Supporting Information

Simple Route to (NH₄)_xWO₃ Nanorods for Near Infrared Absorption

Chongshen Guo,* Shu Yin, Qiang Dong and Tsugio Sato



Fig.S1 The changes of $(ahv)^{1/2}$ as a function of hv.

The band, E_g , was determined using equation of $(ahv) = B(hv - E_g)^n$, where *hv* is the photon energy, *a* energy the absorption coefficient, *B* the absorption edge width parameter, E_g the band gap, and the exponent n depends on the type of optical transition in the gap region. Typically, n is 1/2, 3/2, 2, and 3 for transitions being direct and allowed, direct and forbidden, indirect and allowed, and indirect and forbidden, respectively. For tungsten oxide, the transition is allowed and the band gap is indirect, so the exponent n is expected to be 2. Therefore, $(ahv)^{1/2}$ was plotted as a function of hv from which band gap is obtained. By this method, the band gap value of sample in this work was determined as 2.34eV. By comparison, we know that the $(NH_4)_xWO_3$ gives a lower band gap than tungsten trioxide (reported value was in the range of 2.8 - 3.2 eV)^{S1-S2}, which can be attributed to a fact that the NH_4^+ doping leads to movement of the Fermi energy towards conduction band of WO_3 .^{S3-S4} In addition, the one-dimensional $(NH_4)_xWO_3$ material of this work possesses wider band gap than reported bulk $(NH_4)_xWO_3$ (about 2eV). It was reported that the electronic band gap increases with distortion of WO_6 octahedra that are building of the tungsten oxide framework, hence the increased band gap of our sample is close related to its one-dimensional morphology.

S1 G. Wijs and R. Groot, *Phys. Rev. B*, 1999, **60**, 16463.

S2 G. Zou, H. Li, Y. Zhang, K. Xiong and Y. Qian, Nanotechnology, 2006, 17, S313.

- S3 K. Lee, D. Seo and M. Whangbo, J. Am. Chem. Soc., 1997, 119, 4043.
- S4 S. Raj, T. Sato, S. Souma, T. Takahashi, D. D. Sarma, Priya Mahadevan, J. C. Campuzano, M. Greenblatt and W. H. McCarroll, *Phys. Rev. B*, 2008, **77**, 245120.
- S5 J. Sun, X. Feng, J. D. Sloppy, L. Guo and C. A. Grimes, *Nanoletter*, 2011, 11, 203.

on oniversity Tokohu University Tokonu University Tokohu Universi v Tokohu University Tokohu University Tokohu University Tokohu University

Fig.S2 Photograph of film. The size of glass is 10 cm x10 cm.