doi:10.1017/S1431927616005262
Microsc. Microanal. 22 (Suppl 3), 2016
© Microscopy Society of America 2016

Atomic Resolution Studies of W Dopants Effect on the Phase Transformation of VO_2

Hasti Asayesh-Ardakani[1, 2], Anmin Nie[2], Yihan Zhu[3], Patrick J. Phillips[4], Robert F. Klie[4], Sarbajit Banerjee[5], Gregory M. Odegard[1] and Reza Shahbazian-Yassar[1, 2]

[1.] Department of Mechanical Engineering-Engineering Mechanics, Michigan Technological University, Houghton, MI 49933-1295, USA
[2.] Department of Mechanical and Industrial Engineering, University of Illinois at Chicago, IL60607-7059, USA
[3.] Advanced Membranes and Porous Materials Center, King Abdullah University of Science & Technology, Thuwal, 23955-6900, Saudi Arabia
[4.] Department of Physics, University of Illinois at Chicago, Chicago, IL60607-7059, USA
[5.] Department of Chemistry, Texas A&M University, College Station, TX 77843-3255, USA

Metal-Insulator Transition (MIT) in VO_2 has attracted attention of many theorists and experimentalists for more than fifty years since the discovery of the phenomena by Morin [1]. The distinctive aspects of this martial are structural phase transition, sharp resistivity and optical transparency changes by several order of magnitudes at ~ 340 K [2]. These distinctive properties have inspired many applications such as thermo/electrochromics, Mott transistors, thermal actuators, gas sensors, strain sensors and temperature sensors. Recent efforts focus on controlling of phase transition and adjusting of slight opening around the transition temperature. These efforts mostly concentrate on using different dopants, which result in different material properties and play a critical role in device applications.

In this work, we have focused on the effect of tungsten (W) dopant in the VO_2 matrix by use of aberration corrected scanning transition electron microscopy. The high-resolution Z-contrast imaging of individual single-crystalline $W_xV_{1-x}O_2$ nanowires indicates W atoms in the structure as shown in Figure 1a. Nanowires with different W concentrations (0.2, 0.5, and 0.8 atom %) that correspond to different transition temperatures (330, 314, and 295 K respectively) were studied. The comparison between the strain map analyses of high-resolution images of different nanowires reveals the effect of dopants on phase transition of VO_2 (Figure 1b-c). The dopants create anisotropic stress in the monoclinic VO_2 structure. This stress, which is either caused by the physical or electronic mismatch between W and V atoms, could facilitate the phase transition from monoclinic structure to tetragonal structure. Electron Energy loss spectroscopy was also used to investigate the valence change due to the addition of the W atoms in the VO_2 structure. We also verified the experimental observation by Density Functional Theory (DFT) calculations. [3][4]

https://doi.org/10.1017/S1431927616005262 Published online by Cambridge University Press

References:

[1] F.J. Morin, Phys. Rev. Lett., 3 (1959) 34-36.
[2] V. Eyert, Ann. Phys. (Berlin), 11 (2002) 650-704.
[3] H. Asayesh-Ardakani, et al., Nano Lett., 15 (2015) 7179-7188.
[4] The authors acknowledge funding from the National Science Foundation (Award No. CMMI-1200383, IIP 1311837 and DMR 0847324). The acquisition of the UIC JEOL JEM-ARM200CF is supported by an MRI-R2 grant from the National Science Foundation (Grant No. DMR-0959470).

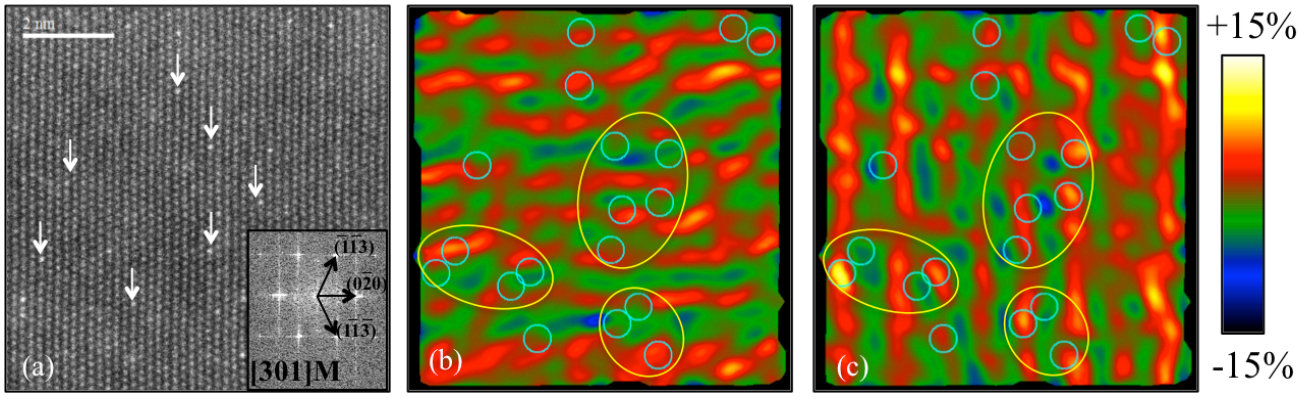

Figure 1. (a) Atomic resolution HAADF image of $W_xV_{1-x}O_2$ nanowires (x=0.5 atom%). Insets correspond to the FFT of (a) which indicates that (a) has been acquired along the [301] zone axis of the monoclinic structure. The spots with higher intensity imply the existance of W in each column as compared to other spots. (b-c) strain maps are along to and perpendicular to $(\bar{1}\bar{1}3)$ lattice planes.

https://doi.org/10.1017/S1431927616005262 Published online by Cambridge University Press