2.2.8 DOCTOR BLADE

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1. INTRODUCTION

Doctor blade (or tape casting) is one of the widely used techniques for producing thin films on large area surfaces. Tape casting is a relatively new process which was originally developed during the 1940's as a method of forming thin sheets of piezoelectric materials and capacitors [1] and is now an accepted precision coating method. One patent, issued in 1952, focuses on the use of aqueous and non aqueous slurries applied to moving plaster batts by a doctor blading device [2]. In the doctor blading process, a well-mixed slurry consisting of a suspension of ceramic particles along with other additives (such as binders, dispersants or plasticizers) is placed on a substrate beyond the doctor blade. When a constant relative movement is established between the blade and the substrate, the slurry spreads on the substrate to form a thin sheet which results in a gel-layer upon drying. The doctor blading can operate at speed up to several meters per minute and it is suitable to coat substrate with a very wide range of wet film thicknesses ranging from 20 to several hundred microns.

There are two generally different coating devices in use: a doctor blade (e.g. a rectangular frame) and a spiral film applicator.

2. DOCTOR BLADE (FRAME)

This kind of doctor blade is also used in combination with a reservoir. The effect of the reservoir geometry on the flow of the sol is described in [3]. The layer is formed by a doctor blade that is either stationary when used with a moving casting surface, or by a frame that moves along a stationary casting surface. The principle is shown in figure 1.

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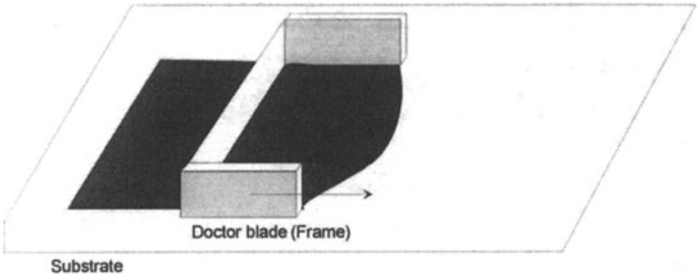

Figure 1. Principle of doctor blading using a frame with a reservoir of coating liquid which is moving relatively to the substrate.

The thickness of the layer is metered by adjusting the gap between the doctor blade and the substrate, as it is illustrated in figure 2.

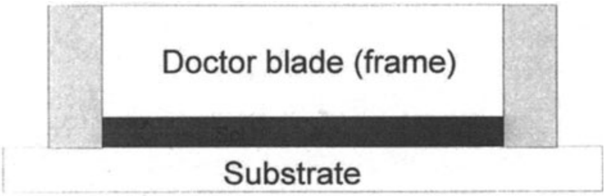

Figure 2. Wet layer thickness control by the gap between the frame and the blade.

The use of dual doctor blades in series has also been described in [4]. These blades provide very precise thickness control of the final layers.

Doctor blade coating techniques are also used for coating plastic foils with coating liquids [5]. In this case, the blade is positioned across a roll and the web is moved underneath the blade, as one can see from figure 3.

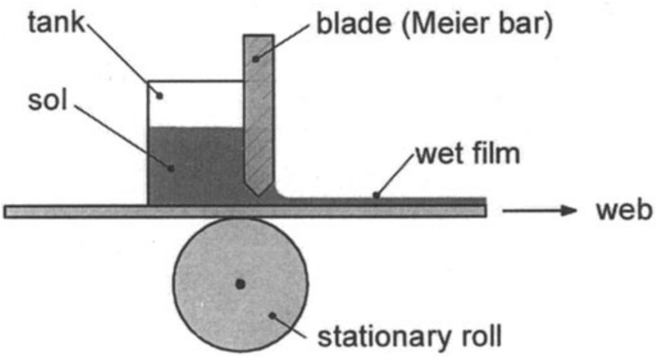

Figure 3. Doctor blade coating technique for plastic foil (Meier bar).

The gap between the blade can be adjusted by precision holders in the range of +/- 10 μm. The tank for the coating sol reservoir can be filled by continuous pumping, in order to avoid bubbles in the reservoir.

3. SPIRAL FILM APPLICATOR

The spiral film applicator is mostly used for coating foils, leather, textiles or other flexible materials with uneven surfaces. By using the spiral film applicator, the underlaying substrate is pressed down and flattened. The principle set-up is shown in figure 4.

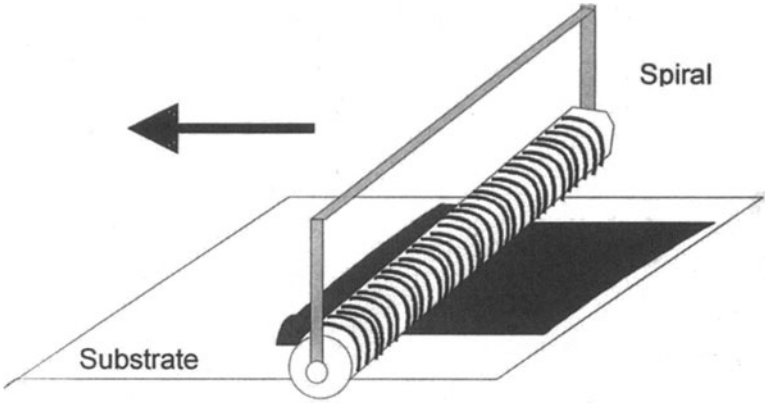

Figure 4. Principle set-up of doctor blading with a spiral film applicator.

The wet layer thickness is defined by the geometry and the size of the gaps, the spirals and the "gap-to-spiral-ratio" as one can see from figure 5.

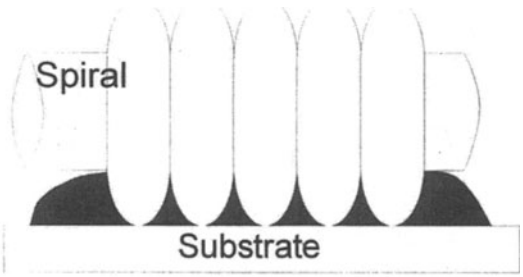

Figure 5. Demonstration of the wet layer thickness control by the geometry and size of the gaps between the spiral and the "gap-to-spiral-ratio".

It is evident, that for both frame and spiral set-up, the wet film thickness is not only depending on the geometry of the coating device, but also on the wetting and the viscosity of the coating sol, as it is described below.

Doctor blades and spiral film applicators are used in concert with tape-casting machines, which are either stationary blade/moving carrier machines or moving blade/stationary carrier machines. Tape casting machines range in size from 2 to more than 35 m in length and to more than 1.25 m in width.

4. LAYER THICKNESS

The theoretical wet layer thickness corresponds to the height of the doctor blade's edge, or the spiral geometry, respectively. However, the wet layer is sheared during the layer application due to the surface tension of the sol, the wetting behaviour and the rheological properties of the sol (dynamic viscosity) and the coating speed. This has the consequence, that the practical wet layer thickness is only 60 to 70 % of the theoretical ones. The final, dried layer thickness of course also depends on the solid content and the densification behaviour of the sol.

An analytical model for the film thickness as a function of the process parameters has been proposed by Chan, Ko and Yan [6].

In [7], the fluid mechanic associated with the flow of the sol-gel-slurry during the doctor blading process is analyzed.

5. REFERENCES

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