Pretreatment of Polymer Substrates with the Dual Magnetron Plasma Treatment Source (DMPTS)

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INTRODUCTION

The envis-ION Dual Magnetron Plasma Treatment Source (DMPTS) is designed to increase the surface energy of polymer based substrates in a vacuum system just prior to the deposition of a thin film in the same chamber. Increasing the surface energy of polymer based substrates can enhance adhesion and change the initial growth characteristics of certain films. Many companies that coat polymer films have known about the positive effects of pretreatment for many years and in turn have also learned the negative effects of overtreatment. The most common ways pretreatment takes place in the vacuum chamber prior to deposition is with plasma created by a glow discharge, a magnetron, or an ion source. Glow discharge plasma sources and large area ion sources are often designed to operate in the kilovolt range and produces very high energy particles that can easily damage the surface of the polymer. Magnetron plasmas can operate at much lower potentials in the hundreds of volts but they also can deposit a film on the substrate before the polymer has reached an ideal treatment level. The DMPTS overcomes a lot of these challenges by creating stable, low impedance plasma inside a cavity. That plasma expands into the vacuum chamber in the form of a wide beam that comes in direct contact with the substrate.

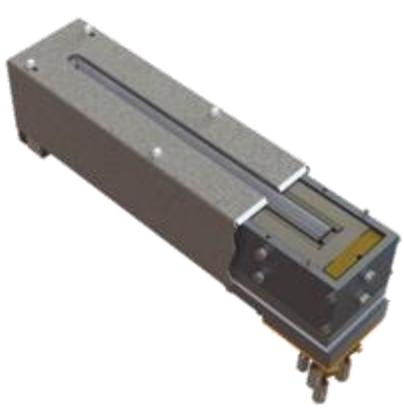

Figure 1: DMPTS Source with Shielding Cutaway

THEORY OF OPERATION

Most low frequency large area plasma sources operate by exposing the substrate to plasma created between two electrodes at different electrical potentials. The DMPTS creates the plasma the same way but utilizes a magnetic confinement and the introduction of the process gases right next to the electrodes to reduce the impedance of the plasma that is created completely within the source cavity as shown in figure 2.

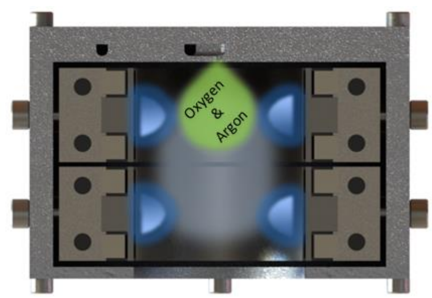

Figure 2: DMPTS Plasma Generation

Instead of utilizing the plasma created between the electrodes, the DMPTS relies on the confined geometry to limit the volume of plasma that can populate the space within the source. As the power is increased, the plasma density reaches saturation and is forced to expand outside the confines of the cavity creating a wide beam of plasma as shown in figure 3. The remote plasma production eliminates many of the problems such as a significant portion of the electrons traveling along the electrical or magnetic path of least resistance which can in turn cause the plasma to be non-uniform. All of the bulk electron transfer occurs between the two electrodes within the DMPTS removing the expanding plasma from the circuit.

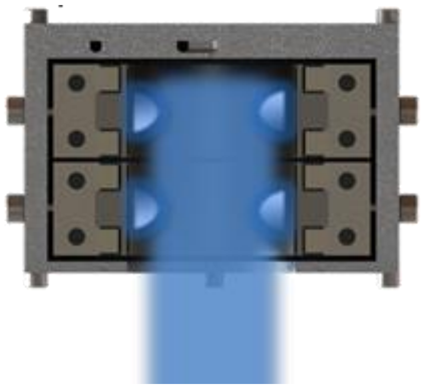

Figure 3: Plasma Expanding Out of the Source

EXPERIMENTAL SETUP

To quantify the usefulness of the DMPTS at enhancing the adhesion sputtered films onto the surface of polymer based substrates. PET, Polycarbonate, and Polyethylene substrates were put through a range of pretreatment exposures and a set of them were coated with sputtered aluminum. The surface energy and adhesion were measured with dyne pens and a grid and tape test according to ASTM 3359.

The DMPTS source was installed in a chamber containing a large drum that spins on a vertical axis. The substrates were mounted to the surface of the drum and the source was mounted to the chamber with a distance of 150mm between the face of the source and the substrate. The DMPST was run on an Advanced Energy PEII 5kW AC power supply that runs at a frequency of 40kHz. The process gases used were a mixture of 90% Argon and 10% Oxygen. The Oxygen was used in the experiment to help reduce the electrodes from sputtering and to help chemically activate the surface of the polymers.

RESULTS

The DMPTS source was able to increase the surface energy of all three polymer substrates to the test limits maximum measurable surface energy of 72 dynes using distilled water. The maximum adhesion of the sputtered aluminum films to the substrates did not necessarily occur when the surface energy reached 72 dynes. For PET the adhesion was 100% using ASTM 3359 without any pretreatment while Polycarbonate required a pretreatment exposure seventeen times higher than what was required to bring the surface energy up to 72 dynes before the adhesion was 100% as shown in figures 4 and 5.

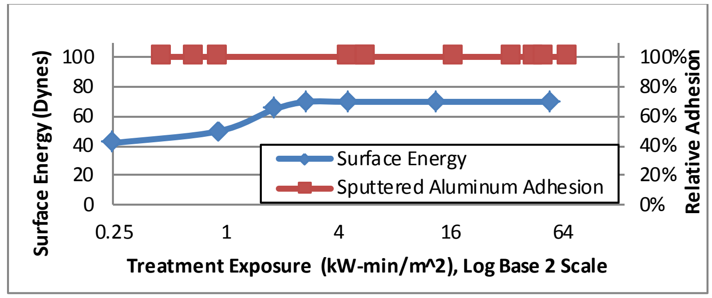

Figure 4: Pretreatment and Adhesion to PET

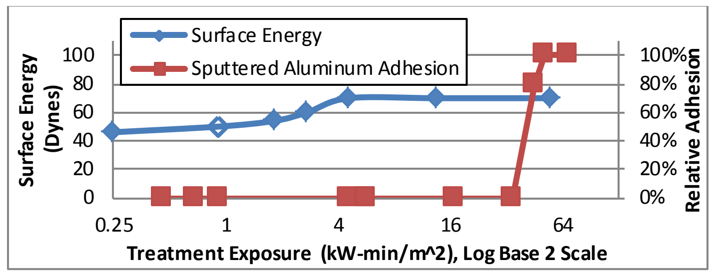

Figure 5: Pretreatment and Adhesion to Polycarbonate

Polyethylene did follow the expected trend of reaching the maximum adhesion and maximum surface energy at the same time as shown in figure 6.

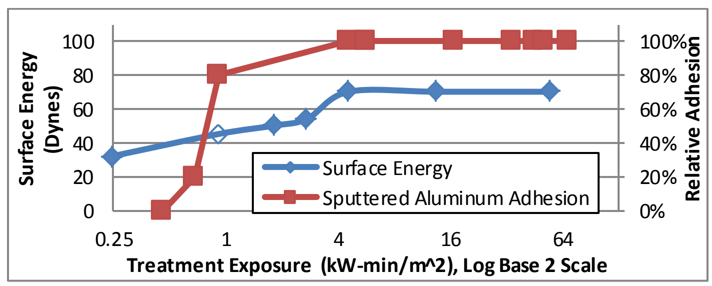

Figure 6: Pretreatment and Adhesion to Polyethylene

CONCLUSION

The DMPTS is capable of providing sufficient pretreatment exposures to enhance the adhesion of thin films to the surface of polymer based substrates without damaging the surface of the materials. This is very important because it can be difficult to gauge how much pretreatment may be required for a specific polymer and by eliminating the damaging high energy particles from the treatment process operators will no longer have to be concerned with the possibility of over treating and damaging the substrates.