In situ photoemission measurements on (Sr, Ca)RuO$_3$/SrTiO$_3$ films grown by pulsed laser deposition

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Photoemission spectroscopy (PES) has become one of the most valuable tools for the study of the electronic structure of the strongly correlated systems. However, because of its short probing depth, the surface should be artificially cleaned to get the PES spectra. This artificial treatment, particularly scraping, can give rise to the surface damage and make the surface electronic structure different from the bulk. One of the possible ways to minimize these kinds of artificial damages is to prepare the film in situ and thus eliminate the need for surface cleaning process. (Sr, Ca)RuO$_3$ film has been important for scientific studies and technological applications and thus has been extensively studied. SrRuO$_3$ is one of the most conductive metallic oxides with very good stability and shows high resistance to chemical corrosion. In this work, we prepared (Sr,Ca)RuO$_3$/SrTiO$_3$ films by pulsed laser deposition (PLD) in situ, and studied them by ultraviolet (UPS) and x-ray (XPS) photoemission spectroscopy. The UPS spectra of as grown films showed two prominent features located around $E_f$ and 1.5eV below, which can be assigned to the coherent peak and the incoherent peak, respectively. In the case of previous PES study using the scraped surface, these two features were not resolved. The angle dependence of the UPS spectra was investigated in order to see whether these features are from angle resolved effect or not and it was concluded that there was no angle resolved effect. When (Sr,Ca)RuO$_3$/SrTiO$_3$ films were annealed in the oxygen deficient ~10$^{-7}$ torr at 400 ºC, the coherent structure lost its spectral weight and the incoherent structure gained its spectral weight. So overall spectrum became similar to the one of scraped surface. In order to look into what happens, Auger spectroscopy, XPS and high resolution x-ray diffraction studies were performed. The UPS spectra in the Ru 4d dominant region of (Sr,Ca)RuO$_3$/SrTiO$_3$ films are also compared with the Ru T$_{2g}$ densities of state from the band structure calculations to see the electron correlation effect.