抵抗変化：電子的メカニズム

Electronic mechanism for resistive switching

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The memristor is a device composed of a thin film of an insulator material sandwiched between two metallic electrodes. This system is capable of storing information via its resistance state, which is written — switched from high electrical conductivity to low conductivity or the other way around — by applying a certain threshold value of voltage across the electrodes and read using a much smaller voltage. We focus on the prototype device, where a thin sheet (some tens of nanometers) is sandwiched between metal electrodes. The titania layer is far from stoichiometric, and in addition to rutile TiO_2, it contains precipitates of the oxygen-deficient Ti_nO_{2n-1} Magnéli phase. This is a widely studied device, but there is no consensus of the physical mechanism that underlies the different resistive states or the switching between them. Proposed mechanisms include *ion drift* and electronic mechanisms, but neither of the proposed mechanisms can account for both the long retention times (years) and fast switching rimes (less than nanoseconds).

We have performed density-functional-based calculations for several Ti_nO_{2n-1} structures, determining that this system contains donor defect like *pseudodefects*, manifested by an intermediate band close to the conduction band minimum and a donor transition similar to defect levels introduced by intrinsic defects in the TiO_2 rutile structure. We also obtained the natural band offset between TiO_2 and several Ti_nO_{2n-1} structures, and discovered that the electrons ejected from the defect levels of the latter material could in principle act as dopants to the former. Finally, we propose a purely electronic model for the switching of the memristor based on classical electrodynamics combined with models for band conductivity and variable range hopping conductivity models to describe the different resistivity states. We thus show that the switching of memristors is governed by the abundance and electronic transitions of defects in the memristor storage media.