Preparation of $LiCoO_2$ Paste Electrodes for High Power Micro-batteries

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Many thin film batteries with crystalline $LiCoO_2$ cathodes have been prepared and evaluated for a wide variety of applications. In particular, thin film (or micro) batteries as a power source for the low power applications such as smart cards, power implantable medical devices, and MEMS application, have been developed for last two decades [1-5]. However, micro-batteries of the high power and small size are required in present, simultaneously.

The power of batteries is dominated by the thickness of cathodes. It has been known to be difficult to make thick cathode film by a sputtering or chemical vapor deposition because of the complex and high cost processing. In this study, the properties of thick film cathodes for high power by the screen printing method and their characteristics have been investigated.

The thick film pastes were formulated from the mixture of $LiCoO_2$ powders as a functional material, carbon black as a conducting agent, ethyl cellulose and terpineol as a vehicle, and Emphos PS-21A as a dispersant. The pastes were prepared and homogenized on a three-roller mill. The thick film patterns were screen-printed onto a SUS current collector / SiO_2 / Si wafer using a stainless steel 400 mesh screen. The screen-printed films were dried at 100 ℃ for 10 min and then the electrochemical properties of the dried thick film cathode were measured.

The microstructure of powders and screen-printed paste thick films were observed with a scanning electron microscope. The rheological behavior of the pastes was determined using a cone / plate rheometer, and the surface roughness of the dried thick film was measured using the contact surface roughness profilometer. The used electrolyte was a solution of 1M $LiPF_6$ in a 1:1 (v/v) mixture of ethylene carbonate (EC) and diethyl carbonate (DEC). Each thick film was electrochemically evaluated by cyclic voltammetry (CV) and galvanostatic cycling. The rate of capacity fade on cycling was monitored as a function of voltage window and current density.

Fig. 1 shows the schematic diagram of the micro-battery whose paste thick film has replaced the thin film cathode. The thick film cathodes could be cost-effectively obtained by screen-printing for high power micro-batteries. Fig. 2 shows the SEM micrographs of the $LiCoO_2$ paste thick film with / without carbon black. The particle size of $LiCoO_2$ and carbon black is about 5 ㎛ and 40 nm, respectively. Total solid content of paste thick film is 80 wt%. The thickness of thick films is about 15~20 ㎛. Fig. 3 shows discharge curve according to the C-rate. The electrochemical evaluation shows that $LiCoO_2$ paste thick film cathodes present the improved electrochemical performance with an initial discharge capacity of 200 μAh/cm^2.

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References

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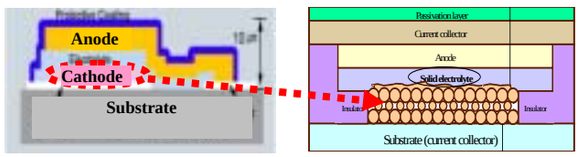

Fig. 1. Schematic diagram of a thin/thick film Li ion battery.

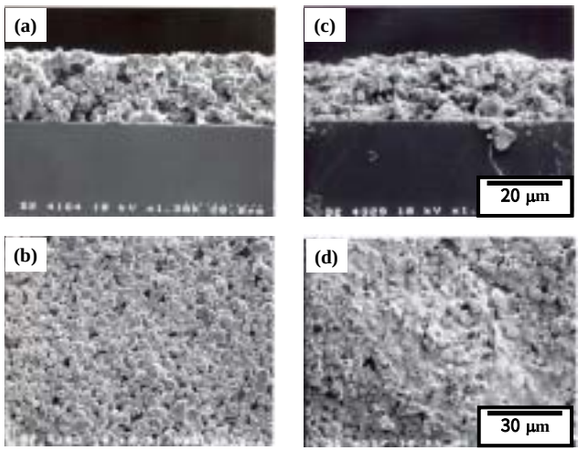

Fig. 2. SEM micrographs of facture and top surfaces of $LiCoO_2$ thick films : (a, b) without and (c, d) with carbon black.

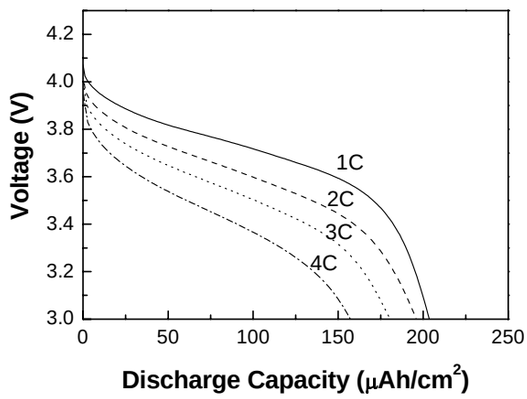

Fig. 3. First-cycle discharge capacities of the $LiCoO_2$ paste thick film at various C-rate.