Characteristics of lithium lanthanum titanate solid electrolyte for all-solid-state lithium thin film battery

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Recently, much attention has been paid to lithium ion conducting solid electrolytes for their possible applications to high energy density thin film microbattery. It has been reported that lanthanum lithium titanate with perovskite-type structure showed a lithium ionic conductivity of as high as 1×10^{-3} S/cm (in bulk) at room temperature. In this work, we prepared the single target of $(Li,La)TiO_3$ by classical soild-state reaction. Films of $(Li,La)TiO_3$ were deposited onto $LiCoO_2Pt/TiO_2/SiO_2/Si$ substrates at various deposition temperatures by pulsed laser deposition (PLD) technique.

First of all $LiCoO_2$ thin films are deposited onto Pt/TiO2/SiO2/Si substrate as a function of Li/Co mole ratio and the deposition temperature by pulsed laser deposition (PLD) for all-solid-state lithium thin film battery below 1μm. Especially, $LiCoO_2$ thin films deposited at 500°C with target of Li/Co=1.2 mole ratio show an initial discharge capacity of 53 μAh/cm^2-μm and capacity retention of 67.6%. The microstructural and electrochemical properies of $(Li,La)TiO_3$ thin films grown on $LiCoO_2/Pt/TiO_2/SiO_2/Si$ structures by pulsed laser deposition (PLD) were investigated at various deposition temperatures.

Figure 1 show schematic configuration of the all-solid-state lithium thin film battery. This thin film batteries need a solid electrolyte like LLTO. Figure 2 shows XRD patterns of LLTO on LCO(100nm)/Pt/TiO2/Sub at various deposition temperatures. $(Li,La)TiO_3$ solid electrolyte forms amorphous state in Fig 1. The Electrochemical properies of $(Li,La)TiO_3$ thin films grown on $LiCoO_2/Pt/TiO_2/SiO_2/Si$ structures by pulsed laser deposition (PLD) were investigated at beaker cell testing with Li metal anode in Ar ambient. Figure 3 show (a) behavior of capacity retention during 100 cycles, and (b) the variation of the initial discharge capacity and capacity retention in $LLTO/LCO/Pt/TiO_2$ cells as a function of LLTO deposition temperature.

The $(Li,La)TiO_3$ thin films grown on $LiCoO_2/Pt/TiO_2/SiO_2/Si$ at 100°C show an initial discharge capacity of approximately 51 μAh/cm^2-μm. and moreover show excellent discharge capacity retention of 90% after 100 cycles, and also good property nearly 70% more than 300cycles. An amorphous LLTO solid electrolyte is possible for application to solid electrolyte for all-solid-state lithium thin film battery below 1μm.

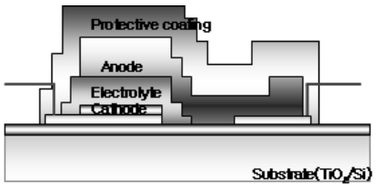

Fig. 1 Schematic configuration of the All-solid-state lithium thin film battery

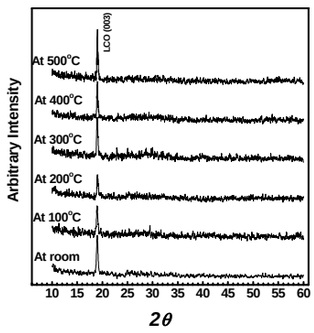

Fig. 2 XRD patterns of $(Li,La)TiO_3$ grown on $LiCoO_2/Pt/TiO_2$ substrate with various deposition temperatures.

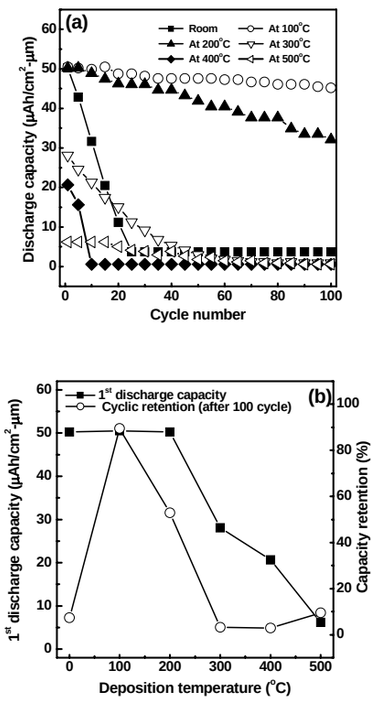

Fig. 3 (a) The behavior of capacity retention during 100 cycles, and (b) the variation of the initial discharge capacity and capacity retention in $LLTO/LCO/Pt/TiO_2$ cells as a function of LLTO deposition temperature.

References

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