Mesoscale Priority Research Direction

Mesoscale Phases: Control of Global Structural and Physical Properties

Opportunity

Many fascinating phenomena, such as high-T_c superconductivity and colossal magnetoresistance, result from chemical doping. Microscopic studies indicate that chemical doping inherently induces mesoscale phase separation, with different electronic/magnetic properties. The global structural and physical properties are controlled by the interplay between these self-assembled mesoscale phases.

Approach

- Use TEM/ELS to probe local chemical composition.
- Use SEM/4-probe-STM to identify mesoscale phases and measure their electrical conductance.
- Use STM to study the local electronic structures and domain walls.
- Use MFM/XAS to probe magnetic properties.
- Compare atomic, nano, mesoscale properties with global structural and physical properties.

Meso Challenge

- How self-assembled mesoscale phases determine the global structural and physical properties (size, geometry, interface, chemical composition etc.).
- What is the fundamental difference between self-assembled mesoscale phases at the atomic level.

Impact

Fundamental understanding of the relationship between chemical-doping-induced mesoscale phase separation and global properties will enable us to manipulate and optimize the important parameters of functional materials.

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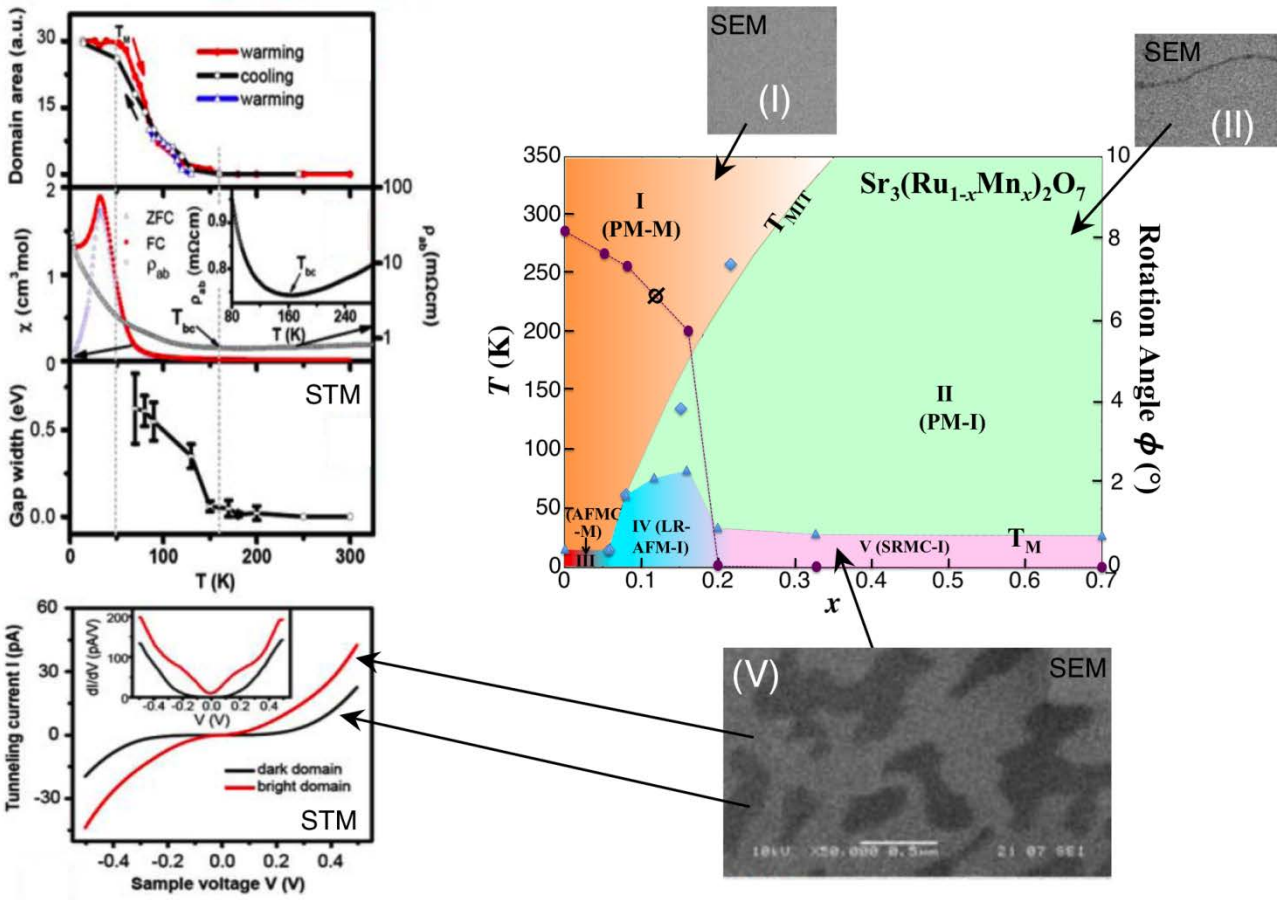
Shown in the right is the phase diagram of $Sr_3(Ru_{1-x}Mn_x)_2O_7$: partial substitution of Ru by Mn results in both metal-insulator transition at T_{MIT} and antiferromagnetic transition at T_M, with $T_{MIT} > T_M$. The combined SEM and STM measurements reveal that insulating domains start to form below T_{MIT} (dark regions in SEM images). The total area of insulating domains increases with decreasing temperature but saturates below T_M.



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