Localized states in advances dielectrics from the vantage of spin- and symmetry-polarized tunneling across MgO

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Research on advanced materials such as multiferroic perovskites underscores promising applications, yet studies on these materials rarely address the impact of defects on the nominally expected materials property. Here, we revisit the comparatively simple oxide MgO as the model material system for spin-polarized solid-state tunneling studies [1,2]. We present a defect-mediated tunneling potential landscape of localized states owing to explicitly identified defect species [3], against which we examine the bias and temperature dependence of magnetotransport. By mixing symmetry-resolved transport channels, a localized state may alter the effective barrier height for symmetry-resolved charge carriers, such that tunneling magnetoresistance decreases most with increasing temperature when that state is addressed electrically. Thermal excitation promotes an occupancy switchover from the ground to the excited state of a defect, which impacts these magnetotransport characteristics. We thus resolve contradictions between experiment and theory in this otherwise canonical Spintronic system, and propose a new perspective on defects in dielectrics [4]. In the process, we shall emphasize a very important nuance to the generally accepted, intuitive paradigm that reducing defect densities will lead to improved TMR ratios. Indeed, as predicted theoretically [5], certain defect species in MgO (that is, M centers) can actually promote resilient magnetotransport under thermal excitation, while others (that is, F/F^{+}) promote a thermally induced TMR decrease due to a more efficient, defect-induced mixing of electronic symmetries.

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