Tuning Crystal Orientation in Layered Oxide Thin Films for High Performance Li-ion Battery

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$LiCoO_2$ (LCO) and their analogues layered oxide materials have been one of the important and most research cathode material for lithium ion batteries. As the battery technology currently transiting towards solid state battery as a safer alternative, the application of LCO and its other promising analogs in such applications are limited by their anisotropic lithium transport in 001 direction. Studies have shown that thin films of polycrystalline LCO prefer to grow with 001 orientation parallel to the substrate, which hinders the ease of lithium exchange with electrolyte[1-3]. To overcome this inherent issue, studies has been conducted on tuning crystal orientation to get desired facile ionic transport across electrode electrolyte interface. However, the overall thickness of film remain within sub-nano regime.[4-6]

Here, using substrate templating approach and Pulsed Laser deposition (PLD) technique, we have successfully tuned $LiCoO_2$ crystal orientation to achieve facile lithium transport across electrode-electrolyte interface. Textured LCO films were grown on Nb doped $SrTiO_3$ (Nb:STO) single-crystal substrates with (111), (110), and (100) lattice plane orientations. Thin films X-ray diffraction (XRD) revealed that the LCO films had the distinct crystal orientation with respect to Nb:STO substrates: LCO (104) on Nb:STO (100), LCO (110)/(108) on Nb:STO (110), LCO (001) on Nb:$SrTiO_3$ (111). These textured films contained island structures, and the morphology of the $LiCoO_2$ film with (111), (110), and (100) films, observed by Atomic Force Microscopy (AFM). The electrochemical properties of 300 nm thick $LiCoO_2$ (104) films were investigated in liquid electrolyte against lithium metal. LCO (104) film has shown excellent capacity and life cycle performance.

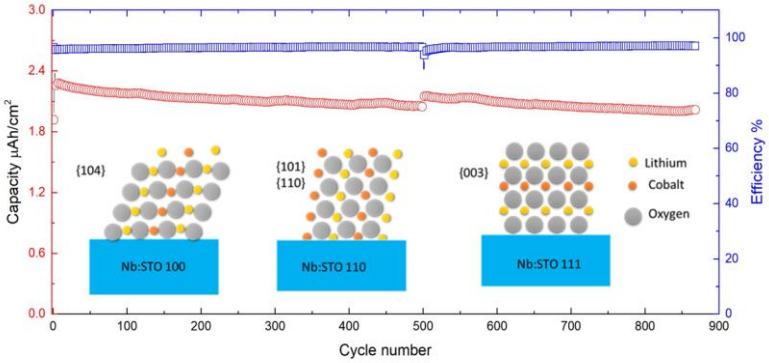

Figure 1. Life cycle performance of LiCoO2(104) film at 5C rate. Inset schematic representing tuning of $LiCoO_2$ crystal orientation

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