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Optical Properties of Infinite-layer Superconductors $Sr_{0.9}Ln_{0.1}CuO_2$ (Ln=La, Gd, Sm)

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We have measured the reflectivity of superconducting infinite-layer compounds $Sr_{0.9}Ln_{0.1}CuO_2$ (Ln=La, Gd, Sm) with T_c = 39 K using a Fourier-transform infrared spectrometer. The high-quality high-purity $Sr_{0.9}Ln_{0.1}CuO_2$ samples were synthesized under high pressure and high temperature. First, we have identified the optical phonon modes from their infrared reflectivity and conductivity spectra. The La- and the Gd-doped compounds exhibited only four ($2A_{2u}$+$2E_u$) out of the five ($2A_{2u}$+$3E_u$) infrared-active phonon modes predicted by a group theoretical analysis whereas the Sm-doped compound exhibited all five modes. We propose the possible atomic displacement pattern for each phonon mode based on reported lattice dynamics calculations and through comparison with the phonon modes of other single-layer high-T_c cuprate superconductors. For the La- and the Gd-doped samples, we investigated the temperature dependence of the optical response functions in a wide temperature range (7 - 300K). In FIR region, the reflectivity is apparently enhanced below about 120 cm^{-1} as temperature decreases across T_c. In the conductivity, a signature of partial gap opening is captured below T_c while strong quasi-particle conductivity reappears at very low frequencies. The value of $2\Delta/k_BT_c$ is about 4.5, which is consistent with maximum gap value of d-wave high-T_c cuprates.

keywords : optical property, phonon, infinite-layer superconductor, FTIR, superconducting gap