Effect of Plasma Immersion Ion Implantation (PIII) with Different Gases on the Surface Properties of Carbon Fibers

Alberto Santos*[1], Mario Ueda[2], Konstantin Kostov[1], and Leide Da Silva†‡[3,1]

[1]Universidade Estadual Paulista (UNESP) – 333, Dr. Ariberto Pereira da Cunha Av., Guaratingueta, 12516-410, SP, Brazil

[2]National Institute for Space Research (INPE) – 1758, Astronautas Av., São Jose dos Campos, 12227-010 , SP, Brazil

[3]Technological Faculty in Pindamonhangaba (FATEC) – 4010, Abel Fabricio Dias Rd, Pindamonhangaba, 12445-010, SP, Brazil

Abstract

During the last decade, carbon fibers (CFs) have been extensively utilized for manufacturing of thermoplastic composites. These high-performance materials have found numerous applications in aerospace, marine and automobile industry due to their favorable engineering properties, such as low density, enhanced toughness, excellent fire resistance and high mechanical strength. However, for obtaining composite materials with high quality it is essential to have good adhesion between the carbon fibers and the polymer matrix. Therefore, in many cases surface modification of the CFs is required. In this work, Plasma Immersion Ion Implantation (PIII) of carbon fibers is aimed to improve the adhesion between the composite layers.

Our PIII system consists of a 600-liters vacuum camera, a sample holder, a glow discharge plasma source and a high voltage pulser. During the PIII process, CF samples (40cm x 23cm in size) were clamped in a holder, which was fixed inside the chamber. By using a mechanical and a diffusion pump the base pressure inside the chamber was reduced to 10-6 mbar. After that a gas precursor was introduced into the vacuum camera until the work pressure of 10-3 mbar was achieved and then the plasma source was turned on. The amplitudes of current and voltage pulse were fixed to 0.5 A and 3.5-4 kV, respectively. CF specimens were PIII treated with air, argon and nitrogen, for 20 minutes. Following the treatment the CFs were characterized by Raman spectroscopy, Scanning Electron Microscope (SEM) and Atomic Force Microscopy (AFM).

The Raman spectra presented different ID/IG ratios for the untreated sample (1.4) and treated samples (5.1 for air; 3.7 for argon and 5.0 for nitrogen). So, the ion implantation in the carbon fibers caused an increase of the crystalline structure disorder (D band). SEM images of all PIII-treated CF fibers exhibit many thin tracks and small particles distributed over their entire surface. These structures are product of the fibers surface sputtering during the PIII process. The results from AFM analysis demonstrated an enhancement of the surface roughness of the samples treated with air (12.1±3 nm) in comparison with the roughness of

*Corresponding author: alberto0900@gmail.com

†Speaker

‡Corresponding author: leidelili@yahoo.com.br

the untreated specimen (6.2±1.3 nm). The samples treated with argon and nitrogen showed no significant change in their roughness. This finding suggests that the PIII treatment of CF with air is the most effective process for surface structural modification of the CFs and it will possibly lead to adhesion enhancing on the fiber/matrix interface.

Keywords: Carbon fibers, Plasma Immersion Ion Implantation, Surface Modification