Interdigitated Flexible Li-Ion Battery by Aerosol Jet Printing

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Abstract : Conventional battery technology includes the assembly of electrode/separator/electrode by standard techniques such as stacking or winding, depending on the format size. In that type of batteries, coating or pasting techniques are only used for the electrode process. The processes are suited for large scale production of batteries and perfectly adapted to plenty of application requirements. Nevertheless, as the demand for both easier and cost-efficient production modes, flexible, custom-shaped and efficient small sized batteries is rising. Thin-film, printable batteries are one of the key areas for printed electronics. In the frame of European BASMATI project, we are investigating the feasibility of a new design of lithium-ion battery: interdigitated planar core design. Polymer substrate is used to produce bendable and flexible rechargeable accumulators. Direct fully printed batteries lead to interconnect the accumulator with other electronic functions for example organic solar cells (harvesting function), printed sensors (autonomous sensors) or RFID (communication function) on a common substrate to produce fully integrated, thin and flexible new devices. To fulfill those specifications, a high resolution printing process have been selected: Aerosol jet printing. In order to fit with this process parameters, we worked on nanomaterials formulation for current collectors and electrodes. In addition, an advanced printed polymer-electrolyte is developed to be implemented directly in the printing process in order to avoid the liquid electrolyte filling step and to improve safety and flexibility. Results: Three different current collectors has been studied and printed successfully. An ink of commercial copper nanoparticles has been formulated and printed, then a flash sintering was applied to the interdigitated design. A gold ink was also printed, the resulting material was partially self-sintered and did not require any high temperature post treatment. Finally, carbon nanotubes were also printed with a high resolution and well defined patterns. Different electrode materials were formulated and printed according to the interdigitated design. For cathodes, NMC and LFP were efficaciously printed. For anodes, LTO and graphite have shown to be good candidates for the fully printed battery. The electrochemical performances of those materials have been evaluated in a standard coin cell with lithium-metal counter electrode and the results are similar with those of a traditional ink formulation and process. A jellified plastic crystal solid state electrolyte has been developed and showed comparable performances to classical liquid carbonate electrolytes with two different materials. In our future developments, focus will be put on several tasks. In a first place, we will synthesize and formulate new specific nano-materials based on metal-oxyde. Then a fully printed device will be produced and its electrochemical performance will be evaluated.

Keywords : high resolution digital printing, lithium-ion battery, nanomaterials, solid-state electrolytes
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