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CURRENT STATE OF VACUUM EQUIPMENT FOR MULTILAYER COATING DEPOSITION ON LARGE AREA OF GLASS

BY

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Abstract. The purpose of this paper is to present the current state for vacuum equipment for multilayer coating deposition on large area of glass. To achieve that purpose two machines are presented and analyzed. The first one is laboratory equipment and the second one is an industrial machine used by a company in production. After analyzing and comparing the two systems, which are representative for the type of equipment's present in the world, conclusions about the utility and functions are presented. Future directions for development in order to improve the performances of new equipments are also presented, including a original one that will be develop and applied in the future.

Key words: vacuum equipment, oxide coatings, multi-layered coatings.

1. Introduction

Sputter deposition is a physical vapour deposition (PVD) method of depositing thin films by sputtering. This involves ejecting material from a

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"target" that is a source onto a "substrate" such as a silicon wafer or glass (Fig. 1) (Jung & Wetphal, 1991).

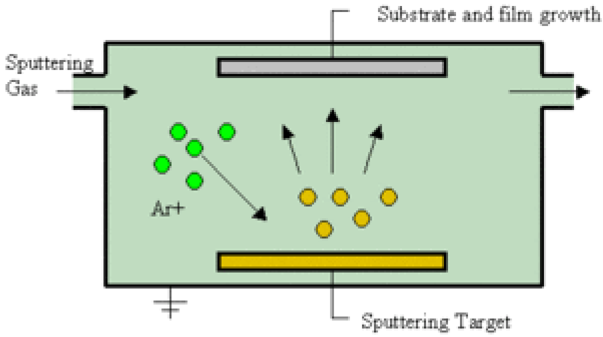

Fig. 1 – The basic system for vacuum equipment.

In Figure 1 the basic system for vacuum equipment for coating deposition is presented. It is compose of a chamber with a high vacuum atmosphere, a sputtering target; a sputtering gas wisely is argon or oxygen and a substrate, on which the target material will be deposited.

The systems that will be studied in this paper have the same operating principle. The research system has a small capability of production and wisely the result cannot be reproducing in the industrial application. The industrial system has a limited number of parameters to control and is difficult an expensive to experiment on.

2. Pre-processing Techniques

2.1. Laboratory Pilot Coating Line

The laboratory pilot UV100 coating line (shown in Figure 2) is composed of three chambers: load module, module of coating deposition and accelerating module with substrate ion treatment device. The modules are distinguished by each other by gate valves, which make it possible pump down each module individually up to pressure $2 \cdot 10^{-5}$ Torr. The pumping system is based on turbo molecular pumps that make it possible to eliminate the oil contamination in vacuum chambers. In addition usage of turbo molecular pumps provides for the stable pumping rate in the range of pressures, required for work of magnetron sputtering devices. The load module serves to loading and unloading of cassette with glass and prior pumping before entering in the deposition zone. The coating deposition module has in its composition two rotary magnetron, located on one side of module and three planar magnetrons, installed on the other side. This makes it possible to install up to five different materials for coating deposition. Length of targets is 800 mm. The distance breathing target and the substrate is 100 mm.

The coating deposition module is practically constantly under vacuum that makes it possible to provide the cleanness of gas environment in the coating process

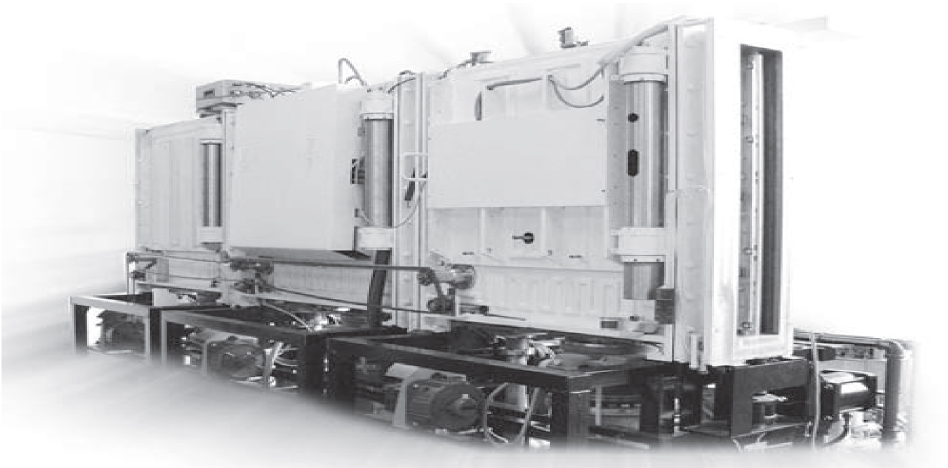

Fig. 2 – Laboratory pilot coating line UV100 (Wolf, 1995).

For substrate pre-treatment the linear ion source with ion energy up to 1000 eV was used. On vacuum machine presented in Figure 2, the controlled gas distributors, allowing producing the controlled gases flows along the length of magnetrons are applied. The vacuum machine is equipped with the reversible cassette drive with variable moving speed. For magnetrons powering on vacuum machine there are the DC power supplies, alternating current power supplies with frequency up to 100 kHz and the power.

Vacuum machine presented in Figure 2 is composed of 10 chambers and 5 stations for glass loading and unloading, pumping, pre-treatment and the coating on both sides of glass. The vacuum machine is equipped with the pumping station based on turbo molecular pumps. The cassettes transportation system provide for continuous flow of cassettes with glasses in zones of magnetron sputtering. For coating deposition are used 52 rotary magnetrons, who work in reactive deposition mode in the atmosphere of argon and oxygen. Vacuum machine is equipped with the control system based on PLC Siemens and PC.

Reactive sputtering process monitoring and controlling is carried out in each zone of dispersion using of emission spectrometers. After each deposition zone the monitoring of optical parameters is made: reflections and light transmission in visual spectrum.

2.2. Laboratory Pilot Coating Line Analysis

The laboratory pilot UV100 coating line from Figure 2 is a very complex machine with a lot of parameters that can be controlled a change. Having a control device after every deposition is a big plus for controlling the process. That means that the parameters in every stage can de individual change and obtained feedback information and the sum of those changes can be determine in final product.

Being so complex this machine needs to be operated by people with a high degree of specialization. Every parameter must be inputted in PC that is linked with the PLC. That means that every change in the process will take a very long time, this is not permitted in industrial application.

This machine has a very high operating and maintenance cost; it can produce a small quantity of coated glass. Because of this reason this type of installation cannot be used on a large scale.

2.3. Goldstone Vacuum Technology

On the basis of German and American latest technology of the reflect glass coating machine, Goldstone has developed the owned unique technology of large area magnetron sputtering coating, it is the economy solution for most developing market.

The machine matches the popular requirements of the market with a high performance price ratio, and it is the best selection for such new developing countries and areas.

With the various coating technology, customizing product design and state-of-the-art manufacturing, Goldstone is devoted to provide the advanced and economy total solution for glass coating application. Goldstone-vacuum is able to design the professional coating equipment for customer's specialized application, develop variety coating process together and provide the continuous technical supporting and upgrading to our customer.

The magnetron sputtering glass coating line made by Goldstone has equipped the latest technology in China for DC cathode, Twin-Mag cathode and Circle Rotary cathode. The machine could be applied widely on the field of reflective glass, Low-E glass, home mirror, automobile rear mirror, solar reflector, solar absorb, ITO coating, etc. the machine features continuous operation, mass capacity, fully automatically and stabile in quality, it is the good solution to instead of traditional coating process.

2.4. Goldstone Vacuum Technology Analysis

The functionalities offered by the application have been implemented in different production plant in the world. This equipment aloes for the parameters to be change in real time and can coat a large area of glass, the target material, being very productive and cost affected. The maintenance cost is low because the installation use the same type of equipment in every cell, for example vacuum puns, rollers. This type of machine can run continues for a match longer period of time because of the size of the targets, the row material, used in the process.

In the industrial process the quality of the product can be tested at the end of the process. This is a big problem because it makes the process difficult to control, to find a cell that is mall factions a trail an error process is required.

Another big problem is the setup time for each new product. To change the type of glass been produce, which different proprieties, a lot of good glass will be lost for calibrating the installation.

3. Future Direction for Development.

3.1. The Comparison between the Two Systems

The systems presented have distinct advantages, the laboratory model allow for a multitude of parameters to be change and controlled after every cell, the industrial system has high productivity, is cost effective an can produce for a long time.

Both systems could be greatly improved with a superior system of command and that cod simulate the process and predict the characteristic of the finale product.

3.2. Proposed Improvements

The sputtering production line is a complex system which needs to use the computer system to control all parts automatically. The system is consisted of industrial PC, PLC, touch screen operation panel and pro-bus. The operator could monitor all equipment's status and process parameters from the main panel. Setting all parameters into the program, then the machine can controlled by computer and achieves the production fully automatically. 50 groups of parameters and process could be restored by customer and you can recall them in any time to repeat the products.

To control the process take a lot of powerful equipment's, several computers systems are link and work together. Every single cell has his one system of control that has an industrial computer a PLC and an electric cabinet.

All of these computers are correlated by a server that can transmit data to the operator and receive instruction from the operating system.

Building a program that can simulate the whole process is a very complex task: an industrial machine can have up to 150 separate cells. In every cell is a separate a different process with own type of target material, specific gases and different built cathodes. To simulate the process is needed to simulate a number of processes like the particle transport process during dc magnetron sputter deposition were performed to determine the energy and angular distributions of the energetic deposition species, energy and angular distributions of the deposition flux, high thickness uniformity over the substrate. Plasma is referred to as the fourth state of matter, and consists of a partially ionized gas. The presence of reactive ions and electrons, and the interactions between them, is the origin of plasma applications. The plasmas that are investigated in this work are low temperature plasmas or gas discharges.

In Figure 3 is represented a personal proposition for the improvement of the process. This will work in parallel with the command of a control system used in a real process on an industrial scale. In an industrial magnetron process to start production on a new type of product or a different type than the previous all the system mast is recalibrated. The recalibration is made by reaching a recipe: power applied in the system, concentration of gases in specific cells of the installation etc. after that recipe condition is reached start the manual calibration ho is a trial an error process. This implies that for a period of time, sometimes several weeks, all that glass ho pass throw the machine will be lost. Beside the glass a significant amount of energy and raw material is lost. That way is important to reduce the time for the setup of a new product.

The system that it is proposed in this article will analyze the parameters that are introduced in the system and the result. Based on this data the control system will run several simulations an present the new optimal parameters.

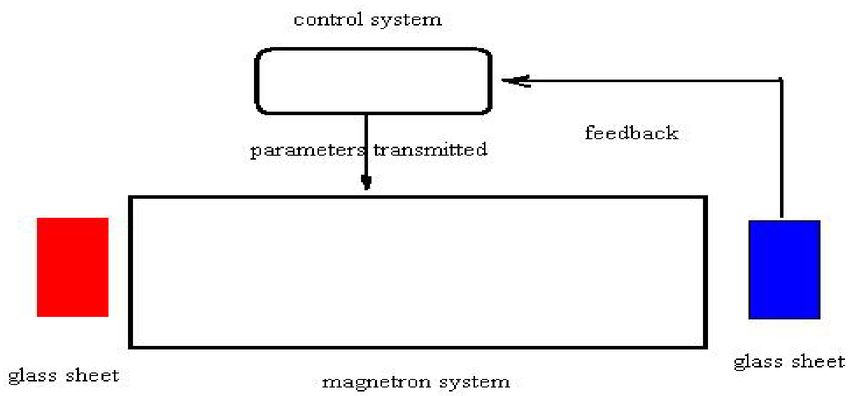

Fig 3 – Automatically Control Scheme.

4. Conclusions

1. The current technology allows control of large number of parameters. Setting these parameters is done manually and it corrects on the way after the first batch produced is analyzed. This way of doing things produce loses in glass.

2. Because the process in the magnetron machine is continuum, in the time spend from analyzing the data and the time that the new adjusted parameters are introduces several sheets of glass will pass throw the magnetron.
3. All that glass will be an out of parameters and therefore be discarded. This will amount to several tons of glass for every time you need to change the product.
4. To avoid those loses we propose to construct an offline system that could be calibrated to simulate the machine and test the initial parameters.
5. The reasons are straightforward. For a typical coating plant, one of the main costs is the installation cost. It is a major advantage to have equipment that can realize a large throughput which fits specifications like required deposition speed, uniformity, reproducibility, or target life-time.
6. This means that manufacturers strive to a minimum "setup time," which requires from them the ability to predict whether the proposed design will work or not before the machine is actually built.
7. This could be achieved by simulating the machines' characteristics. Of course, also the possibility of optimizing the deposition parameters without actually performing any real world experiment is attractive.

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STADIUL ACTUAL AL ECHIPAMENTELOR CU VACUUM PENTRU DEPUNERILE MULTISTRAT PE SUPRAFAŢĂ MARE DE STICLĂ

(Rezumat)

Lucrarea de faţă prezintă un stadiu actual al echipamentelor pentru producerea sticlei magnetron. Pentru a atinge acest scop, în lucrare sunt prezentate şi analizate două instalații. Prima este un echipament de laborator, iar cea de a doua este un echipament industrial folosit de o companie in producție.

După analiza şi comparația celor două sisteme, care sunt reprezentative pentru tipurile de sisteme existente, sunt trase concluzii despre dezvoltarea ulterioară. Sunt prezentate, de asemenea, direcțiile viitoare de dezvoltare ale noilor echipamente.