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Electronic phase separation at the $LaAlO_3/SrTiO_3$ interface[1]

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In the last few years we have seen a number of new properties to emerge at the interface between two insulating oxides. However the origin of these properties remains unclear and needs further investigation. In this talk I will discuss our recent studies on oxide interfaces in which we vary various parameters such as oxygen content and crystal orientation, and use different polar layers and heterostructures. Surprisingly, at the $LaAlO_3/SrTiO_3$ interface a remarkable combination of strong diamagnetism (superconductor like), paramagnetism and ferromagnetism can coexist with the quasi two dimensional electron gas (Q2DEG) when prepared under a more oxidizing condition. The ferromagnetic phase is stable even above room temperature and the diamagnetism below a relatively high temperature of 60 K. Our measurements show that the free surface of $SrTiO_3$ may be responsible for all these fascinating phenomena. The phenomena are explained due to the selective occupancy of interface/surface sub-bands of the nearly degenerate Ti orbital in the $SrTiO_3$. On changing the interface orientation, we unexpectedly can also obtain conductivity at the $LaAlO_3/SrTiO_3$ interface prepared on (110)-oriented $SrTiO_3$. The conductivity is found to be highly anisotropic, which is a novel feature for these oxide Q2DEGs and of potential interest for applications. I will discuss various possible models that can explain this intriguing observation and also review various interfaces prepared using different polar layers coupled to other functional materials which result in new phenomena.

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