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Comparative performance analysis of various coating techniques for organic/polymer solar cell: A review

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ABSTRACT

Various coating techniques are used for organic solar cells and efforts are made to increase life of cell and increase efficiency as well. Author has tried here to analyze the performance of those methods. Spin coated cells with high power conversion efficiencies over 6% have been reported.(6,7,8,)

KEYWORDS : ink,coating,film,knife,strip,dimensional

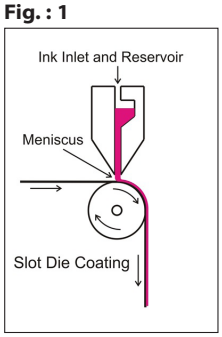
To make a solar cell film, ink is needed. Ink is a liquid - mostly it is a solvent, which could be water, organic solvent or chlorinated organic solvent. In this solvent, the material is to be dissolved whose layer is to be deposited.

So the wet film is formed from the ink, using the deposition method which will be dried which will constitute a layer on the surface which will in end constitute a particular layer in your solar cell. The solar cell stack is a multilayer structure and in its functional form typically it comprises at least 4 or 5,8 to 10 or 14 different layers that each serve a purpose.

There are different coating techniques which form an even homogenous layer. Mostly they are non-contact techniques. That means that they are either spraying the material, the ink onto the surface.We can just be pouring it over it, or forcing it through a narrow gap between a moving web and a knife. There by creating a liquid film that is of wet thickness. When this dries an even dry film will be formed.

(1) Slot die coating technique: It is very scalable, very useful, in the context of organic photovoltaic at least. It controls the wet thickness within a given range.

Fig. : 1



(2) Spin coating: Uniform thin film to flat substrates is deposited by this method. On the center of the substrate, usually a small amount of coating material is applied, which is either spinning at low speed or not spinning at all.

In order to spread the coating material by centrifugal force the substrate is then rotated at high speed. A machine used for spin coating is called a spinner.

It is not useful from industrial point of view. With this technique very small substrates can be made which are reproducible. These very small size substrates are spined. One of the disadvantages is that ink is lost from the outskirts of a fast spinning object. So in reality the majority of ink is thrown away and ends up inside the spin coater. So from a materials parsimony point-of-view, it is a wasteful technique. But from the point-of-view of being a reproducible laboratory technique, it's very, very useful. And perhaps that's also why it's been extremely successful and the majority of solar cells reported today have been prepared by spin coating.

Rotation is continued while the fluid spins off the edges of the substrate, until the desired thickness of the film is achieved. The applied solvent is usually volatile, and simultaneously evaporates. To get thinner film, angular speed of spinning is kept high. Viscosity and concentration of the solution and the solvent affects the thickness of film.

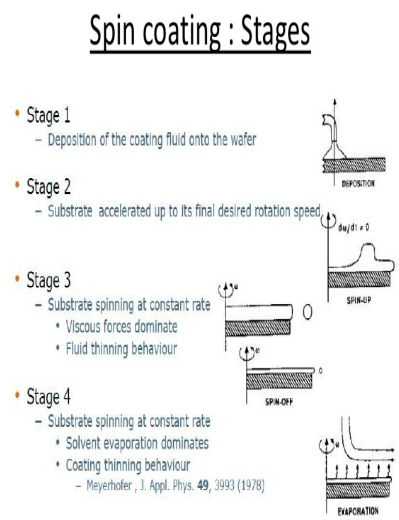
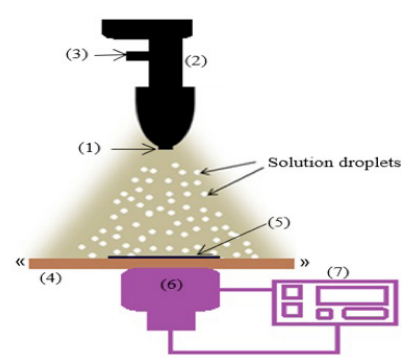


Fig.: 2

(3) Spray coating: It is more useful. It is possible to use a shadow mask to form a pattern. It is very difficult to control when it comes to establish in a fixed morphology. Also, in making a pattern through mask, there is quite a significant waste because it requires spraying ink over masks, over areas that don't want to be coated on surface; this ink has to go somewhere. This ends up on mask, of course. But generally it's viewed as inherently zero dimensional coating Technique. It is a highly scalable technique.

Fig. : 3 (1) Ultrasonic nozzle tip (2) 2D travelling arm (3) solution inlet (4) holder plate with controlled temperature (5) substrate (6) ultrasonic vibration transducer box (7) function generator for ultrasonic piezoelectric transducer.



(4) Knife coating technique: In this technique ink is put on the surface. Ink is poured over the surface, and forced it between a gap formed between the required area or surface to be covered and a knife and. There's a well defined gap between surface and the knife. This gives an even wet layer. And this technique is also a non contact technique, and it only allows for fully coated surfaces. But it has inherently good film thickness control. It is a highly scalable technique.

One common thing about all the techniques is that the ink is always very exposed to the atmosphere. For spray coating, droplets are seen flying. For spin coating, a wet film is exposed during drying. And for knife coating, ink is kept in bath in front of the knife is also in full air exposure. In the case of knife coating, it is possible to make a chamber around it to a certain extent. But generally, there's a large amount of air contact.

The slot die coating method is a completely closed system, so the ink is only exposed, at the very point of application. Wet thickness can be controlled by this technique.

But for any given ink, any given surface which is been coated with a given surface energy, given surface tension for given ink, there is a range of thicknesses at that can be achieved by controlling a pump. Ink is pumped into this coating head. As the substrate moves, the speed of wet can also be controlled or speed of substrate. And with those two parameters, the wet thickness can be controlled, and thereby, in the end, also, the dry thickness.

Like knife coating, slot die coating gives very, very smooth films. In addition to, making zero-dimensional films, slot die coating actually has the possibility to make one-dimensional patterns, so a stripe, a continuous stripe of ink.

Dimensionality: Coating methods were zero-dimensional. This is the truth but with a little modification. The spray coating method could be patterned into a shape, a two-dimensional shape, or something else, if you did it through a mask.

Thickness can be controlled. Vertical control in the coating is achievable. Slot die coating could make stripes. Coating techniques generally apply an even layer in the horizontal plane. Whereas those modifications can include different dimensionality in the vertical Plane.

Spray coater sprays. A thicker layer is build up with a slot die coater. One-dimensionality in the lateral plane can be achieved. A slot die coating head with several slots after the each other. So a wet layer of three different inks in the same coating step can be formed. So as the web passes, simultaneously three different liquids can be deposited on top of each other. Those three different liquids lie on top of each other in the wet film, and when they dry out, the solids that are in each of the inks, in this case the black, the red, and the green ink, they end up in the dry film on top of each other.

So it's a zero-dimensional film, there is actually a dimensionality in the vertical plane with material A, and material B, and finally, stacked on top of both A and B, material C is provided.

So the coating techniques do allow for some sort of dimensionality, but it's not something that is visible to the human eye.

Conclusion: If current challenges can be overcome, solar energy will be an important part of a sustainable energy future. With proper fabrication of a cell, life and efficiency of a cell can be increased. Coating techniques helps in this direction.

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