Mesoscale Priority Research Direction

Nanoscale materials engineering for mesoscopic functionality

Opportunity

Complex correlated electron materials exhibit a wide range of fascinating and, potentially, technologically revolutionary behaviors such as, colossal magnetoresistance, multiferroicity, and high temperature superconductivity. Creating artificial nanoscale structures of these materials open an new avenue of exploiting their mesoscopic functionality.

Meso Challenge

How to grow and characterize these artificial structures with atomic precision? How to understand the coupled structural and physical properties? How to design the material growth in order to control the material functionality for technological applications?

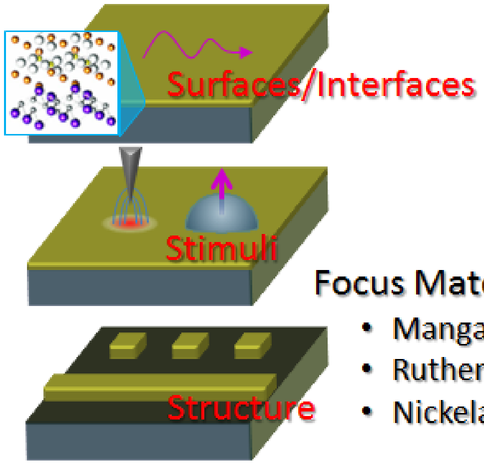
How do remarkable properties of matter emerge from complex correlations of the atomic or electronic constituents and How do we control these properties ?

Impact

New generation of electronic devices built with mesoscale functionality.

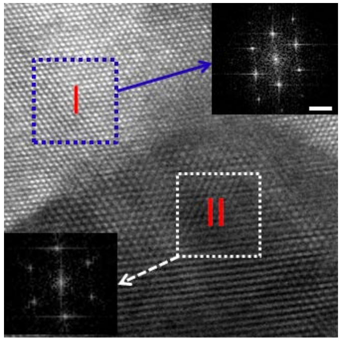
Approach

Combining molecular beam epitaxy (MBE) and laser-MBE for both thin film/heterostructure growth and patterning with comprehensive in/ex-situ characterization such as using STEM to probe local structure/composition and SEM/4-probe-STM to identify mesoscale phases and measure their electrical conductance, to understand the emergent phenomena and eventually control the associated functionalities.



Focus Materials:

- Manganites
- Ruthenates
- Nickelates



STEM in-plane image of an artificial columnar nanocomposite oxide film (V_2O_3-$La_{0.7}Sr_{0.3}MnO_3$)

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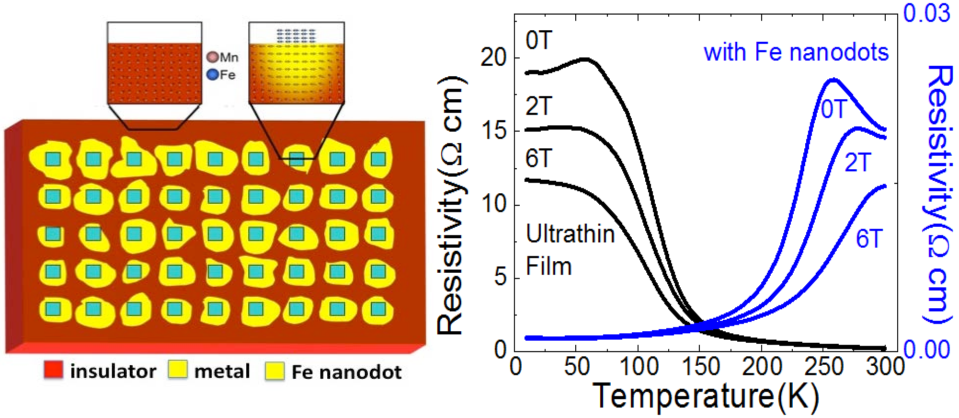
Through a surface magnetic dot decoration on the surface, it is possible to control the electron spin in a frustrated complex manganite compound in manganite thin film of $La_{0.7}Ca_{0.3}MnO_3$, The result was a complete recovery of the bulk magnetoresistance and active temperature range . It was also discovered that changing the density of the nanodots on the film surface allowed these properties to be highly tunable.

These findings offer a new means to quantitatively investigate the balanced energetics that drive complex materials and promise a simple way to increase and tune critical temperatures in frustrated films for future applications.



Tunable metal-insulator transition in magnetic dot-coated manganite film. This demonstrates that it is possible to induce a local metal insulator transition using magnetic exchange field between a magnetic Fe nanodot and the local Mn spins in a manganite thin film. T. Z. Ward, et al., *Phys. Rev. Lett*. **106**, 157207 (2011)

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