New Vacuum Equipment for Multilayer Coating Deposition on Large Area Glass

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ABSTRACT

In this paper the design of in-line vacuum machine for multilayer coating deposition on both sides of sheet glass is considered. For deposition of oxide coatings method of magnetron reactive sputtering on alternating current is used. For reception of high economic benefit are used rotary magnetrons with metal and ceramic targets. For quality monitoring optical methods of measuring of spectral characteristics of transmission and reflection are applied. Modeling of coating structure and the subsequent reproduction of these parameters in vacuum machine allows to receive unique coatings on the large area glasses.

INTRODUCTION

Last years glasses with functional multi-layered coatings, such as antireflective, low-e, sunprotective, UV-blocking, special filters etc, find more wide application. Traditionally most producers of equipment for large area glass coatings use coating deposition on one side of glass. For these aims vacuum machines are used with glasses motion in a horizontal plane and coating deposition in the direction from top to bottom. Such arrangement allows substantially simplify transportation device of glass. In this case generally the glass is moved without special cassettes. However horizontal glass moving in case of all its advantages has its limitations and imperfections. Principal is the possibility of condensate downfall on glass and the generation of defect areas, which are well looked over by sight. In addition, at the horizontal moving it is more difficult to organize coating deposition on both sides of glass. On this basis, we accepted a decision about the use of vertical scheme of glass moving. In addition, one of major tasks at creation of such equipment there is a design and modeling of technological processes for subsequent use on an industrial machine.

EXPERIMENTAL

To simulate coating deposition processes in industrial vacuum machine the pilot vacuum machine UV100 (Figure 1) was used.

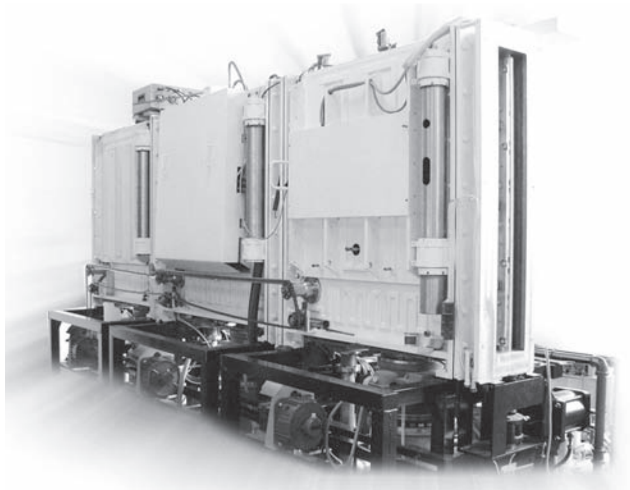

Figure 1: Laboratory pilot coating line UV100.

The vacuum machine 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 $2*10^{-5}$ torr. The pumping system is based on turbomolecular pumps that make it possible to eliminate the oil contamination in vacuum chambers. In addition usage of turbomolecular 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 – 800 mm. Target-substrate distance – 100 mm. The coating deposition module practically constantly is under vacuum that makes it possible to provide the cleanness of gas environment in the coating process. For substrate pretreatment the linear ion source with ion energy up to 1000 eV was used. On vacuum machine the controlled

50th Annual Technical Conference Proceedings (2007) ISSN 0737-5921

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 supply with pulse current.

For process monitoring and controlling the optical emission spectrometers allowing to work in transition sputtering mode are used. Utilization of transition mode to produce high deposition speeds in case of reactive sputtering is used [1]. On vacuum machine the coatings of titanium oxides and silicon oxides were deposited. For silicon oxide deposition the targets from the alloy 90% silicium and 10% aluminum were used. The silicon oxide deposition was held in reactive mode in argon and oxygen environment, in this case deposition rate for silicon oxide was more then 45 nm*m/min. For titanium oxide deposition it was used cathodes from titanium oxide TiO_x.

In Figure 2 the dependences of deposition speed for titanium oxide in case of different powers and oxygen flows are presented.

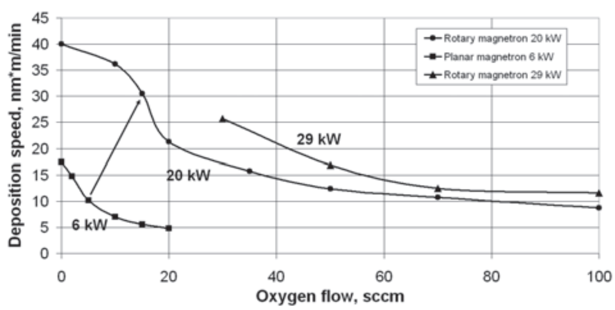

Figure 2: Deposition speed of TiO_2 at different powers and oxygen flows.

The experiments were conducted on planar and rotary magnetrons by the length 800 mm. From experimental data one can see that the rotary magnetrons make it possible to increase the deposition rate several times as much. More efficient targets cooling allow to obtain higher power density of per plasma track unit length. So for planar magnetron the specific deposition rate up 0,0625 nm*m/min/cm, and for rotary – 0,1875 nm*m/min/cm. The similar results were obtained for deposition of silicon oxide. One of key parameters to produce the coating with high light transmission is low absorption, which is determined by the absorption index. Therefore we studied the dependence of absorption index from type of magnetron and flow of oxygen during production of coating from titanium oxide. The results of research are presented in Figure 3.

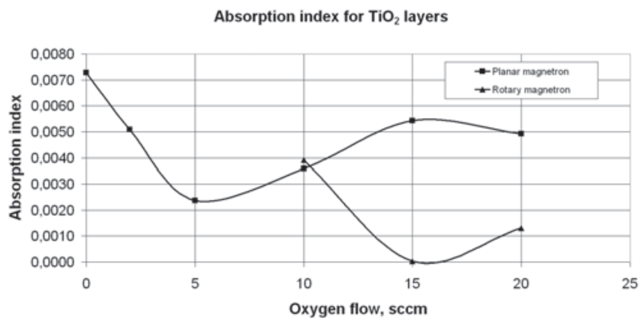

Figure 3: Absorption index for TiO_2 at different types of magnetrons and different oxygen flows.

As a result of absorption index research it was shown out that smallest (closes to zero point) values are obtained in the case of rotary magnetron usage and during production of optimum coating structure, which there is provided in case of specified oxygen flow. This in the next time gives an indication of the preferred application of rotary magnetrons to produce such type of coatings.

On the basis of the research conducted by us has been developed and was produced the vacuum machine for double-sided antireflection coating deposition. The general view of vacuum machine is presented in Figure 4.

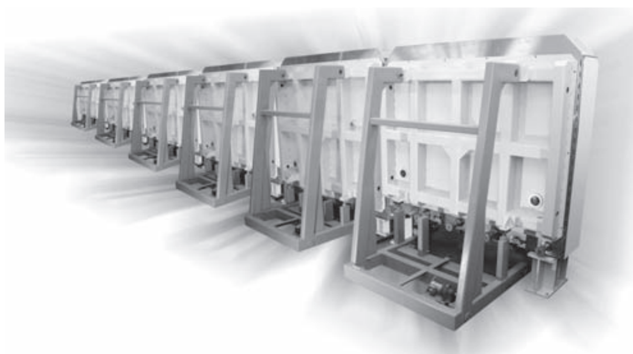

Figure 4: Industrial vacuum line for large area glass coating.

Vacuum machine is composed of 10 chambers and 5 stations for glass loading and unloading, pumping, pretreatment and the coating on both sides of glass. The vacuum machine is equipped with the pumping station based on turbomolecular 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.

CONCLUSIONS

On the base of the conducted researches developed and made a new industrial vacuum line for deposition of different types multi-layered coatings on both sides large area glasses. Vacuum machine is equipped with measuring and controlling devices for producing of high-quality optical coatings.

REFERENCES

1. E. Yadin, V. Kozlov, and E. Machevskis, “Control of Transparent Conductive and Antireflection Coating Deposition Processes,” *47th Annual Technical Conference Proceedings of the Society of Vacuum Coaters*, pp. 650-652, 2004.