LCC - Liquid Contactless Coating
(Curtain Coating and Spray Coating)
“LCC Technology (Liquid Contactless Coating) - Best choice for PV and/or PCB?"

By Theo Langer

If - as a producer of solar panels and/or PCB boards - you are forced to continuously improve your yield, LCC (Liquid Contactless Coating) technology deserves a serious consideration. This material transfer method without any physical contact is unbeatable in terms of least amount of stress applied to your product.

The main contenders within the LCC category are curtain coating and/or spray coating. And exactly these two technologies are the specialty of all4-PCB in Switzerland.

Both technologies have a long standing history within the coating industry. The same is true for the involvement of all4-PCB’s management in these technologies.

Starting in the early 80’s the all4-PCB management was instrumental to introducing curtain coating to the PCB industry worldwide.

During these days they were responsible for fine tuning all three main components of this technology – Material, Process, and Equipment. Their curtain coating turnkey approach was so successful that it resulted in the world market leadership for curtain coating of soldermask in the PCB industry back then.

In the year 2000 the whole curtain coating know-how was transferred into a new company “all4-PCB”. Here this comprehensive knowledge was used to develop the second major liquid contactless coating application method – spray coating.

As we will see further below the two technologies: curtain coating and spray coating complement each other and, together, enable the user to tackle a wide range of application challenges.

Another, popular LCC method – spin coating – ought to be mentioned here as well. Further below we will look at its application and features.

Technology Definitions

Curtain Coating:
Substrate to be coated passes through a falling sheet (curtain) of resin. The resin is either pumped through a slotted die or over an open weir and onto the substrate. The amount of material leaving the die or weir and the speed of the substrate web determine the coating thickness.

Spray Coating:
Although there are many spray coating technologies (e.g. airless, thermal, electrostatic, plasma, conventional (LVHP)), this technical newsletter will mainly concentrate on the HVLP (high volume low pressure) spray coating approach. As the name suggests, this technology uses a high-volume of air at low atomization pressures (i.e., 0.1 to 10 psi) to atomize material.
Main Characteristics of Curtain Coating and Spray Coating

Curtain Coating:
Curtain Coating is used for flat substrates and has the highest transfer efficiency (100%) of all LCC methods. It is one of the most popular coating technologies in the printed circuit board industry for applying solder mask. Depending on the specification of the end user and the material used, typical dry film thicknesses of 20-80 µm are achieved. Curtain coating is ideal for high production rates. State-of-the-art fully automated lines are capable to run tact cycles of 20 s.

HVLP Spray Coating:
Automated HVLP spray coating – when used on flat substrates – provides the user with very good transfer efficiencies of up to 80 – 85%. It is a popular production process used in the PCB and photovoltaic industry. State-of-the-art equipment must have features protecting the edges from getting coated. The coating thickness range is larger than the one provided by curtain coating. It ranges from sub micron to double digit microns. Coatings of organic as well as inorganic nature are possible.

Curtain Coating in the early years of leather impregnation

A Schoop gun developed in Switzerland in 1909 (the oldest thermal spray process)

State-of-the-art fully automated double sided curtain coating line of the year 2010 (developed in Switzerland)

State-of-the-art fully automated single sided HVLP spray coating tool of the year 2010 (developed in Switzerland)
More Details on Spray Coating and Curtain Coating

Over 40 years ago HVLP spray coating has its origin in Europe. Also today the leading fully automated HVLP spray coating systems for the PCB and PV industry are designed and built in Europe. Compared to conventional high pressure set-up systems sophisticated HVLP systems supply air at a much lower velocity producing a softer, easier to control spray. Benefits of HVLP include less overspray and less paint wastage. Transfer efficiency can be as high as 85%. HVLP spray coaters for volume production are very cost efficient.

Modern Spray coating systems, as the one shown on the previous page provide the user with patented edge protection (see below) and a system technology that are unmatched in terms of lowest possible material consumption.

![Spray coated substrate with edge free solder mask coating](image1)

![specifically tuned spray technology enables very low active material consumption](image2)

Conventional contact coating technologies (e.g. roller coating) do not only apply unnecessary physical stress to the substrate but also far more material than the above described spray coating technology. This is only one reason why spray coating is gaining more popularity in the PCB and PV industry.

Where thicker coatings or material applications are required, the industry tends to use curtain coating. Thus, the process will still benefit from the important stress-free contactless coating approach and, in addition, gain higher coating thicknesses plus highest possible productivity.

Regardless of substrate width, edge-free coating is always guaranteed with curtain coating, making it also a method that is highly versatile and flexible.

A huge difference to contact coating technologies is that curtain coating and spray coating adjust the edge free coating on the fly, saving set-up time for valuable production time. Contact coating technology cannot do this.

Today, to coat flat substrates either in PCB and/or solar panel manufacturing there is hardly a better technology (cost-wise, quality-wise and productivity-wise) than curtain coating and/or spray coating.

If you talk to all4-PCB in Switzerland or North America, we will be able to go in much more detail and find the technical solution that fits your specific needs.
What is the Preferred Coating Method for Wafer?

The substrates of wafers are very thin, small and fragile. Here, curtain coating is not recommended. The most popular LCC methods used here are spray and/or spin coating.

all4-PCB investigated these two LCC methods, in order to find the best coating method for our customers. We concluded to recommend spray coating rather than spin coating. Below you can see our all4 evaluation set-up during testing.

A group of researcher from the Delft University of Technology compared the costs of photo resist coating using spin and spray coating systems. Below you can see two charts of their findings.

Conclusion: The greatest disadvantage of spin coating is its low coating efficiency. As much as 95% of the material is spun off the wafer during the coating process. This unnecessary waste drives up production costs, and considerably reduces mileage.

The resist volume applied in spray coating can be controlled by several parameters, such as layer thickness and the solids content of the resist solution. The left graph shows that spray coating can coat 2-3 times more wafer than spin coating. For achieving a low-cost manufacturing goal, spray coating is the clear winner.
No wrap around?
Sharper edges?
Finest droplets?
Least amount of volume?