Highlights

Activity E - Advanced materials and techniques for organic electronics, biomedical and sensing applications - 2021

Anisotropic Temperature-Driven Strain Dynamics in VO_2 Solid-State Microactuators

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VO_2 is a particularly appealing material for the development of solid-state micro- and nano-actuators due to its phase transition characterized by a large lattice change associated with a high energy density. Its martensitic transformation is strongly anisotropic: upon heating the *c*-axis contracts by almost 1%, while the *a* and *b* axes expand by about 0.5 and 0.4%, respectively. Such anisotropic behavior could be fully exploited or almost compensated by controlling the microstructure of VO_2. In this work we characterize the in-plane strain state of VO_2 thin films grown on top of MgO(100) and MgO(110) substrates. The microstructures of VO_2 on MgO(100) are "tasselleted", i.e. made of orthogonal VO_2 domains that results in an almost-isotropic behavior. VO_2 grown on top of MgO(110), instead, is characterized by aligned domains showing wider strain dynamics and marked anisotropy. We perform a quantitative analysis of the strain state of VO_2 across its phase transition and along different lattice directions by measuring the profile of suspended micro-bridges aligned along different directions. Strain is obtained by calculating the profile lengths of the buckled bridges and comparing them with their nominal values (flat state). Our results show that the strain dynamics and anisotropy of VO_2 devices is comparable with bulk values and can be controlled by the VO_2 crystalline microstructure. Moreover, we demonstrate that there exists an interplay between electrical resistivity and strain which is mediated by the bridge geometry, where clamping conditions allow the accumulation of tensile strain but relax compressive one by buckling.

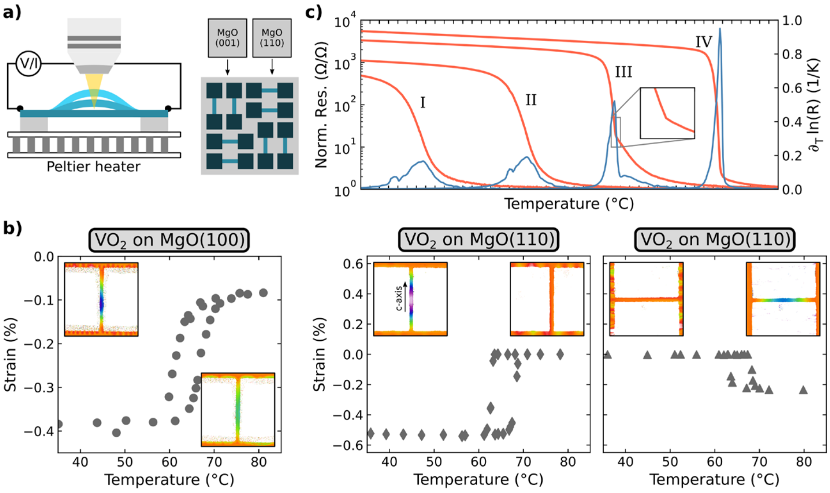

Fig. 1: a) Experimental configuration relied on the concurrent measurement of the electrical resistivity and the profile of double-clamped micro-bridges fabricated from VO_2. b) In-plane strain of VO_2 as a function of temperature as obtained from optical profilometry data (extremal cases and bridge directions are shown in the inset). Different MgO substrate cut-planes determines different VO_2 crystalline microstructures, affecting strain dynamics and absolute values across the phase transition. c) R(T) and its relative derivative for two orthogonal bridges on MgO(100) and MgO(110). I and II are comparable while III and IV shows anisotropy due to different strain state of the bridges at different temperatures, the kind marks the transition from buckle to flat condition.