Laser Ablation Surface Treatment of Structural Aerospace Composites and Metal Alloys for Adhesive Bonding

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Introduction

NASA Langley Research Center (LaRC) has been involved over the past decade in the development of laser ablation as a method to surface treat aerospace structural fiber reinforced composites (CFRPs) and metal alloys. [1-18] Laser surface treatment has been shown to be a rapid, high precision, and reproducible method for surface treatment of these materials, and is amenable to automation. The laser ablation process removes surface contamination such as silicones, creates surface roughness, and chemically activates a surface for bonding. The degree of ablation is controllable by adjusting laser parameters. In the case of CFRPs, ablation can be performed without damage to any underlying carbon fibers. In the case of metal alloys, ablation is possible without surface embrittlement, heat damage or creation of undesirable grain structures or morphologies. The optimum laser treatment conditions are substrate dependent and generally are influenced by laser wavelength and pulse duration (typically fixed for a laser system), and laser power. In the case of metal alloys such as Ti-6Al-4V, the laser ablation process eliminates the need for several steps of the conventional processes, including hydrofluoric (HF) acid and caustic treatment. These steps are often conducted in dip tanks and require costly facilities and environmentally unfriendly liquids. In addition, the laser can create nano-porosity on the Ti-6Al-4V alloy surface allowing for sol-gel penetration and thereby creating a gradient interface with improved temperature and mechanical performance. NASA LaRC has also been involved with the development of in-line characterization methods compatible with the laser treatment process to rapidly determine the presence of key contaminates such as silicones that, even at very low concentrations, are a threat to adhesive bonding. A spectroscopic technique called micro-laser induced breakdown spectroscopy (u-LIBS) has been developed to rapidly detect silicones at concentrations below those known to cause bonding problems. This technique requires no sample preparation, vacuum or inert atmosphere, has no practical size limitations, and provides nearly instantaneous feedback to the operator. This presentation will give an overview and update of these developments with specific examples highlighted.

Acknowledgements

The authors acknowledge funding from the NASA Advanced Composites Project and thank: Hoa Luong, Sean Britton, and Michael Oliver for laminate fabrication and specimen preparation. They also thank interns Guillermo Morales, Allison Crow, Dan Caltaldo, Nikita Budwal, Anna Zetterberg, Taylor Fulton, Keisharra Eldridge, Alexandria Arthur, James Dowdell, Joseph Dennie, Teersa Kramer and graduate student Hieu Truong.

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