R2R-Technologies for the Production of OPV

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As research and development for organic electronic devices shifts into high gear the need for larger-than-lab production equipment becomes evident. As experts in laser micro machining, 3D-Micromac started the development of laser based roll-to-roll patterning processes for organic electronic devices six years ago.

Working hand in hand with leading research partners, 3D-Micromac strives to offer complete modular production lines including not only the laser patterning step but also deposition processes such as coating and printing, as well as required processes for thermal treatment, packaging and separation steps.

For the coating step the so-called "slot-die coating" technology is proposed as an easy, precise and effective way for applying solution-based materials to a substrate. Depending on the ratio of solid parts, such as metal nano scaled particles or conjugated polymers, dry layers of several microns down to 30nm can be deposited with a very homogenous distribution. Typical values for the relative thickness variation of the wet film range from 10% down to 1% in cross direction and machine direction making the slot-die coating technology a suitable fit for post process steps with high demands on the layers homogeneity.

In order to achieve the best possible efficiency of the OPV follow-up process steps like drying and annealing are of utmost importance. 3D-Micromacs solution for these thermal treatments is the integration of micro-wave and hot air into a single drying and annealing system. In contrary to pure classic hot air ovens the integration of microwave technology allows for a very efficient energy transport into the material which reduces the operational costs and increases the maximum throughput of the oven. However, as the microwave radiation has to be able to interact with the material, the use is commonly known to be limited to a very small range of materials. The major and most obvious use of microwave technology therefore is the drying of water based thin films (comparable to consumer electronic microwaves), but the technology is also able to introduce energy into electrical conductive materials and thin films with a surface resistivity of down to 7Ω/□. This feature enables the use for the production of OPV based on substrates with TCO layers. In device layouts the energy can be introduced into the TCO material and the generated heat is then dissipated into the surrounding material and can be used for not only drying but also annealing steps. The required control of the energy distribution in the oven is realized through a special design of the dryer chamber and magnetrons. With this approach the overall size and energy demand of the unit compared to a dryer using solely hot air can be reduced significantly.

The patterning step for the functional surface covering layer can be realized by laser micromachining processes applying ultra-short pulsed laser sources. These laser sources provide laser pulses with pulse durations well below 10ps which is necessary in order to minimize negative effects such as particle generation bulging and heat affected zones making them feasible for thin film applications. Furthermore different wavelengths and optical setups for the beam guidance can be chosen depending on the material system and the layout of the OPV.

The combination of such a variety of processes into one modular production line, 3D-Micromac's microFLEX, which not only meets the requirements for a controlled environment but also allows for a later change of the process sequence or an easy extension of existing capabilities is unique in the current landscape of available equipment and will be presented in the talk.