Electric-field induced doping of $YBa_2Cu_3O_7$

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Electrostatic doping by means of electric double layer (EDL) techniques has recently been demonstrated to be an ideal tool to study the physics of high Tc cuprates. They enable controlled changes of carrier concentration [1,2] by making use of an ionic liquid as a gate dielectric. A high density of charge carriers (as high as 10^{14-15}cm^{-2}) is accumulated at the oxide interface to screen the strong electric field generated within the EDL. Large changes of the doping concentration allow exploring wide regions of the phase diagram and examining boundaries between superconducting and non superconducting phases. Aside from these electrostatic doping effects, recent studies of the EDL gating revealed that the electric field may also create vacancies in these oxides [3], which in turn may have a doping effect that could resemble that obtained from traditional chemistry methods.

We have recently addressed the doping mechanisms involved in EDL gating of a thin film of the high temperature superconductor $YBa_2Cu_3O_{7-d}$ (YBCO) by combining experiments and theory [4]. In order to explain our experimental results of in-situ x-ray absorption spectroscopy and electric transport measurements, we performed density functional theory simulations of the NEXAFS region for electrostatically doped YBCO and for oxygen doped $YBa_2Cu_3O_6$, using bulk calculations, in order to assist the interpretation of the data. Our computed spectra show that the measured NEXAFS is compatible with a progressive decrease of oxygen coordination of the Cu, suggesting changes in the oxygen content of the sample. We demonstrate that the reduced Cu-O coordination is specifically taking place at the CuO chains of the cuprate and not affecting the superconducting CuO planes [4]. Recently, we explicitly addressed the role of the electric field by computing the vacancy formation energy and the energy barrier for oxygen migration as a function of an applied field on a thin film of YBCO and discuss our results in the context of our previous experiments.

1 A. T. Bollinger et al., Nature (London) **472**, 458 (2011)

2 J. García-Barriocanal et al., Phys. Rev. B **87**, 024509 (2013)

3 J. Jeong et al., PNAS **112**, N4 1013 (2015)

4 A. Perez-Munoz et al., PNAS **114**, 215 (2017)