Methods to generate plasma assistance for vacuum-based web coating processes

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Vacuum web coating is an important manufacturing process that is used to produce technological thin films for a wide variety of applications, such as solar cells, displays and solid state lighting. Plasma assistance is used in vacuum web coating systems to improve quality of end products. Some typical industrial application examples where plasma/ion treatments are employed are: moisture barrier films (e.g. SiO_2; plasma treatment is used to improve adhesion and barrier properties), light barrier films (e.g. Al; plasma treatment is used to improve adhesion and barrier properties), ITO coatings (plasma treatment is used to improve adhesion and uniformity of electrical properties), plastic optical devices (plasma treatment is used to provide anti-reflective surfaces), etc.

Thin film adhesion to a polymer web is one of most important quality characteristics of a coated product. It can be improved significantly by web plasma pre-treatment methods, which are now used routinely in roll-to-roll coating systems. Magnetically enhanced plasma treatments are established processes to enhance quality and performance of vacuum coated web products.

In this paper an overview of three different methods to generate plasma assistance for vacuum based web coating processes is given. The techniques covered are i) magnetron-based DC and AC discharges, ii) anode layer type plasma jets and iii) hollow cathode-based high density plasma sources.

Magnetron –based plasma treaters

Magnetically enhanced glow discharges (e.g. using single/dual planar and/or rotatable magnetrons) form a branch of relatively new (as opposed to more conventional radio frequency and/or microwave discharges) plasma treatment processes to enhance the quality and performance of plasma processed and/or vacuum coated web products. Notably, dual rotatable magnetrons have recently been successfully applied for the high rate production of nano-structured functional polymeric web surfaces [1, 2].

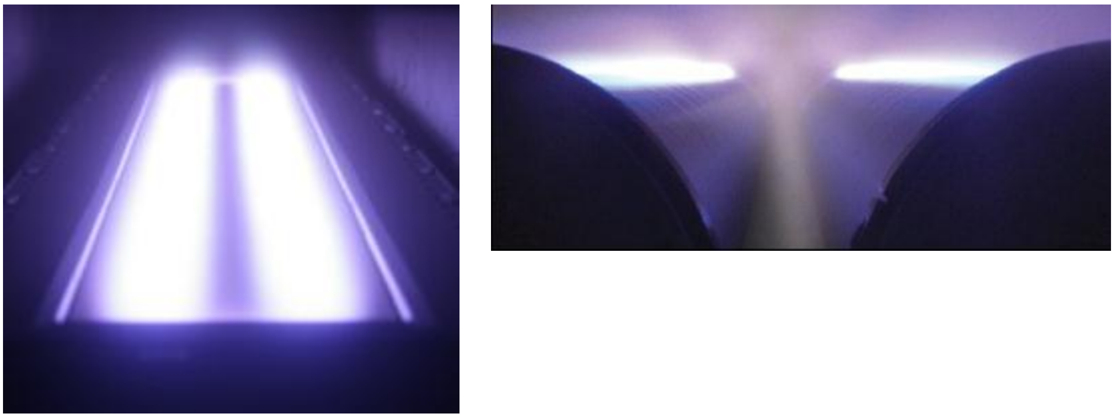

Figure 1. Gencoa planar and rotatable (dual) magnetron based plasma treatment devices.

Figure 1 shows an example of a 1600 mm long and 250 mm wide (sputter target width) planar magnetron based plasma treater. These devices are available in any length and usually operated at low voltages, often in a range between -200 V to -400 V. Their main application areas are reactive (e.g. O_2 containing) plasma substrate pre coating treatments for purposes of cleaning, surface activation and/or production of desired functional surface morphologies. For precise treatment and surface chemistry control closed loop feedback process control can be used.

Anode layer type ion beam

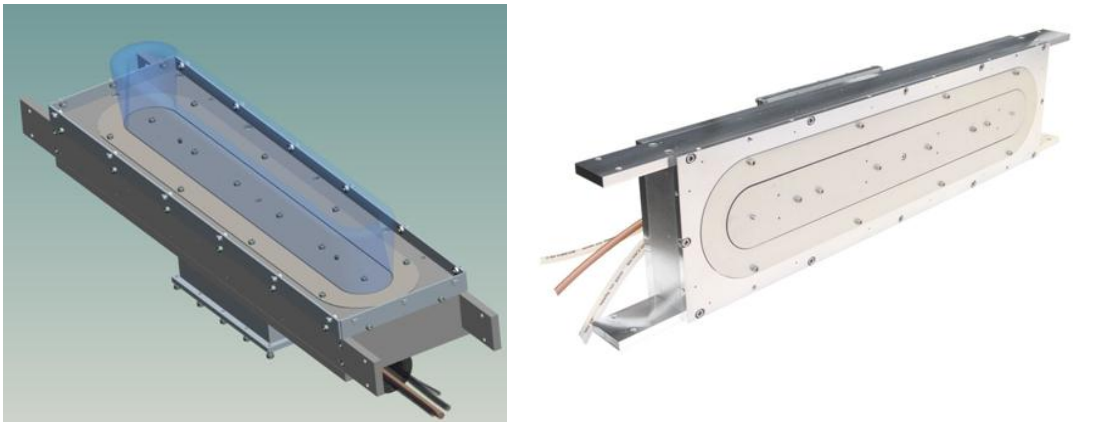

Figure 2. Gencoa IM series anode layer type ion beam.

Linear ion sources by Gencoa (Figure 2) are based on anode layer type closed drift thruster concept. They represent a robust and flexible means of pre-cleaning polymer and glass substrates prior to thin film deposition. The plasma jets impact the substrate to burn-off hydrocarbons and activate the surface to promote adhesion of the deposited film.

The intense plasma jets are generated by a combination of the magnetic and electrical field across a narrow gap through which the gas or mixture if gases pass. DC power modes can be applied with typical voltages in the 1.5-3kV range to provide relatively high energy plasma pre-treatment. A higher magnetic field strength version with pulsed DC power can generate plasma jets at sub 1kV for lower substrate damage type plasma treatment.

The robust and easy to service design is available in any length and a variety of internal, external or cantilever mounts. A unique feature is the internal graphite anode that is simple to replace and very long in life due to the very low sputter yield of carbon. Under normal operating conditions the anode should have a life of around 6 months before replacement.

The use of pure argon gas or Ar and reactive gas mixtures (e.g. $Ar + O_2$) generate the most effective plasma cleaning processes. Almost any combination of gases can be used. The plasma can also be used for deposition and polymerisation via the gas phase.

The IM series are not recommended for metallic substrates or very high speed web movements. Gencoa provide a range of different customised solutions based upon high power magnetically enhanced plasma generation electrodes.

Linear hollow cathode plasma source

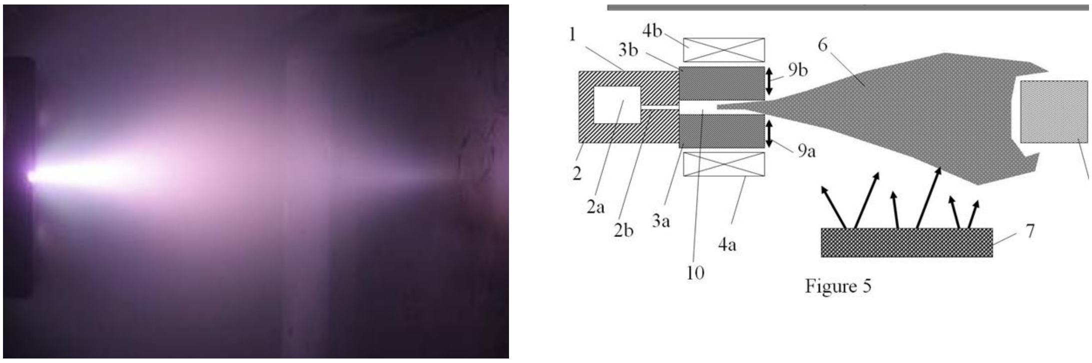

Figure 3. Gencoa linear hollow cathode plasma source.

Gencoa magnetically enhanced linear hollow cathode plasma source exploits the so called hollow cathode effect, which allows formation of dense plasma discharges characterised by relatively low voltage and large current. Applications of linear hollow cathode plasma sources range from plasma pre-treatment to plasma assisted thermal evaporation and chemical vapour deposition. Same as the two previously described plasma sources linear hollow cathode plasma source is available in any length.

Keywords: vacuum web coating, plasma assistance, plasma pre-treatment

References

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