Preferential reduction of extended defects in perovskite surfaces

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Perovskite oxides such as strontium titanate ($SrTiO_3$) are extensively studied due to their exceptional electronic and catalytic properties, which hold promising potential for applications in energy conversion and electronics. In these materials, the electronic transport properties are closely related to the oxygen nonstoichiometry, which can be manipulated via redox reactions leading to a self-doping by oxygen vacancies [1]. By nanoscale investigations on single crystals and ceramics employing high-resolution imaging techniques such as local-conductivity atomic force microscopy (LC-AFM), scanning nearfield optical microscopy (SNOM), and fluorescence lifetime imaging microscopy (FLIM) we are able to demonstrate that this reduction process is highly complex and heterogeneous on the nanoscale. Along extended defects, such as dislocations and grain boundaries, there are easy reduction sites where oxygen vacancies are preferentially generated. In this way, filaments with high conductivity evolve around the dislocations in the originally insulating matrix and act as nanoscaled short circuits [2]. Upon application of mechanical stress, these filaments can even be moved through the crystals along with the dislocations [3]. These findings not only can explain failure mechanisms in solid oxide electrolytes, but also raise fundamental questions regarding the mechanisms of electronic transport and superconductivity in self-doped transition metal oxides.

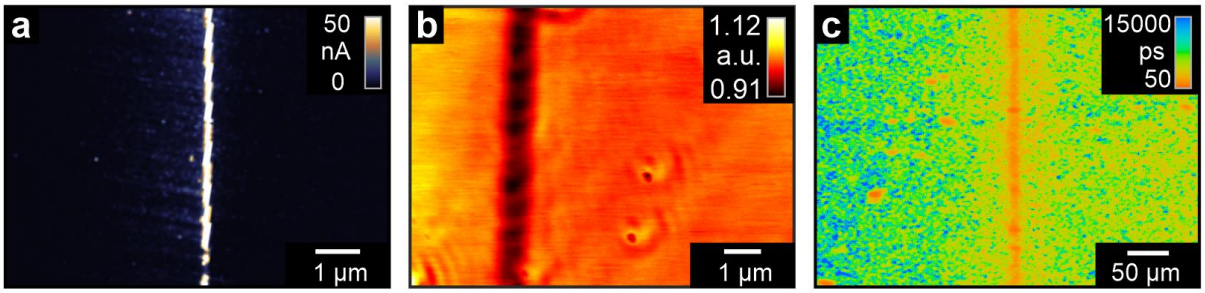

Fig. 1. Investigation of a bicrystal boundary of $SrTiO_3$ after thermal reduction under vacuum conditions. a) LC-AFM Current map, b) SNOM transmission, c) FLIM lifetime.

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