SURFACE LATTICE DYNAMICS OF SINGLE-LAYERED TRANSITION-METAL OXIDES: Sr_2RuO_4 AND $La_{0.5}Sr_{1.5}MnO_4$[1]

Ismail,[2] J. Zhang,[3] R. Matzdorf,[4] R. Jin,[5] D. G. Mandrus,[6] and E. W. Plummer[7]

Transition-metal oxides (TMOs) have been investigated extensively because this class of materials exhibits a fascinating array of phenomena because of a strong coupling among lattice, charge, spin, and orbital degrees of freedom. Creating a surface by breaking the symmetry is a way to disturb the coupled system, thus providing a fresh approach for studying the spin-charge-lattice coupling in the complex materials. The couplings (i.e., electron-phonon, magnon-phonon, magneto-elastic, etc.) can be revealed in the phonon dispersion and lifetime. Consequently, studying the surface lattice dynamics is an important step for understanding the behavior of surface TMOs.

In this work, the lattice dynamics of single-crystal Sr_2RuO_4 and $La_{0.5}Sr_{1.5}MnO_4$ surfaces cleaved in ultrahigh vacuum were studied. These two systems have the same type of lattice structure in the bulk, but completely different physical properties. Sr_2RuO_4 is a good metal and a *p*-wave superconductor below ~1.5 K while $La_{0.5}Sr_{1.5}MnO_4$ is an insulator undergoing orbital and charge ordering at a temperature of about 220 K and is antiferromagnetically ordered below 110 K, respectively. The surface of Sr_2RuO_4 has a C(2 × 2) reconstruction while the surface of $La_{0.5}Sr_{1.5}MnO_4$ keeps a (1 × 1) truncated structure. For both systems, three surface optical phonon features (ω_1, ω_2, and ω_3) were clearly observed (Fig. 1). In Fig. 1, ω_1 is an external mode due to vibration of the Sr/La atom along the *c*–axis. ω_2 is the out-of-plane Ru(Mn)-O-Ru(Mn) bending mode, and ω_3 is a stretching mode associated with the vibrations of the oxygen atoms against the Ru(Mn) ion. Linewidths of surface optical phonons of ω_1, ω_2, and ω_3 are found to be 5.3, 2.5, and 7.5 meV for Sr_2RuO_4, and 1.8, 4.2, and 8.8 meV for $La_{0.5}Sr_{1.5}MnO_4$, respectively. The large linewidth

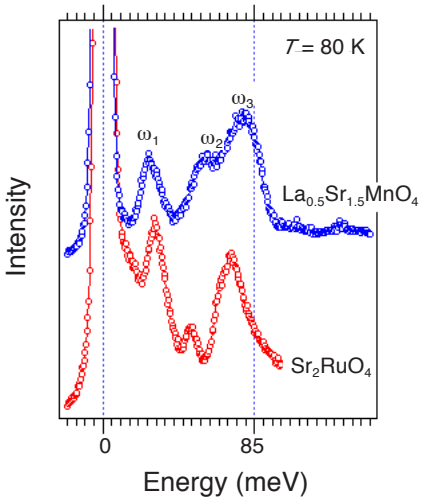

Fig. 1. Electron energy loss spectra at the zone center of the Brillouin zone.

of ω_1 for Sr_2RuO_4 shows that there are two phonons because of surface reconstruction. Surprisingly, the linewidth of ω_1 for $La_{0.5}Sr_{1.5}MnO_4$ is small, indicating this phonon mode is purely from a pure Sr atom because of Sr segregation at the surface, but without surface reconstruction. All surface modes for both systems are significantly higher in energies than the corresponding bulk modes, indicating that the surface properties of these systems are appreciably different than in the bulk, which will be true for TMOs in general.

---

1. Summary of paper to be published.
2. Postdoctoral research associate from The University of Tennessee (funded by NSF DMR 0105232).
3. Florida International University, Miami, Fla.
4. Universität Würzburg, Würzburg, Germany.
5. ORNL/ORISE postdoctoral research associate.
6. ORNL/UT joint faculty participant.
7. UT/ORNL Distinguished Scientist.