Preparation of high quality epitaxial $LiNi_{0.8}Co_{0.2}O_2$ thin films using pulsed laser deposition for all-solid-state lithium battery

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All-solid-state lithium batteries have been promising energy storage devices for vehicles and smart grids due to their potential for enhanced safety and high energy density. However, all-solid-state lithium batteries have been suffering from low power density. The decrease of the interface resistance between solid electrolyte and electrode materials is of essential to achieve high power density. Despite the importance of the design and fabrication of the low resistance interface, the understandings and control of interface resistance values remain inadequate.

One approach for investigating the properties of ionic transport across the solid electrolyte and electrode interfaces is to use thin-film batteries consist of epitaxial films. The epitaxial thin films provides well-defined interface atomic structures and crystal orientation, making possible to evaluate the interface resistance quantitatively. We have previously reported the extremely low resistance (8.6 $\Omega\cdot cm^2$) at the $LiCoO_2/Li_3PO_4$ electrolyte interface in the thin film lithium battery by utilizing all-in-vacuum process system [1]. As a further development, it is quite important to expand the materials variety. In this study, we selected one of the practical cathode materials: $LiNi_{0.8}Co_{0.2}O_2$ (a = 2.8676Å, c = 14.1689Å) isostructural with $LiCoO_2$, and the epitaxial thin films were synthesized by pulsed laser deposition technique.

Figure 1 shows the out-of-plane XRD pattern of a *c*-axis oriented $LiNi_{0.8}Co_{0.2}O_2$ epitaxial thin film (70 nm) on Al_2O_3(0001) substrate, grown under 600°C substrate temperature (T_{sub}) and 100 mTorr oxygen partial pressure (P_{O2}). Figure 2 shows the *c*-axis lattice constant diagram for the thin films when synthesized under varied T_{sub} and P_{O2}. This mapping indicates that the *c*-axis lattice constant approaches to the bulk value under higher P_{O2} in the range of 550-650°C. The film quality depends on film growth parameters and the optimization of the film growth condition is necessary to achieve the high quality. We report the details of the thin film growth and thin-film lithium battery performances.

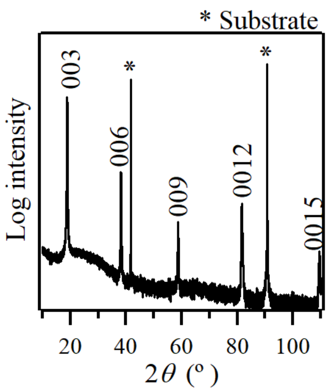

Fig.1 Out-of-plane XRD pattern

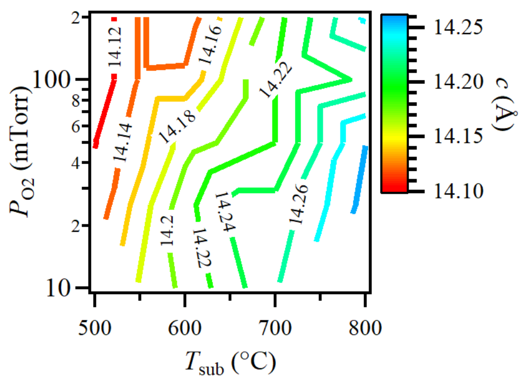

Fig.2 The *c*-axis lattice constant mapping

Reference:
[1] M. Haruta *et al*, Nano Lett., **15** (2015) 1498.