Synthesis of Ruddlesden-Popper type $Sr_3Cr_2O_7$ epitaxial thin films

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Ruddlesden-Popper type perovskite oxides $A_{n+1}B_nO_{3n+1}$ have been intensively studied because of their varieties of physical properties stemming from the layered structure and tunable composition. Among them, $Sr_3Cr_2O_7$ is an antiferromagnetic Mott insulator with a characteristic singlet orbital ordering based on the spin and orbital degrees of freedom [1]. In addition, its superconductivity was theoretically predicted for the $3d^2$ electronic state [2]. However, $Sr_3Cr_2O_7$ has been scarcely synthesized because high temperature and pressure are necessary, in general. In this study, we developed a synthetic route of *c*-axis oriented $Sr_3Cr_2O_7$ epitaxial thin film with high crystallinity by pulsed laser deposition (PLD).

A high-density $Sr_3Cr_2O_8$ pellet synthesized by spark plasma sintering was adopted as a PLD target and ablated by KrF excimer laser (λ = 248 nm). The $Sr_3Cr_2O_7$ films were synthesized on $(LaAlO_3)_{0.3}(SrAl_{0.5}Ta_{0.5}O_3)_{0.7}$ (LSAT; lattice mismatch: 1.0%) (100) and $SrTiO_3$ (STO; lattice mismatch: 1.9%) (100) single crystal substrates at substrate temperatures of 800 °C and 815 °C, respectively, in Ar atmosphere, which is beneficial for reducing the oxidation state of Cr ion from 5+ to 4+ [3].

In the X-ray diffraction (XRD) θ–2θ patterns, only 00*l* diffractions without any impurity peak were observed for the $Sr_3Cr_2O_7$ thin films on both LSAT and STO substrates (Fig. 1). Epitaxial growth of the $Sr_3Cr_2O_7$ thin films were confirmed by the 10$\underline{17}$ spot peaks in reciprocal space mapping. Sharp rocking curves around the 00$\underline{10}$ peak with full width at half maximum of 0.030° and 0.46° were observed for the thin films on LSAT and STO substrates, respectively, indicating good crystallinity. For the thin film on LSAT, particularly, an atomically flat surface with a step-and-terrace structure was observed (Fig. 2). These results indicated first successful synthesis of high-quality $Sr_3Cr_2O_7$ epitaxial thin films.

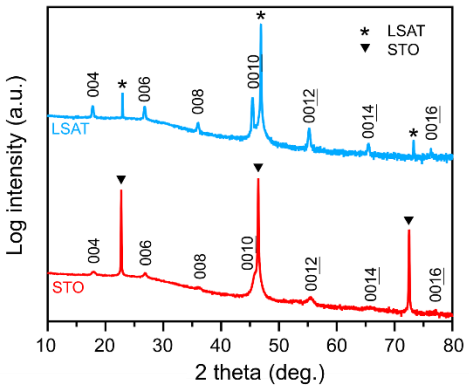

Fig. 1. X-ray diffraction θ–2θ patterns for $Sr_3Cr_2O_7$ epitaxial thin films on LSAT (100) and STO (100) substrates.

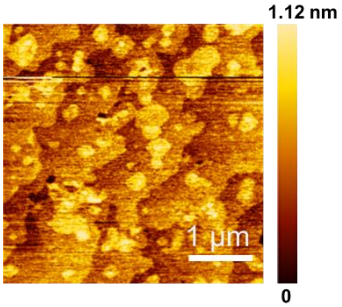

Fig. 2. Atomic force microscope image for $Sr_3Cr_2O_7$ epitaxial thin film on LSAT (100) substrate.

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