Preparation of thin film model electrodes by APID (Atmospheric Pressure Ion Deposition)

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Thin films of functional organic and inorganic materials and their possible applications have a wide range of interest. Saf et al [1] reported an experimental setup for processing organic and inorganic materials into thin structured films under atmospheric pressure. The process, based on an electrospray technique, can be divided into two steps: the dispersion of the injected solution and the ionization, followed by the extraction of the ions and their deposition on the target. A scheme of the experimental setup is shown in Fig. 1, Figure 2 shows the deposition of the ions onto the target. First micro-droplets are formed and dried (the drying step before the deposition is the difference to related methods), generating ions that are focussed by electrostatic lenses (Fig. 3). The potential applied to the lenses gives control over the resulting ion beam. In order to get a deposition of constant thickness or patterns the heated target is moved by a positioning stage in accordance with the experimental parameters.
This setup can be chosen for the preparation of thin film model cathodes used for the investigation of electrode reactions in lithium ion batteries. The advantage of cathodes manufactured in this way is the possibility to prepare electrodes without any conductive additives or binders. On the other hand, designed addition of carbon back or polymers is possible as well as the preparation of "gradient materials" by adequate choice of precursor solutions. Moreover, by APID thin layer electrodes (typical thickness 100 – 500 nm) can be easily prepared, resulting in very small diffusion limitations. In conclusion APID is a powerful tool for the preparation of test electrodes, rendering possible the experimental separation of effects of conductive additives and binders, whereas conventional slurry-based composite electrodes by nature provide only "composite information".
Preparation of the electrode: The active/conductive material can be deposited e.g. on ITO or aluminium current collectors. $LiMn_2O_4$ electrodes can be prepared using following conditions: precursor solution: $Mn(NO_3)_2.4H_2O$ (50 mmol/l) and $LiNO_3$ (25 mmol/l) in ethanol, flow: 0.5 ml/h, deposition time: 30 minutes, U_{HV}: 5.1 kV., substrate temperature: 400°C. Electrodes prepared in that way can also be used for investigations by the electrochemical quartz microbalance (ECQM), measuring mass changes of the electrode [2], as well as for the electrochemical mass spectrometry (EMS), detecting volatile compounds appearing during film formation or decomposition of the used electrolyte [3].

Acknowledgement

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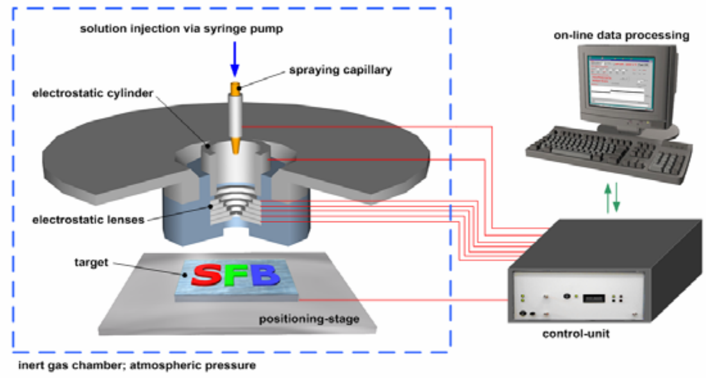

Fig.1: Instrumental setup for APID spraying process; spraying capillary, cylindrical electrode, a set of electrostatic lenses and the target.

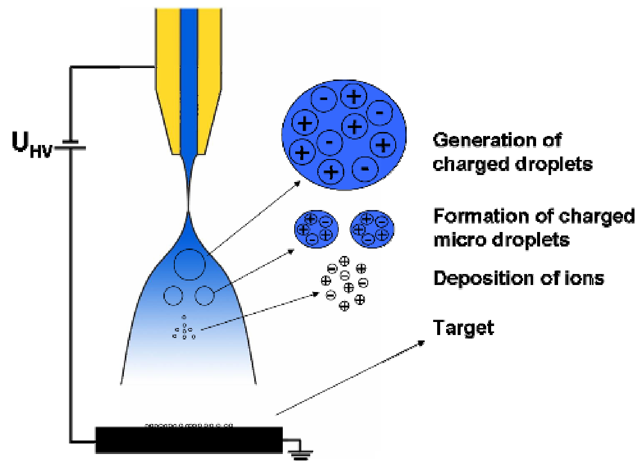

Fig.2: APID spraying process; forming of microdroplets, drying and deposition of the ions onto the target.

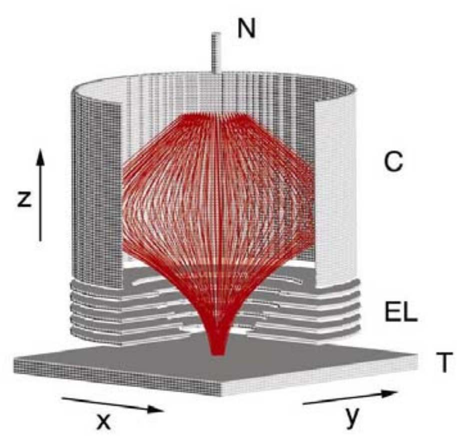

Fig.3: Simulation of ion trajectories inside the electrode/electrostatic lenses. Needle (N), cylindrical electrode (C), electrostatic lenses (EL) and target (T).

References

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