$LiCoMnO_4$ as cathode material for 5 V solid state thin film Li batteries prepared by magnetron sputtering

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The spinel structured $LiCoMnO_4$ is a promising cathode material for future high energy density solid state batteries. By using $LiCoMnO_4$ as cathode material a cell voltage above 5 V vs. Li/Li^+ can be reached and in comparison to nowadays typically used $LiCoO_2$ cathodes the energy density can be increased by 25% [1]. Whereas the high operating voltage is essential with respect to energy density, it is also a criterion for exclusion when it comes to the selection of a suitable electrolyte. While conventional liquid electrolytes suffer from decomposition reactions at the high operational voltage above 5 V vs. Li/Li^+ [2], solid state electrolytes with their wide electrochemical stability window are more suitable for the realization of high voltage batteries. Solid electrolytes also offer additional benefits like for example the utilization of lithium metal as anode material and an inherent safety due to the lack of combustible electrolyte solvents.

In this presentation the preparation of $LiCoMnO_4$ thin film cathodes by radio frequency magnetron sputtering and the incorporation of the cathode material in solid state thin film batteries are addressed.

Firstly, the general parameters for the $LiCoMnO_4$ thin film deposition process were studied. The as-deposited amorphous thin films were prepared using a $LiCoMnO_4$ powder sputter target and different substrate materials. The following analysis of the thin films after heat treatment in ambient atmosphere by Raman spectroscopy and X-ray diffraction revealed, that a temperature of 550°C is sufficient to crystallize the material in the desired spinel structure. Additionally, measurements by nuclear reaction analysis and secondary ion mass spectrometry were carried out to analyze the elemental distribution within the $LiCoMnO_4$ thin films.

In a successive reactive magnetron sputtering process a LiPON thin film electrolyte was applied by using a Li_3PO_4 sputter target and nitrogen plasma. Afterwards, solid state thin film batteries were set up by using lithium metal as anode material. The concluding electrochemical testing by cyclic voltammetry and charge/discharge measurements showed a clear electrochemical activity of the $LiCoMnO_4$ thin film cathodes above 5 V vs. Li/Li^+.

References:

[1] H. Kawai, M. Nagata, H. Tukamoto, A.R. West, J Power Sources, 81 (1999) 67-72.

[2] J.B. Goodenough, Y. Kim, Chem Mater, 22 (2010) 587-603.