# Surface Mott-insulator transition of layered perovskite $Ca_{2-x}Sr_xRuO_4$

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Strong coupling between electronic, lattice, orbital and spin degrees of freedom in transition metal oxides has attracted significant interest to these materials. Unique combinations of properties enable immense potential for oxide electronic devices with novel functionalities. Understanding the fundamental physics of reduced dimensionality involved in surface/interface properties is vital for the realization of such devices. Here we investigate the surface behavior in the family of layered calcium-strontium ruthenates, $Ca_{2-x}Sr_xRuO_4$, using a combination of electron spectroscopy and scanning probe microscopy techniques. $Sr_2RuO_4$ is a layered metallic perovskite exhibiting p-wave superconductivity below ~1.5K, while the small size of Ca ions in $Ca_2RuO_4$ results in tilt and rotation of the $RuO_6$ octahedra giving rise to antiferromagnetic insulating properties. Single crystals of several members of layered calcium-strontium ruthenate family are grown using optical floating zone technique. High Resolution Electron Energy Loss Spectroscopy (HREELS) is used to study charge and lattice dynamics for different phases of $Ca_{2-x}Sr_xRuO_4$ crystals and thin films. The shift of surface phonon energies due to differences in electron screening is observed at 120K, significantly lower than corresponding bulk transition temperatures. Electronic and structural properties of these surfaces are studied by variable temperature Scanning Tunneling Spectroscopy (STS) and Low Energy Electron Diffraction (LEED). It is found that broken symmetry on the $Sr_2RuO_4$ surface results in the rotation of $RuO_4$ octahedra along the c-axis, changing the relative in-plane Ru-O bond length and shifting the surface phonon energies. The substitution of Sr ions in $Ca_2RuO_4$ crystals results in a rotation plus a tilt of the $RuO_6$ octahedra creating a metal-insulator transition evident by reduced electron screening and shifting of surface phonon energies through the phase transition. This behavior is compared to bulk properties and implications for the coupling between lattice and charge degrees of freedom are discussed.

Oak Ridge National Laboratory, managed by UT-Battelle, LLC, for the U.S. Dept. of Energy under contract DE-AC05-00OR22725.