2.2.4 FLAT-SPRAY PROCESS FOR OPTICAL COATINGS ON COLD GLASS

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1. INTRODUCTION

The thickness of optical coatings lies in the range of 100 nm and thickness variations of less than 5% are demanded for high quality coatings.

Among the wet chemical coating techniques, the dip-coating is used for the production of interference multilayers for antireflective large area glasses shop windows (Amiran®), pictures (Mirogard®) and car mirrors [1]. The use of spin, spray or spray-spin coating techniques is limited to special cases [2,3] and smaller substrate sizes. The main advantage of the dip coating technique for large area application is that the coating thickness can be controlled very precisely by controlling the viscosity of the coating sol and the withdrawal speed [4,5]. However, this technique has also some disadvantages:

1. It requires a high volume of coating sol and large tanks and despite of long pot life (several months) only about 20% of the sol can be used [6]. The long pot lifes are obtained using sols with low pH values, which cause corrosion and environmental problems. On the other hand, the sol can be „contaminated“ by the large number of substrates dipped in the sol (leaching) and by the environment (dust), causing quality problems.

2. Since the withdrawal speeds are in the range of a few cm/min, long processing times are required. For example the dip coating process of a 1 m x 1 m glass pane takes about 10 minutes [7] under industrial conditions.

The flat-spray coating technique offers high throughput and uses only „fresh“ sol. In the following the obtention of a PbO-SiO₂ coating containing Au colloids was chosen as an example [8,9]. 100 nm thick layers having ruby red to violet colors with peak optical densities up to 2 allowed to easily detect visually any unevenness of the layer.
2. PRINCIPLE OF THE FLAT-SPRAY COATING TECHNIQUE

A typical flat spray coater (Venjakob) is shown schematically in figure 1.

![Figure 1. Scheme of the Venjakob flat spray coater](image)

The glass panes are moved from the right to the left on a metallic conveyor belt with an adjustable speed from 0.47 to 1.67 m/min. The coating is applied in a closed spray booth using two high-volume low-pressure spray guns (Krautzberger HVLP), mounted crosswise on one axis. They move perpendicularly to the direction of the substrate transport with a fixed program. A water curtain of about 2 m³ is circulating under the conveyor belt and 7000 m³/h filtered air is flowing in the spray booth for mist control. After passing a flash-off zone the coatings can be dried at temperatures up to 250 °C with IR radiation.

With optimized sol parameters and spray parameters, the flat-spray technique can be used to get optical coatings with controlled thicknesses in the range of about 200 nm.

3. OPTIMIZATION OF THE SOL AND PROCESS PARAMETERS

The basic idea is the preparation of sufficiently thick wet films in order to obtain a smoothing out of the layer after the spray deposition. Sols for the preparation of oxide layers are usually prepared from methoxy- or ethoxysilanes [10,11] which leads to hydrolysis and condensation products with high vapor pressure at room temperature (128 mbar for methanol and 59 mbar for ethanol [12]). When sprayed at room temperature the evaporation rate of the very fine droplets is very high and the droplets are almost dry when they hit the substrate's surface. For example, if a PbO-SiO₂ coating sol is used, which had originally been developed for Au-colloid containing ruby red coatings on glass and which is diluted with a solvent mixture from ethanol:isopropanol:n-butanol = 1:1:1 for dip coating, the homogenous coatings could not be obtained at all, although the spray coating parameters like spray distance, material pressure, atomizing pressure and the