PL-CT-3

THE PLASMA ELECTRONIC PARAMETERS ON POLYMER AND POLYMER-METAL COMPOSITES PROPERTIES

[1,2]J.C. Palacios, [1,2]M.G. Olayo, [1]G.J. Cruz*, [3]J. Morales, [3]R. Olayo

[1]Departamento de Síntesis y Caracterización, ININ, Apdo Postal 18-1027, D.F., CP 11801, México,
[2]Posgrado en Materiales, FQ-UAEM, Paseo Tollocan y Colón, Toluca, Mex., CP 50000, México
[3]Departamento de Física, UAM-I, Apdo. Postal 55-534, D.F., CP 09340, México.
*gcc@nuclear.inin.mx

Introduction

The physical and chemical properties of the materials synthesized by plasma are widely influenced by the electronic and thermodynamic conditions of the plasma. The electronic variables and their influence on the chemical composition, deposition rate and the morphology of polymer and plasma polymer-metal composites films are presented in this work. The parameters studied were the glow discharge power and the electronic density and energy in different zones of the reactor.

Results

The materials were synthesized by dc glow discharges in the same reactor and similar electric configuration as those used in [1]. The power was varied from 15, 25, 35 and 50 W. Air was used as a medium for the metallic sputtering. The cathode potentials were between 680-1235 V with currents between 21-47 mA. The synthesis time varied from 60 to 300 min. The reactor volume was around 954 cm^3. The polymers were formed on the reactor walls and on the backside of the electrodes. For their posterior analysis, the polymers and the composite films were separated from the reactor surfaces swelling them with distilled water and organic solvents.

The reactor was divided in 3 zones: between the negative flange and the cathode (Z1), between the electrodes (Z2) and between the anode and the positive flange (Z3). For the plasma polymerization, two flat stainless steel electrodes of 6.5 cm diameter were used. For the syntheses of polymer-metal composites, the cathode was a 3.5 cm diameter made of a silver-cooper alloy; the anode was the same as the one previously described.

Polymers and composites of polyaniline and polythiophene were prepared and characterized by scanning electron microscopy and energy-dispersive X-ray microanalysis. The plasma parameters were obtained with a single electrical probe, as described in [2].

Plasma parameters

The plasma parameters were obtained from the glow discharges before the polymerization reactions to prevent that the fast deposition of the polymer changes the operation conditions of the probe. Fig. 1 shows a V_p-I_p characteristic curve corresponding to the Z1 collected at all the power range studied.

The figures 2 and 3 correspond to the electronic density and energy respectively at the different reactor zones. The electronic densities were between $1X10^{15}$ and $7X10^{15}$ electrons/m^3, while the electronic energies were from 4 to 10 eV.

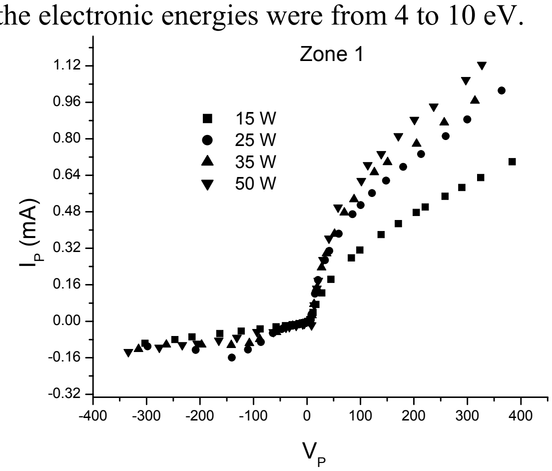

Fig. 1– Characteristic V_p-I_p curves, corresponding to the Z1. The current I_p, flowing from the plasma is increased as the voltage V_P applied to the probe is increased due to the power variation.

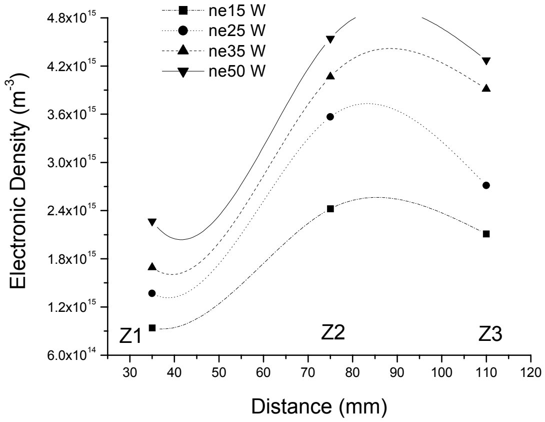

Fig. 2 – The highest electronic density is found at Z2 and decrease in considerable form at Z1. The electronic density is increased in accordance with the applied power.

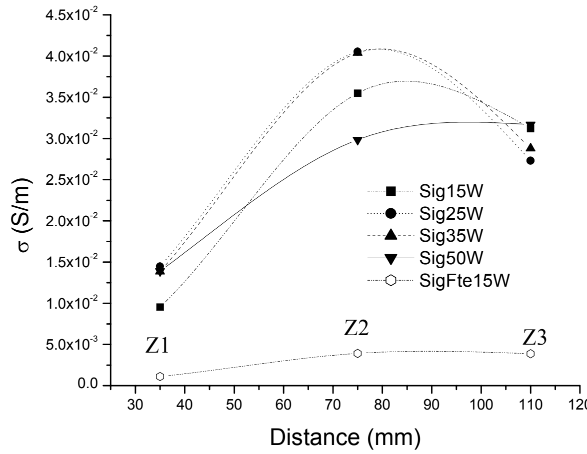

Fig. 4 – The bulk electronic conductivity was estimated as a function of the electronic current density.

The Fig. 4 shows the bulk electronic conductivity of the plasma. Values between $9.5X10^{-3}$ and $40X10^{-3}$ S/m were observed. The conductivity of the plasma can be related with the ionization extent and the mobility of the charges inside the reactor. The bulk electric conductivity calculated from the dc power is presented in the same figure. Smaller values were observed. This can be associated to pressure variations inside the reactor and to the estimation of the current density of the electrical probe.

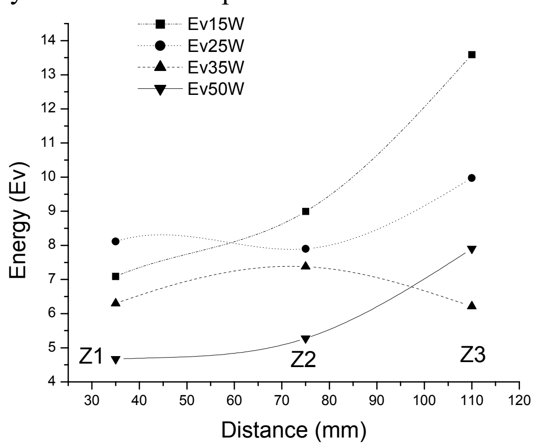

Fig. 3 – The highest electronic energies are presented at the Z3. This can be associated to the electrical attraction of electrons to the positive flange. The quantitative behavior of the curves can be associated to pressure fluctuations.

The best growth rate of polymers was presented nearby the electrode zone (Z2). However, the entire reactor, including the both flanges and the backside of the flat electrodes, were covered by the polymers. On the other hand, the metal deposition rate was favored in Z2 and lightly in the zone between the cathode and the negative flange (Z1), but not in the zone between the anode and the positive flange (Z3). This effect can be associated with the higher electron energy observed in this zone, where the smaller mean free path of the neutral metal atoms could give higher recombination rates of electrons with the positive metal ions.

Acknowledgement

The authors wish to thank to Conacyt for the partial support to this work.

References

1. J. C. Palacios, M. G. Olayo, G. J. Cruz, J. Morales, R. Olayo, International Journal of Polymeric Materials, 2002, 51, 529-536.
2. D. J. Ball, Journal of Applied Physics, 1972, 43, 3047-3057.