ANISOTROPY OF OPTICAL CONDUCTIVITY OF $SrRuO_3$ THIN FILMS OBSERVED BY TERAHERTZ TIME-DOMAIN SPECTROSCOPY

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$SrRuO_3$ (SRO) has attracted a great interest since interesting characteristics and capability of application to future functional devices with transition metal oxides that have perovskite or perovskite-like structures. SRO shows quite high electrical conductivity compared with the other oxide materials, and ferromagnetism below about 160 K. Because of these useful characteristics, SRO is expected to be applied to bottom electrodes of oxide devices or spintronics devices.

In this study, we deposited SRO thin films on various substrates by a pulse laser deposition method, and measured electric and optical characteristics of the SRO films in order to observe strain effects. Especially, we measured complex optical constants of the SRO films in a terahertz (THz) frequency region by THz time-domain spectroscopy (THz-TDS) in order to apply SRO to future high-frequency devices that can operate in a THz region.

SRO thin films were deposited on MgO(100), $(LaAlO_3)_{0.3}(SrAl_{0.5}Ta_{0.5}O_3)_{0.7}$ (LSAT)(100), $DyScO_3$ (DSO)(110) substrates. MgO and LSAT have cubic structures, and the lattice constants are 0.4212 nm and 0.3868 nm, respectively. DSO has orthorhombic structure and the lattice constants of $[1\bar{1}0]$ and [001] directions are 0.39457 nm and 0.39435 nm as a pseudocubic, respectively. We confirmed that all the films were good c-axis orientated by X-ray diffraction.

At room temperature, though we could not find any anisotropy for the SRO thin films on MgO and LSAT, large anisotropy was observed for the SRO films on DSO in direct-current(DC) conductivity measurements. DC conductivity of the SRO films on DSO for DSO$[1\bar{1}0]$ direction was 3333 $\Omega^{-1}cm^{-1}$ that was nearly equal to a bulk SRO crystal. However, DC conductivity of the film for DSO[001] direction was 319 $\Omega^{-1}cm^{-1}$ that was about a tithe of that of the DSO$[1\bar{1}0]$ direction.

We also measured optical conductivity of the SRO films in a THz region by THz-TDS at room temperature. Large anisotropy was observed for the SRO film on DSO, while no anisotropy was observed for the SRO films on MgO and LSAT as DC measurements. The frequency dependences of the optical conductivities of all the films were roughly flat in a measurable frequency region, and the values of the optical conductivities of all the films in a gigahertz region approximately corresponded to the value of the DC conductivities of the films. We also measured thickness dependence of the optical conductivities of the SRO films on DSO. The optical conductivity of the 80-nm thickness SRO films for DSO$[1\bar{1}0]$ direction increased as compared with that of the 250-nm and 120-nm thickness SRO films for DSO$[1\bar{1}0]$ direction, though that of all the SRO films for DSO[001] direction had almost the same values.

From these results, such an anisotropic conductivity of the SRO thin films on DSO seems to be due to different amount of strains between $[1\bar{1}0]$ and [001] directions caused by a DSO substrate.

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