Temperature dependent polarity reversal in Au/Nb:$SrTiO_3$ Schottky junctions

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Interfaces between correlated materials, particularly, those between transition-metal oxides have become the subject of intensive research in recent years because of the appearance of novel physical properties that do not exist in each bulk material [1]. This stream of research is being driven not only by scientific curiosity but also by the anticipated device applications in future "oxide electronics". The fundamental concepts of semiconductor physics such as *p-n* junctions and Schottky barriers basically remain valid for the oxide interfaces: the built-in potential and the Schottky barrier height are determined by the work function difference between the two materials unless a dipole layer is formed at the interface. Therefore, the unusual phenomenon of polarity reversal reported in the present paper was rather unexpected and surprising, especially for such well-known, widely-used materials as gold and $SrTiO_3$.

The Au/$SrTiO_3$ interface at room temperature exhibits typical I-V characteristics of a Schottky barrier formed between an n-type semiconductor and a metal. At low temperatures, < 75 K , however, the authors have found that more current flows for reverse bias than for forward bias! In order to explain this behavior, they take into account the strong temperature-dependence and non-linearity of the dielectric constant of $SrTiO_3$, a material which is close to a ferroelectric instability and shows strong quantum dielectric fluctuations [2]. Because of the huge enhancement of the $SrTiO_3$ dielectric constant at low temperature, the Schottky barrier thickness under the reverse-bias condition is dramatically reduced and electrons go through the barrier via *tunneling* rather than thermal excitations, giving rise to the enhanced electrical current.

The impact of the present result may be two-fold:

(i) Since $SrTiO_3$ is the most widely used material in oxide hetero-structures, the characteristic dielectric properties of the $SrTiO_3$ will have to be more carefully considered in various aspects of oxide interfaces.

(ii) There may be other unexplored temperature-dependent phenomena in oxide interfaces and hetero-structures involving $SrTiO_3$. Those phenomena are waiting for us to discover.

From a more general point of view, the present work demonstrates the importance of electric fields extending over many lattice spacings and their (metallic and dielectric) screening in condensed matter. One is reminded that in the original idea of metal-insulator transition, due to Mott [3], the screening of long-range Coulomb interactions plays a crucial role. Sufficient attention to such interactions has not lately been paid in the field of strongly correlated systems. The present work as well as the recent work on polar oxide interfaces [1,4] remind us of rich physics associated with microscopic and macroscopic electric fields in transition-metal oxides.

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