Improvement on polymers PMMA and UHMWPE surface hydrophobicity using plasma immersion ion implantation

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Resumo. *Polymer dielectrics are used in several areas. Previous works have shown a great influence of hydrophobicity on the surface breakdown (BD) voltage of some dielectrics. The use of energetic particles to modify polymer surfaces is a method widely employed. In this work, the surface of ultra-high molecular polyethylene (UHMWPE) and poly-methyl-methacrylate (PMMA) polymers samples has been modified by a treatment technique known as plasma immersion ion implantation (PIII). After treatment by PIII, it was shown that the polymer wettability decreased and its surface hydrophobicity improved. The treated samples were characterized using contact angle measurements with distilled water and compared before and after the PIII treatment to verify respectively changes on surface hydrophobicity. Surface flashover was tested by using a special breakdown testing pulser.*

Key Words: Plasma immersion ion implantation, dielectric, hydrophobicity

1. Introduction

Surface hydrophobicity characteristics can have great influence on surface flashover of several materials as shown in literature [Wilson 2012 and Kirkici 2007]. Surface flashover are very common in dielectrics or insulators, for instance in polymers components that are used for space application that are submitted to partial vacuum in lower orbit satellites [Lee 1998]. The impact of energetic ions on the surface changes the atomic bonds, modifying surface energy and structure of the polymer by the use of the PIII technique. In this case, the PIII treatment was applied for treating polymers used as high voltage dielectrics, such as UHMPE and PMMA.

2. Methodology

The HV Blumlein pulser type was used for the nitrogen PIII treatment and more details of this system is described elsewhere [Rossi 2008]. The nitrogen ions was implanted using 20kV/5µs/100Hz pulses applied to the polymer surface during 10 minutes. The PIII system schematic drawing is shown in Fig. 1. The samples of polymers were polished to 1µm grana. Clean-up was made by isopropyl alcohol. The vacuum chamber reaches a low pressure of the order of $1x10^{-3}$ Pa. Nitrogen plasma was performed using a glow discharge (GD) source with 0.3 Pa treatment pressure. Tungsten hot filament was used to start the GD more easily and to lower the plasma potential avoiding excessive sputtering. Samples of commercial PMMA of 10 mm square shape with 2 mm thickness and, polymer UHMWPE samples with 20 mm diameter were used to test this method too. A metallic grid (made of stainless steel) was necessary to attract the ions to the polymer surface. The negative pulses were applied on the metallic grid positioned on the polymer surface. The hydrophobicity was assessed by measuring the surface contact angle using distilled water and an optical contact angle meter.

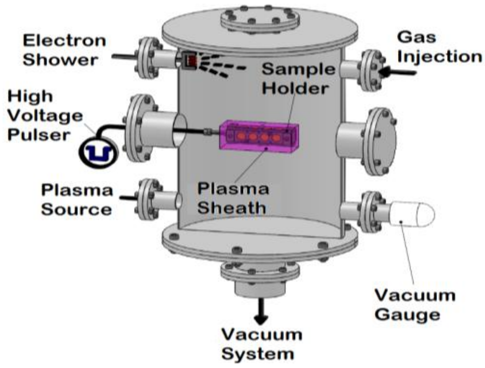

Figure 1. Schematic drawing of the PIII system used.

3. Results and Discussion

The treatment of PMMA and UHMWPE with nitrogen PIII was performed with success. In this process, hydrogen radicals are removed from carbon chains in the polymer structure and, consequently, links of carbon-carbon and cross-linked chains are formed. Absorption or adsorption processes of oxygen can also occur by changing the surface energy. The distilled water drop on PMMA surface was used on the pristine sample (left) and the corresponding contact angle measured after PIII treatment (right) showed a great increase with hydrophobic characteristics, varying from 65º to 90º, as shown in Fig. 2-a. The contact angle of UHMPE changed less, varying from 94º to 98º approximately, as shown in Fig. 2-b.

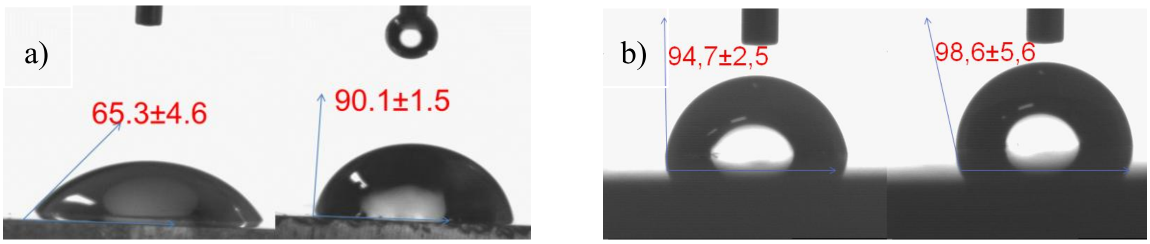

Figure 2. Pristine (left) and treated (right) samples with respective contact angles measured: a) PMMA and b) UHMWPE.

4. Conclusion

Surface characteristics have changed as indicated by the contact angle increase. Due to this effect, a more hydrophobic surface was obtained. This indicates that the resistance to the surface flashover has increased, being an important surface characteristic for insulators operating with partial vacuum in space applications, for instance, in satellites at lower earth orbits (LEO).

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