THE SPIN COATING METHOD, FOR THE DEPOSITION OF THIN LAYERS, USED IN IMPLANTOLOGY

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Abstract: The paper presents the Spin Coating Method of depositing thin layers as a good alternative to increase the antimicrobial activity of the metallic materials used in impantology.

Key words: Spin Coating, thin layers

1. INTRODUCTION.

The Spin Coating method is one of the most common techniques for depositing thin films on substrates. It is used in a wide range of industrial and technological sectors. The advantage of deposition by this method is its ability to quickly and easily produce very uniform films ranging from a few nanometers to a few microns in thickness. The use of this method in organic electronics and nanotechnology is widespread and has formed the basis of many of the techniques used in the semiconductor industry. It also has some differences due to the relatively thin films and high uniformity required for efficient device preparation, as well as the need for self-assembly and organization to occur during the casting process [2].

2. PRINCIPLE OF THE METHOD

Deposition by this method generally consists of applying a thin, uniform film to the surface of a substrate by pouring a solution of the desired material while the substrate is being spun.
The main steps of the spin coating process are shown in figure 1.

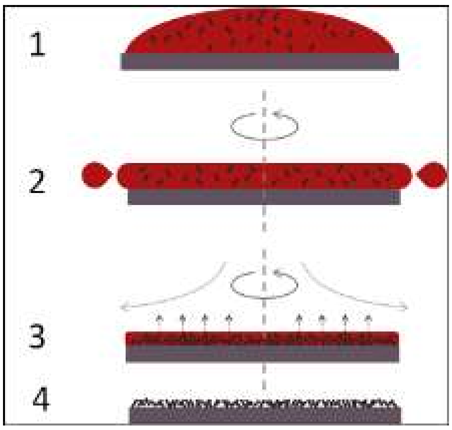

Figure 1. The main stages of the Spin Coating method [5]

First, the substrate is covered with the solution containing the substance to be deposited dissolved in a solvent (1).

Then, the substrate is rotated at high speed and the solution deposited in the previous step is spread over the entire surface of the substrate, a part being even thrown out, depending on the speeds at which it is being worked(2), [1,3].

The air flow dries most of the solvent, leaving a plasticized film (3) - before the film dries completely to form the newly deposited film (4), [4,5].

Spinning the substrate at high speed (typically > 600 rpm) means that the centripetal force combined with the surface tension of the solution causes a uniform deposition of the liquid layer. After this, the solvent evaporates so that the material to be deposited forms a uniform film.

In many areas of organic electronics and nanotechnology, the casting and drying steps of a solution are an integral part of the technology and are where all the "action" takes place. In all the examples below, the main stage of this process is the drying stage of the deposited solution:

- deposition/crystallization of a small molecule or polymer
- self-assembly of block copolymers
- phase separation of a polymer-fullerene mixture
- aggregation / assembly of nanoparticles and colloids

The properties of the film depend not only on its physical characteristics (thickness, uniformity), but also very much on the processing (drying time and conditions). This is compared to many spin coating processes such as photoresist application where the end result is largely independent of the exact application route. Because of this, there is a wider variety of techniques that are often used in organic electronics and nanotechnology - especially in a research environment, [6].

For industrial processes, spin coating would be recommended to be done at speeds higher than 1000 rpm to ensure the best uniformity. However in nanotechnology, rotation speeds of up to 300 rpm can be used to slow down the drying process. Slow dripping without spinning is a good way to provide highly ordered nanoscale films, but at the expense of uniformity on the substrate. The steps of this method are shown in figure 2.

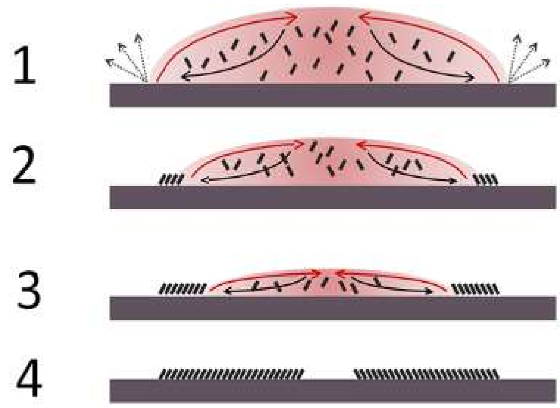

Figure 2. The steps of thin film formation by ultra-slow spin spinning [5]

The steps of thin film formation by spin at very low speeds are described below:
- a small molecule in a solvent is first distributed on the substrate and, as the solvent begins to evaporate, produces internal currents (1).
- the drop shrinks by retracting its edges due to internal currents(2).

- by slowing down the evaporation rate, it is possible to produce very ordered films at the edges (3).
- however, the coverage along the surface is usually uneven (4) [5,7].

For most applications, the most important consideration is the film thickness produced during spin coating. In general, the thickness of the deposited film is proportional to the inverse of the spin speed squared as in the equation below, where t is the thickness and ω is the angular velocity:

$$t=\alpha \frac{1}{\sqrt{\omega}} \quad (1)$$

This assumes that the film deposited at four times the speed will be half the thickness of the original layer. Thus, using the above equation, the variation of the deposited film thickness can be graphically plotted as a function of the rotation speed.

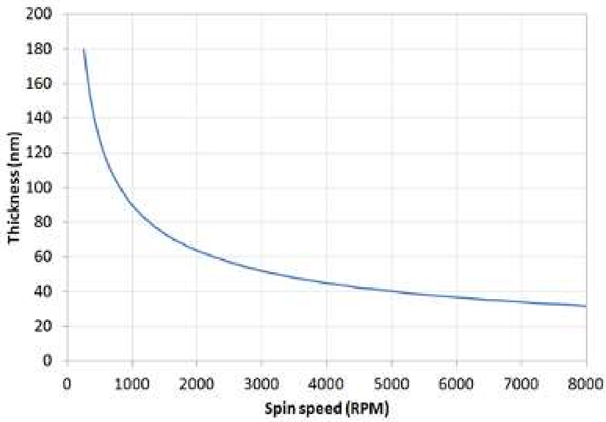

Figure 3. The variation of the thickness of the deposited layer according to the rotation speed [5]

The exact thickness of a film will depend on the concentration of the solution and the evaporation rate of the solvent (which in turn depends on the viscosity of the solvent, vapor pressure, temperature and humidity). Typically, the thickness of a deposited layer is measured either by ellipsophily or by surface profilometry (Dektak). The spin speed can be adjusted to give the desired film thickness.

The range of spin speeds available is important because it defines the layer thickness that can be obtained from a given solution. In general, uniform films can be produced relatively easily by spinning from about 1000 rpm, but in most cases good film quality can be obtained up to 500 or 600 rpm. The most common devices will also reach a maximum speed of between 6000 and 8000 rpm. Therefore, the spin speed variation range has an order of 10 (from 600 rpm to 6000 rpm) which causes a maximum film thickness variation of a factor of order $\sqrt{(10)} = 3.2$.

For example, a solution that gives a film thickness of 10 nm at 6000 rpm will give a thickness of about 32 nm at 600 rpm and if a thicker film is required, then the concentration of the solution should be adjusted. Conversely, if a solution yields a thickness of 100 nm at 600 rpm, the minimum thickness that can be obtained without dilution of the solution will be 32 nm.

This dependence on the square root of the spin speed is both an advantage and a disadvantage.

The disadvantage is that the range of thicknesses that can be obtained from a given solution spans a relatively narrow range. On the other hand, the advantage is that it allows a precise control of the film thickness in this range.

The maximum thickness that can be produced from a given material/solvent combination also depends on the maximum concentration of the solution obtained, i.e. the solubilization capacity of the material in the solvent. For materials with high solubility (100 mg/ml or higher), thicknesses greater than 1 µm can be achieved. Meanwhile, for certain conjugated polymers with low solubility (a few mg/ml), the maximum thickness could be limited to around 20 nm.

For most standard spin coating techniques, the goal is to keep the substrate spun until the film is completely dry. As such, this will depend mainly on the boiling point and vapor pressure of the solvent used, but also on the ambient conditions (temperature and humidity) under which the process is carried out.

For higher boiling (and/or low vapor pressure) solvents, drying can take considerably longer (up to ten minutes in some cases) and therefore these solvents are most commonly used as additives, [2,8].

3. CONCLUSIONS

The Spin Coating method is a simple and inexpensive method of depositing thin films on metal surfaces. The advantage of deposition by this method is its ability to quickly and easily produce very uniform films ranging from a few nanometers to a few microns in thickness. The use of this method in organic electronics and nanotechnology is widespread and has formed the basis of many of the techniques used in the semiconductor industry. It also has some differences due to the relatively thin films and high uniformity required for efficient device preparation, as well as the need for self-assembly and organization to occur during the casting process.

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