SURFACE TREATMENT OF CARBON FIBERS BY PLASMA IMMERSION ION IMPLANTATION (PIII) FOR ENHANCEMENT OF THE THERMOPLASTIC COMPOSITES INTERFACE

Leide Lili G. Silva*[1,2] and Mario Ueda[2]
[1]*Faculdade de Tecnologia de Pindamonhangaba - FATEC*
[2]*Associated Plasma Laboratory-LAP, National Institute for Space Research – INPE, São José dos Campos,*

1. Introduction

The carbon fibers have been used for manufacturing of thermoplastic composites, such as carbon-reinforced polyetherimide (CF/PEI). This material has many aerospace and industrial applications [1] due to its favorable properties, such as enhance toughness, excellent fire resistance and recyclability. Plasma processing of carbon fibers is aimed to provide better contact and adhesion between individual plies and thus minimize the humidity content in the composite interfaces. This study presents the preliminary results of the surface treatment of carbon fibers by using plasma immersion ion implantation (PIII).

2. Experimental

The carbon fiber substrates (plain weave with 3000 monofilaments/cab) were treated by PIII using the nitrogen and oxygen as gas sources. The treatment parameters are following: p = $6x10^{-3}$ mbar, f= 200 Hz, pulse length = 20 μs, pulse voltage = -3.0 kV and treatment time = 10 min. Since the oxygen plasma is very reactive, the treatment time was reduced to 1 min. In addition, oxygen plasma treatment without fiber bias voltage was applied for 10 min. The treated and untreated samples were characterized by Raman spectroscopy, scanning electron microscopy (SEM) and atomic force microscopy (AFM).

3. Results and Discussions

The Raman spectra shown in Fig. 1 present the characteristic D and G bands at approximately 1355 and 1582 cm^{-1}, respectively. These values are in agreement with those found in the literature for carbonaceous materials [2]. However, the bands width (FWHM) of the PIII treated samples is higher than that of the standard one. This finding may be associated with decrease of the fiber crystallinity after the treatment due to the introduction of nitrogen atoms into the carbon structure. As can be seen in Figure 2 the SEM of the treated samples revealed small particles distributed over entire surface of the fiber. These particles are produced because of fibers surface sputtering during the PIII treatment that removes the epoxy layer covering as-received samples. Results of AFM analysis showed a slight decrease of the fiber medium roughness (Ra) – from 32 nm for the untreated sample to 27 nm for the sample treated for 10 min with N plasma. These results are coherent because the PIII process for 10 min was the most severe treatment as observed in the SEM morphologies. On the other hand, for production of composite material is essential to have good adhesion between the carbon fiber and the polymer matrix without decrease of the carbon fiber mechanical resistance. Therefore the nitrogen PIII for 1 min. seems to be the best condition for fiber treatment. Further analysis of composite mechanical properties is under way.

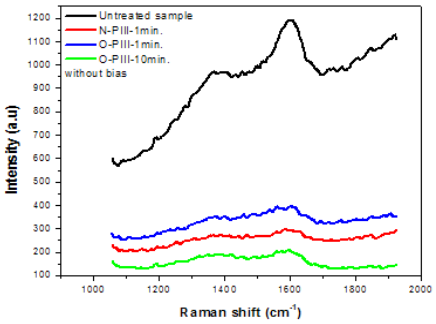

Fig. 1. *Raman spectra for the untreated and treated carbon fiber samples.*

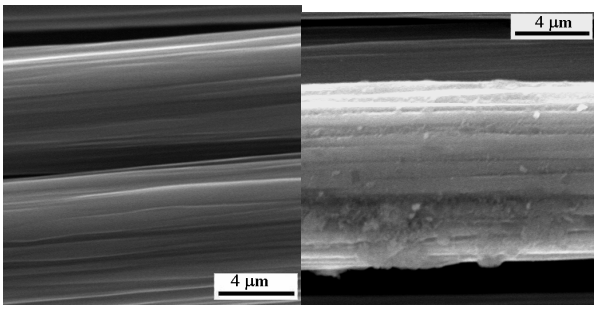

Fig. 2. *SEM images of untreated (left) and N-PIII treated sample (right) for 10 minutes.*

4. References

[1]- M.Hou, L. Ye, H.J. Lee and Y.W. Mai, Composites Science and Technology, **58**, 181-190, (1998).
[2]- Burakowski L., Ms. Thesis, ITA, São José dos Campos, (2001).

Acknowledgments

This work was supported by CNPq (process: 382838/2004-1).

*Corresponding author: leidelili@yahoo.com.br