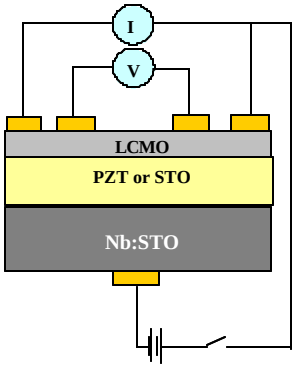
Manganite based Field Effect Transistor: New Materials Science ⇔ new device potential

The transistor (resistivity controlled by gate voltage) is basic to modern technology, and for 50 years the material of choice has been silicon. But as device dimensions shrink to the nanometer scale, silicon's low carrier density creates problems.

New materials and new control methods are needed!

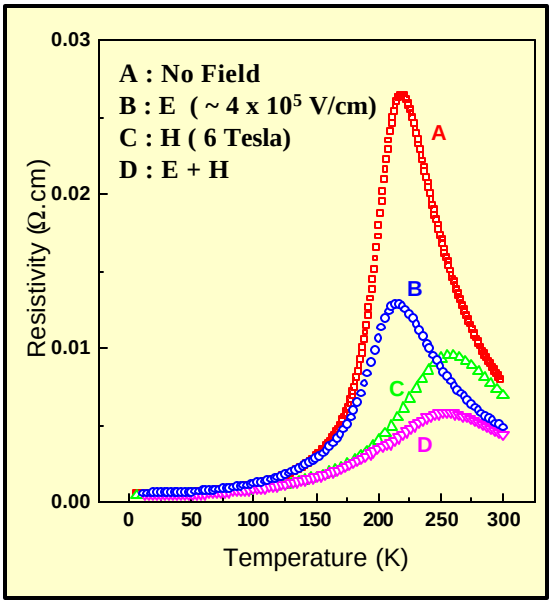
We found: large field effects in $La_{0.7}Ca_{0.3}MnO_3$, a 'colossal' Magnetoresistance Manganite

Key feature: **electronic phase coexistence** (EPC),



Device Geometry

Result



Electric field effect (curve A->curveB): a small voltage (~ 6 volts across ~15 nm dielectric/ferroelectric) cuts resistivity of $La_{0.7}Ca_{0.3}MnO_3$ in half;

Magnetic field effect (curve A ->curve C) : A large ~ 6 Tesla magnetic field is needed to cut resisitivty of $La_{0.7}Ca_{0.3}MnO_3$ in half.

Podzhorov…. Cheong, Phys. Rev B 64, 140106R, 2001

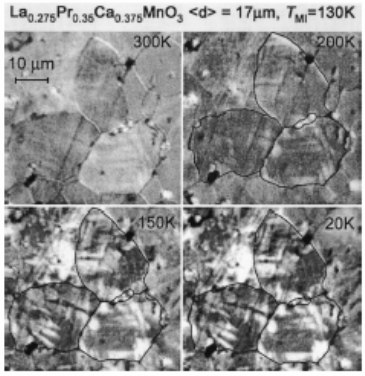
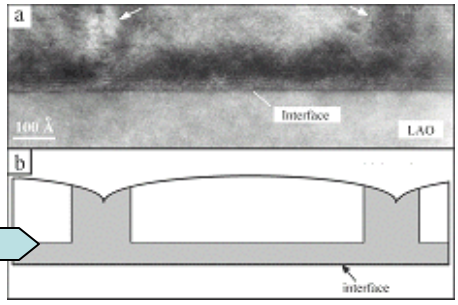
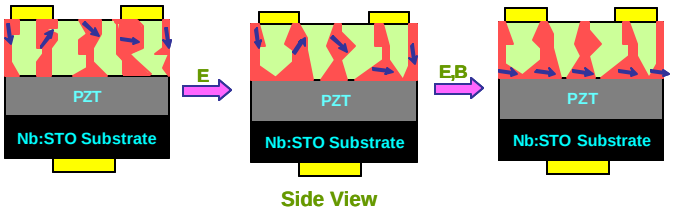


FIG. 3. Polarized optical micrographs of the polycrystalline $La_{0.275}Pr_{0.35}Ca_{0.375}MnO_3$ sample with average grain size $\langle d \rangle = 17\,\mu m$ and the MIT temperature $T_{MI} \sim 130$ K, taken at various temperatures on cooling. Bright regions correspond to the CO phase; dark ones to the cubic parental lattice.

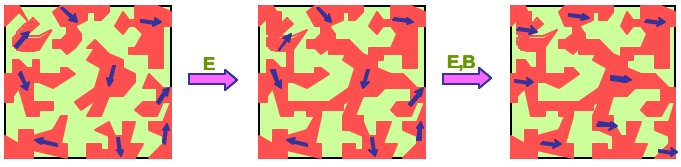
EPC shown by our MRSEC in Bulk and Thin Films under strain

Biswas et al. Phys. Rev. B 61, 9665, 2000.





Model of field effect based on EPC



Wu, Ogale, Garrison, Nagraj, Biswas, Chen, Greene, Ramesh, Venkatesan, Millis, PRL 86, 5998, 2001