Highlights

RESEARCH AREA 2 - Functional and Complex Materials for Innovative Electronics and Sensing - 2023

Pattern Formation by Electric-Field Quench in a Mott Crystal

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The control of the Mott phase is closely linked to the spatial reorganization of electronic states. Out-of-equilibrium driving forces often give rise to electronic patterns that are not present in equilibrium, though their nature can be difficult to discern. In this study, we reveal the formation of nanoscale patterns in the Mott insulator Ca_2RuO_4. We demonstrate how an applied electric field induces a spatial reconstruction of the insulating phase, which, uniquely upon deactivating the electric field, reveals nanoscale stripe domains (Fig. 1). These stripes contain regions with differing octahedral distortions, which we directly observe using high-resolution scanning transmission electron microscopy (Fig. 1). The nanotexture is influenced by the orientation of the electric field, and it is both nonvolatile and rewritable. We also provide theoretical simulations of the charge and orbital reconstruction triggered by the dynamic changes in the electric field, offering a clear mechanism behind the formation of the stripe phase (Fig. 2). Our findings pave the way for the development of nonvolatile electronics that leverage voltage-controlled nanometric phases.

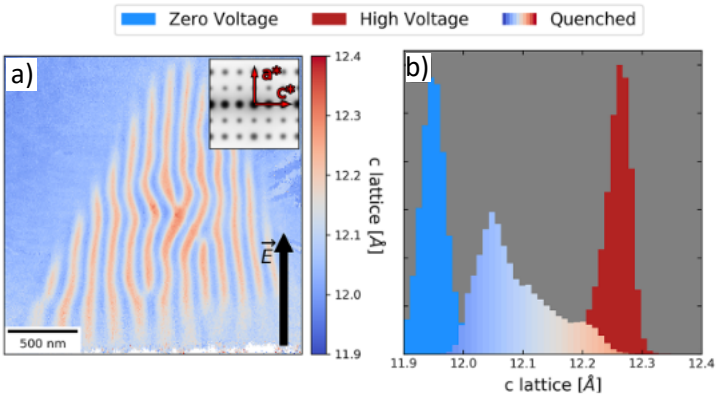

Fig. 1: (a) The real-space map of the *c* lattice parameter after the voltage is quenched to zero amplitude for a given orientation of the electric field. (b) The histogram of the lattice parameter at zero voltage and maximum applied voltage indicates the distribution of the lattice parameters amplitude for the corresponding voltage configurations. We find that after the quench the distribution exhibits a bimodal line shape reflecting the occurrence of stripes or domains with unit cells having short and long *c* lattice parameters.

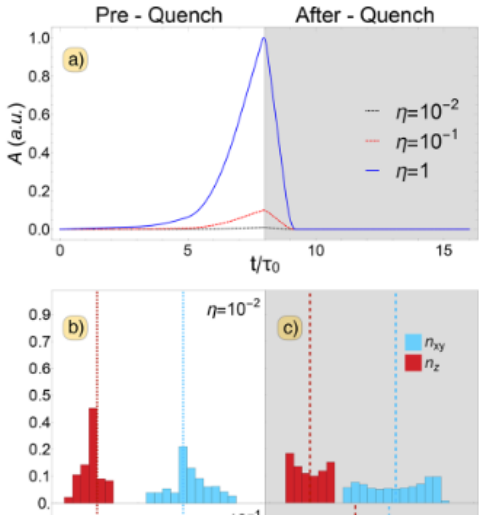

Fig. 2: (a) The electric field is introduced via a time dependent potential that is switched off after a characteristic time interval. The η parameter sets the strength of the electric field. Time distribution of the density of the d_{xy} and (d_{xz},d_{yz}) orbitals at the ruthenium site before (b) and after the quench (c) demonstrating orbital and structural reconstructions from short to elongated octahedra.

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