underlying resin/fiber interfaces. In the case of peel plies care must be exercised to avoid inadvertent contamination from elements of the peel ply itself as well as damage during ply removal. The widespread use of high stiffness fibers (> 340GPa) for space applications has highlighted the susceptibility of the fiber/matrix interface to damage that can compromise bond performance. Investigators at The Aerospace Corporation are examining composite bonding issues with an emphasis on surface preparation techniques.

The aim is develop methods that reduce preparation variability, enhance bond performance while minimizing interface damage. A promising line of research utilizes an atmospheric pressure plasma jet (APPJ) to replace abrasion procedures. Developed in the late 1990's, APPJ is a non thermal glow discharge plasma using a mix of gases (inert and active) that are activated to