XANES investigation of the Metal-Insulator transition in VO2: from multi domain systems to single domain limit

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Transition metal oxides (TMO) are typically correlated systems and one of the most studied system is the vanadium dioxide (VO_2). Strongly correlated systems exhibits a large variety of exotic and interesting properties such as high temperature superconductivity, half metallicity and metal insulator transitions. Because of the interplay between electrons and lattice, VO_2 undergoes a hysteretic metal insulator transition (MIT) around room temperature (~340 K) with a change in resistivity of different orders of magnitude [1], paired to a complex structural phase transition (SPT) starting from an insulating monoclinic phase at low temperature to a final stable metallic phase at high temperature with the rutile symmetry.
VO_2 is also extremely sensitive to chemical and physical perturbations such as stress and strain [2] that slightly tune the MIT temperature. Moreover, as other TMOs, it is characterized by a phase separation, intermediate phases at the nanoscale with different micro- and nano-domains having different electrical, structural and optical properties [3-5]. All these phenomena make VO_2 an extremely interesting case-study with a wide range of potential applications in optics, sensors and novel memory devices [6-7].

Actually, the occurrence of an extremely fast reversible electronics and structural transitions is unusual and the nature and the driving mechanism of the VO_2 MIT are still under debate despite decades of efforts since its first observation in 1959 [8-9]. Because of the strong interplay between lattice and electronics properties, to investigate the MIT transition it is necessary to use a technique, which have also the sensitivity to probe local structural and electronics properties simultaneously. XANES spectroscopy is a suitable method capable to probe the local electronic properties and the local structure changes induced by the MIT in this complex system.

Considering this framework, on one hand, we are interested in studying how stress\strain affects VO_2 features in multi-domain systems (thin films), on the other hand, to explore the intrinsic behavior of the MIT in the single domain regime (nanoparticles).
We present here preliminary results from XANES spectra measured with the Auger yield technique on thin films of 16 and 32 nm, proving that mostly vanadium 3d electrons are involved in the MIT process.

We will discuss the results and experimental perspectives based on the synthesis and characterization, both "on the flight" and deposited, of VO_2 nanoparticles of 5-10 nm using a Pulsed Microplasma Cluster Source (PMCS) [10, 11]. Since nanoparticles' size is smaller than the average VO_2 domain dimensions [12] it is possible to go toward single domain limit and disentangle the MIT features from complex domain dynamics and in the gas phase experiments, also from the substrate interaction.

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