BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LIX (LXIII), Fasc. 4, 2013
Secţia
CONSTRUCŢII DE MAŞINI

PLASMA TECHNOLOGIES FOR GLASS COATING

BY

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Received: August 7, 2013
Accepted for publication: September 25, 2013

Abstract. Last year's glasses with functional multi-layered coatings, such as antireflective, low-e, sun protective, UV-blocking, special filters etc., find more wide application. The purpose of this paper is to present and analyze some of the technologies used by the biggest companies in the world for coating large surfaces of glass. In the beginning of the paper are presented different cases when plasma can be used an then presenting their advantages: a low operating cost, possibility of obtaining high quality product on a large scale, the process can be applied on different type of material geometry. A large scale use of plasma is the off-line coating of the glass, with the special application the magnetron. In the main paper the principle of magnetron application is presented and further possible development of plasma assisted deposition that are followed in the world and personal conclusion about the further development. The further development that are presented in this paper are the improvement of thickness uniformity, better managing of the magnetic fields and reducing the setup time for a new product.

Key words: multi-layered coatings, offline coatings, plasma treatment.

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1. Introduction

Historically, there are two ways to apply coatings to glass. During the pyrolitic (on-line) process, the coating is applied during float glass production. The off-line process occurs after the glass has been produced, using a magnetron sputter vacuum deposition coater. Generally, the latter process offers increased coating options and a broader range of performance options than the pyrolitic process. In this paper the magnetron sputter vacuum deposition coater is presented and analyzed.

The magnetron technology had made grate advances in the last years but they are a lot of room for improvement. One of these things in a better managing of the magnetic fields, the current systems uses a lot of energy to function. An improvement of thickness uniformity is another point for improvement. To reach the minimum thickness of deposition on the entire surface of the target a greater overall layer of deposition is needed. Because of this extra thickness a greater amount of row material is needed. The area of improvements with the greatest benefit for the future is reducing the setup time for a new produce. To successful produce a new product means that sometimes several weeks of production will be lost.

To improve the process, a better control of the process is needed. They are two ways: building better machines with broader range of performance options and simulate the process to obtain better parameters for the existing machines.

2. Plasma Treatment

2.1. Plasma in Industry Applications

Plasma can be used in many different cases whenever you would like to better adhere materials together or to change a surface property to suit your needs. With this trend-setting technology it is possible to modify virtually any surface. Plasma technology offers several versatile applications, for example:

- cleaning surfaces of any residues, oils, or contamination;
- activation of various materials before gluing, painting, etc.;
- etching and partial removal of surfaces;
- coating of parts with several possible types of layers (PTFE-like, protective barriers, hydrophobic, hydrophilic, friction-reducing, etc.).

Compared to other methods, like flame treating or using chemicals to treat a surface, plasma technology exhibits many important advantages:

- many surface properties can be obtained exclusively with this procedure;
- can be used in online production or operated independently;

- environmentally friendly process;
- regardless of geometry you are able to treat powder, small parts, discs, fleece, textiles, tubing, bottles, circuit boards, etc.;
- fabricated parts will not be mechanically changed;
- heating of the parts is minimal;
- operating costs are very low:
- extremely safe to operate;
- process is extremely energy efficient.

Because of those many important advantages this technology will be used on a large scale in the future. Using plasma technology make possible to producing good on a large scale with a minimum cost and a high quality. That way is important to have a better control of the process.

2.2. Offline Coatings

Offline coatings are added after the basic float (or annealed) glass has been manufactured and cut. Offline coatings were previously considered less resistant but latest techniques now use a magnetron coater which results in an exceptionally durable coating, which can even be heat treated for toughening.

The magnetron coater uses a technique known as sputtering to apply layers of metal oxide to the glass under vacuum conditions. This offline process allows a much wider range of formulas to be used, including those with reflective properties needed for solar protection and the most energy effective forms of Low E glass.

Using these formulas it is possible to determine the characteristic of the finale product with some degree of success. Building an accurate simulation is difficult because every magnetron machine build has specific design and control capabilities.

In the future a way to improve the process is to develop an automatic system that can simulate the entire machine and take in consideration all of the parameters.

3. System Architecture

Offline coating process has specific challenges to achieve. For a successful process certain parameters will be needed. Glass is coated in vacuum at $2\cdot10^{-5}$ mbar, a high degre of vacum will improve the process.

Glass is moving at approximately 2-6 m/min and it has 3.2 m wide; the system needs to cover a large surface of glass in a short time. Coating must be applied continuously for a long period_(up to 10 days continuously), the machine must function at exact same parameters for a long time.

3.1. The Process of Physical Vapours Deposition

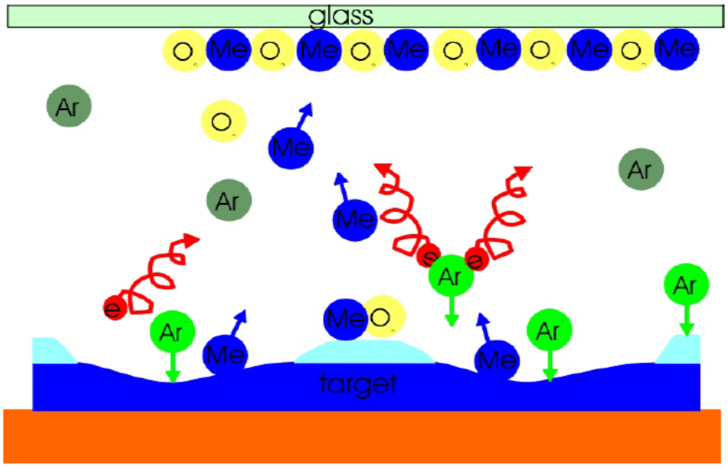

Fig. 1 – Physical process in the magnetron machine **[**Larsoon B.**]**
Ar-Argon gas molecule, e-electrons, Me-methal, O-oxigen molecules**.**

In Figure1 are represented some of the physical process that occur in the magnetron machine. A gas [for example Hexamethyldisiloxane (HMDSO), Hexamethyldisilazane (HMDSN), Tetraethylen glycol dimethyl ether, C2F6, is introduced to the plasma chamber. Because of plasma polymerization, layers will be deposited on the surface.

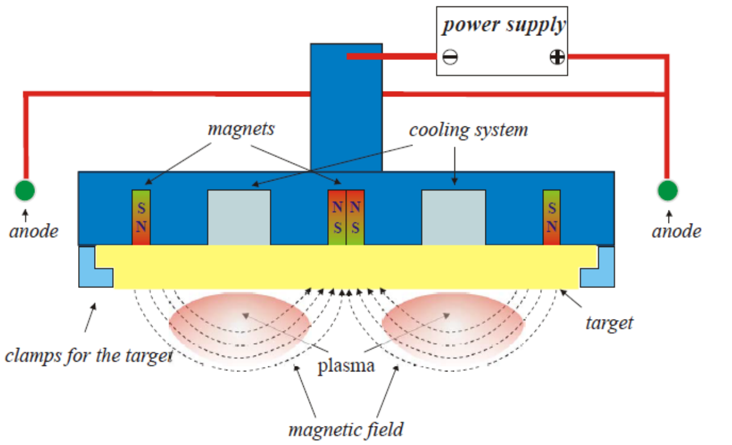

Fig. 2 – DC magnetron cathodes (RandhawaVac.).
Target- material that will be applied on the glass sheet.
Anode, N,S -power supply polarities.

In Figure 2 a schematic function of the magnetron installation is presented with enfaces on the plasma magnetic field interaction. The magnetic field contains and directs the plasma, different plasma and magnetic field is needed for every different material that will be applied on the glass.

In Figure 3 a two stage process are presented; in the first step the glass is coated with a material and in the second with another. In an industrial application up to 200 stages are used to deliver the final product.

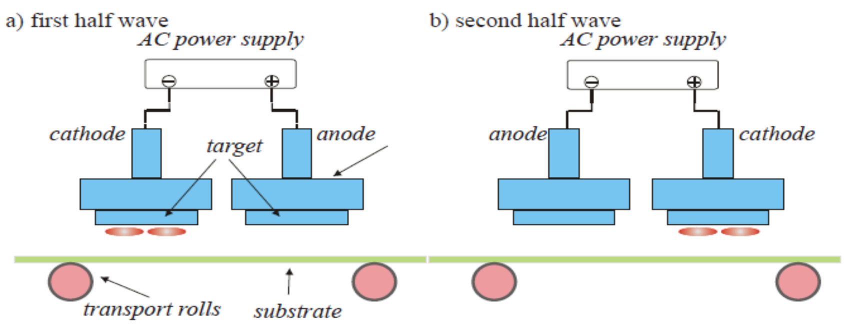

Fig. 3 − Glass flow throw magnetron instalation (Suzuki, 1998).
(a) Target- material that will be applied on the glass sheet. Substrate-the sheet of glass.
(b) Anode, cathode- machine polarities.

4. Further Development of Plasma Assisted Deposition

Due to the effects of low energy and high density ions in the plasma a high rate of high quality coating is expected. In Japan, MgO coating as a protective layer in plasma display panels and AR coating as well as ITO coating by high density plasma assisted depositions are under development. In most cases, the plasma source is use to evaporate the source materials. However, taking into consideration the freedom of control, a combination of this plasma source with high energy EB sources to evaporate the material seems to be more advantageous.

Hollow cathode activated depositions is in principal, a similar technology. Although this has not been industrialized for glass coating considering the extremely high depositions rate (3600-10 800 nm.m/min for Sio2, 1800-2700 nm.m/min for Al2O3 and 900-1400 nm.m/min for TiO2) and dense glass-like structure, it is also a candidate for a future technology with glass. A longer life for the source and improvement of thickness uniformity is assured (from the current level of ±10 to ±2%).

5. Conclusions

Last year's glasses with functional multi-layered coatings, such as antireflective, low-e, sun protective, UV-blocking, special filters etc, find more wide application. Better control of the process and development of new function for coated glass is link to the control of the plasmatic process. There are three mains way of improvements:

- improvement of thickness uniformity;
- better managing of the magnetic fields;
- reducing the setup time for a new produce.

Any changes and improvements in the field of plasma technologies for glass coating are very expensive. The high setup cost of any new installation is an important factor in developing a new technology. Improving the existent installations to produce in more efficient manner will be more probable.

Improving the thickness uniformity will aloud to reduce the amount of material for coating spend in the process. One of the material common used is high quality silver. Better managing of the magnetic fields allows directing the flow of the material to the intended target that is the sheet of glass. An incorrect magnetic field will scatter much of the material used for coating. Instead of coating the glass the magnetron will be coated.

That means that the whole installation can run for a limited period of time, after that a shutdown is needed to clean the inner chambers.

Cleaning implies dismounting all the magnetron coating cell and seen to a specialized shop to be sandblasted. If the factory has a big order it will waste valuable time. Beside that every start up of the machine implies a new setup time in which the hole lot of glass that pass throw the magnetron will be sent to became culets. Reducing the setup time for a new produce is the most desirable. To successful produce a new product means that sometimes several weeks of production will be lost. Building a simulator for the whole process is a future way to improve the process.

This will allow reducing the setup time for a new product from several weeks to a few hours or less. Using a simulator it will be possible to improve of the parameters with grate reduction on the amount of energy, raw material and a better quality of the overall final product.

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TEHNOLOGII DE OBȚINERE A PLASMEI PENTRU SISTEMELE DE DEPUNERE A OXIZILOR PE STICLĂ

(Rezumat)

În ultimii ani, sticla acoperită cu straturi multiple și cu proprietăți speciale, cum sunt antireflexia, transmisia luminoasă scăzută, blocarea razelor ultraviolete etc. a fost folosită în multiple aplicații.

Lucrarea de faţă are drept scop prezentarea şi analiza unor tehnologii folosite de cele mai mari companii din lume pentru depunerea oxizilor pe suprafețe mari de sticlă. In prima parte a lucrării sunt prezentate unele din avantajele folosirii acestei tehnologii pe scara industrială, cum ar fi: cost scăzut de operare, posibilitatea obţinerii pe scară largă a unor produse de calitate. In momentul de faţă, o aplicație industrială a acestui proces este acoperirea unor suprafețe de sticlă, mai precis echipamentul industrial numit magnetron. In cuprinsul lucrării sunt prezentate echipamentul magnetron cu principiile sale de funcționare și posibilitățile de dezvoltare ale procesului, precum şi concluziile personale despre dezvoltarea acestuia. Imbunătățirile propuse în articol sunt: creșterea uniformității stratului depus, un control mai bun al câmpului magnetic și reducerea timpului de ajustare a parametrilor pentru un produs nou.