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Electrostatic vs. Electrochemical Doping and Control of Ferromagnetism in Ion-Gel-Gated La$_{0.5}$Sr$_{0.5}$CoO$_{3-\delta}$


Recently developed ionic liquid/gel gating techniques have proven remarkably expedient in the study of charge density effects in a variety of conductors. Much remains to be learned, however, about the exact gating mechanisms (i.e., electrostatic vs. electrochemical), particularly in oxides, where oxygen vacancy formation and diffusion is facile. In this work we demonstrate that in ion-gel-gated La$_{0.5}$Sr$_{0.5}$CoO$_{3-\delta}$ (LSCO) films, transport, AFM, and XPS measurements indicate that negative gate biases induce reversible electrostatic hole accumulation, whereas positive biases irreversibly induce oxygen vacancies [1]. This is rationalized in terms of the known redox stability of LSCO, with broad implications for electrolyte gating of hole- vs. electron-doped oxides. Clear voltage-control of magnetic and transport properties is then demonstrated under hole accumulation, including a 12 K shift in $T_C$ probed via anomalous Hall effect [1]. Further to this, in operando probes have also been applied, including synchrotron X-ray diffraction directly revealing expansion in unit cell volume due to oxygen vacancy formation under positive bias, and polarized neutron reflectometry to probe the gate-voltage-dependent depth-profile of chemistry and magnetization. [1] Walter et al. ACS Nano. (2016).

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