Turning insulators into metals!

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The electric field induced metallization of insulating oxides is a powerful means of exploring and creating novel electronic states. Recently large internal electric fields from polar surfaces have been used to create emergent metallic, superconducting and magnetic states at interfaces between two insulating oxides. However, the origin of the metallicity is a subject of considerable debate, especially as to whether charged carriers are induced electrostatically. We show that by placing various oxide surfaces and thin films in contact with charged fluids these nominally insulating materials can be transformed into metallic conductors and that the mechanism is rather due to the flow of ionic currents of oxygen to and fro between the oxide surface and the liquid[1]. We discuss, in particular, the electrolyte gating of epitaxial films of vanadium dioxide (VO_2). VO_2 exhibits a transition from an insulating to a metallic state above a metal-insulator transition temperature, T_{MIT}, that depends on strain induced in the film by epitaxy with underlayers and/or the substrate material and crystal orientation. Using in-situ gating we use x-ray diffraction to show that the out-of-plane lattice constant can be reversibly changed by more than 3.5% using ionic liquid gating. The possibility of novel, highly energy efficient "liquid" electronics is discussed.

1 J. Jeong, N. Aetukuri, T. Graf, T. D. Schladt, M. G. Samant, and S. S. P. Parkin, Science **339**, 1402 (2013).