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Origins of conducting channel at $LaAlO_3/SrTiO_3$ heterointerface investigated by *in situ* ARPES HYANGKEUN YOO, LUCA MORESCHINI, AARON BOSTWICK, Advanced Light Source, LBNL, ANDREW WALTER, Brookhaven National Laboratory, NSLS II, TAE WON NOH, Seoul National University, YOUNG JUN CHANG, University of Seoul, ELI ROTENBERG, Advanced Light Source, LBNL — The high-mobility conducting interface (CI) between $LaAlO_3$ (LAO) and $SrTiO_3$ (STO) has revealed many fascinating phenomena. But the formation mechanism of the CI has not been conclusively explained. Here, we investigated the CI formation between LAO and STO by *in situ* angle-resolved photoemission spectroscopy. By directly imaging the LAO polarity-induced built-in potential (V_i) at each step of the LAO growth, we demonstrated that the V_i is proportional to the LAO thickness and the conducting interface is appeared above 3 unit cells of LAO. However, we found that the V_i and the critical thickness are strongly dependent on the amount of the surface oxygen vacancies controlled by the synchrotron ultraviolet-irradiation and the oxygen gas exposure. This indicates that the only polar catastrophe, theorized to explain the CI formation above a critical thickness, is not adequate. Instead, our results point to a decisive role played by the oxygen vacancy, and explain why the V_i and the critical thickness as reported in several works show some variation, rather than being a universal quantity.

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