Dynamics of the inhomogeneous antiferromagnetic domains across the insulator-to-metal Mott transition in V_2O_3

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Mott insulators are among the most promising materials for the next generation of completely new solid-state devices characterized by novel emerging functionalities [1,2] and ultrafast speed [3,4]. Vanadium-based oxides have been intensively studied due to the possibility of controlling the Mott transition by means of small variations of chemical doping, temperature, pressure, and, more recently, by applying external electric fields or by changing the electronic band population by means of ultrafast laser pulses [5,6]. In particular, we will focus on vanadium sesquioxide (V_2O_3), a prototypical Mott insulator that exhibits a Metal-to-Insulator transition (MIT) occurring at T_{MIT} ~160 K and characterized by a resistivity change of several orders of magnitude. The microscopic mechanism driving the MIT in this material is still the subject of a lively debate. Recent results unveiled a complex interplay between electronic correlations, lattice deformation and intrinsic inhomogeneities at the nanoscale [7]. Here, we present a study, based on photoemission electron microscopy (PEEM), of the temperature-driven MIT in 40 nm V_2O_3 films, epitaxially grown on Al_2O_3 [8]. By tuning the photon energy across the vanadium *L*-edge (≈513 eV), we imaged the formation of nanometric antiferromagnetic insulating domains oriented along the V_2O_3 crystallographic directions and we investigated their melting during the thermally-driven MIT. As a complementary tool, we investigated the MIT by ultrafast optical spectroscopy. The ultrafast charge dynamics, triggered by a pump-induced non-equilibrium orbital polarization, presents strong connections with the spatial distribution of AF domains at the nanoscale. The combination of time and spatially resolved techniques sheds new light on the microscopic mechanisms underlying the MIT and paves the way to the use of optical pumping to manipulate the V_2O_3 band population up to the point of photo-inducing the complete collapse of the insulating gap [9].

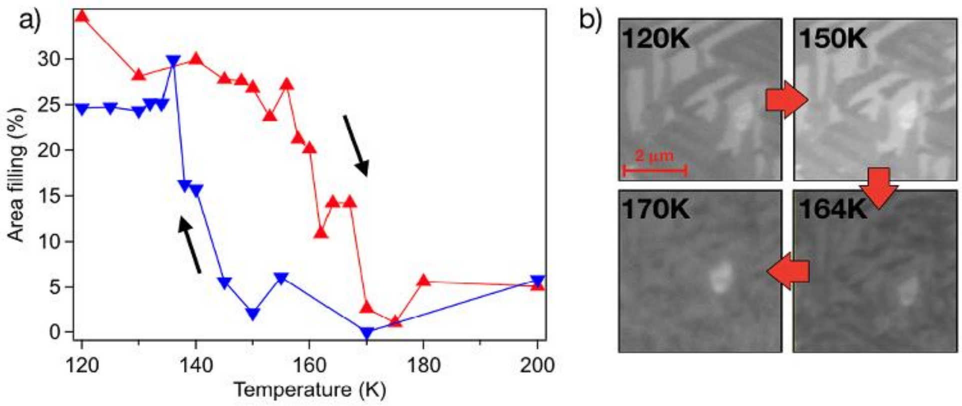

Figure. a) Hysteresis cycle obtained calculating the percentage of area filling of the dark gray domains in the PEEM images. b) PEEM images taken at 120, 150, 164 and 170K.

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