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Artificial charge-modulation in atomicscale perovskite titanate superlattices

AKIRA OHTOMO, Institute of Materials Research, Tohoku University

In research for exploring new phenomena and functioning devices based on oxide heterostructures and artificial superlattices, it is important to understand the interfacial electronic structure, which is quite distinct from the bulk electronic states because of epitaxial strain and charge/polarization discontinuity. This aspect is also related to the charge ordering phenomena seen in bulk perovskites. Thus, the atomic-scale study to measure and design the interfacial electronic structure is highly relevant. We have grown a number of perovskite titanate superlattices by pulsed laser deposition, specifically controlling oxidation, surface crystallization kinetics, surface termination and layer thickness. In an abrupt interface between band insulator, $SrTiO_3$, and Mott insulator, $LaTiO_3$, we found that the extra electrons on the Ti site distribute on a length scale exceeding Thomas-Fermi screening length, due to a large induced lattice polarization. This results in a metallic interface down to low temperature. We also found a conducting interface in $SrTiO_3/LaAlO_3$ superlattices. In this case, the conductivity can be controlled over a wide range by changing the composition of the interface. We have also grown solid solution films consisting of $SrTiO_3$, $LaTiO_3$, and $LaAlO_3$ within the framework of charge modulation in perovskite titanates. A variety of electronic states was developed and will be discussed in terms of optical absorption spectra and transport properties comparing with those of the superlattices.