991
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Atomic Resolution Study of W-Doped VO_2 Nanowires

Hasti Asayesh-Ardakani[1, 2], Anmin Nie[1, 2], Peter M. Marley[3], Yihan Zhu[4], Patrick J. Phillips[2], Sujay Singh[5], Farzad Mashayek[6], Ganapathy Sambandamurthy[5], Ke-bin Low[7], Robert F. Klie[2], Sarbajit Banerjee[3], Gregory M. Odegard[1] and Reza Shahbazian-Yassar[1, 2,6]

[1]Department of Mechanical Engineering-Engineering Mechanics, Michigan Technological University, Houghton, MI 49933-1295, USA
[2]Department of Physics, University of Illinois at Chicago, Chicago, IL60607-7059, USA
[3]Department of Chemistry, University at Buffalo, State University of New York, Buffalo, New York 14260-3000, USA
[4] Advanced Membranes and Porous Materials Center, King Abdullah University of Science & Technology, Thuwal, 23955-6900, Kingdom of Saudi Arabia
[5]Department of Physics, University at Buffalo, State University of New York, Buffalo, New York 14260-3000, USA
[6]Department of Mechanical and Industrial Engineering, University of Illinois at Chicago, Chicago, IL60607-7059, USA
[7]Research Resource Center, University of Illinois at Chicago, IL60607-7059, 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 phenomena 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, memristors, thermal actuators, gas sensors, strain sensors and temperature sensors. Recent efforts focus on controlling of phase transition and domain structures in finite size VO_2, which results 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 MIT of individual single-crystalline VO_2 nanowires 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 dopant atoms in the structure as shown in Figure 1a. The strain map analysis of high-resolution images reveals the effect of dopants in MIT of VO_2 (Figure 1b-c). The dopants create anisotropic stress and structural distortions into the VO_2 structure. This stress facilitates the phase transition form monoclinic structure to tetragonal structure. We also verified the experimental observation by Density Functional Theory (DFT) calculations.

References:

[1] FJ Morin, Phys Rev Lett **3** (1959), p. 34.
[2] V Eyert, Ann Phys (Berlin) **11** (2002), p. 650.

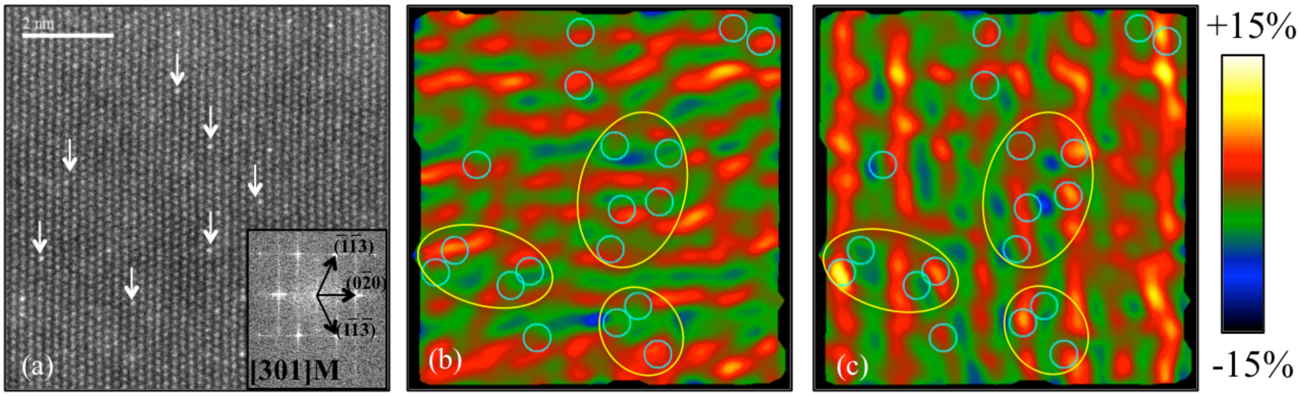

Figure 1. (a) Atomic resolution HAADF image of $W_xV_{1-x}O_2$ nanowires. Insets correspond to the FFT of (a) which indicates that (a) has been acquired along the [301] zone axis of the monoclinic structure. The spots with higher intesity implie the existance of W in each column as compared to other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

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