Comment on "A transparent metal: Nb-doped anatase TiO_2" [Appl. Phys. Lett. 86, 252101 (2005)]

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In a recent letter,[1] the resistivity of the Nb-doped anatase TiO_2 films on (100) strontium titanate ($SrTiO_3$) substrates was measured to be $(2-3)\times 10^{-4}$ Ω cm at room temperature and showed a metallic feature. Based on their experimental results, Furubayashi *et al.* claimed that Nb-doped TiO_2 films were a transparent metal. But the resistivity value of Nb-doped TiO_2 films on $SrTiO_3$ substrates is not reliable due to the Nb diffusion into the $SrTiO_3$ substrate at high temperature. Our results show that the resistivity of Nb-doped TiO_2 films on (0001) sapphire is much higher than that of the films on (100) $SrTiO_3$.

In our experiment, (100) $SrTiO_3$ and (0001) sapphire were used as the substrates for 50 nm $Ti_{1-x}Nb_xO_2$ ($x=0,0.05$) thin film deposition. Films were deposited by pulsed laser deposition method in the same experimental condition (1.3×10^{-3} Pa oxygen, 820 K) as described in Ref. 1. Electrical properties of the undoped and Nb-doped TiO_2 on two different substrates were investigated at room temperature. Figure 1 shows two typical current-voltage curves of the two samples on different substrates. When Nb-doped TiO_2 films were deposited on (100) $SrTiO_3$, the measured resistivity was calculated to be in the range of $(2-5)\times 10^{-4}$ Ω cm, which is in good agreement with the value reported in Ref. 1. But the resistivity of Nb-doped TiO_2 film on sapphire substrate was found to be as high as 0.5 Ω cm, which was much higher than that of the film on (100) $SrTiO_3$ substrate.

$SrTiO_3$ is a perovskite metal-oxide insulator, which can be doped to be an *n*-type semiconductor by Nb substituted on the Ti sites.[2] In fact, Nb-doped $SrTiO_3$ films with the resistivity as low as 3.6×10^{-4} Ω cm have been epitaxially grown on single-crystal (100) $SrTiO_3$ substrates by laser molecular beam epitaxy method.[3] When Nb-doped TiO_2 films were deposited on $SrTiO_3$ substrates at high temperature, a very low resitivity Nb-doped $SrTiO_3$ interfacial layer would form due to the Nb diffusion into the $SrTiO_3$ substrate. Thus the measured resitivity value of $(2-3)\times 10^{-4}$ Ω cm of Nb-doped TiO_2 film in Ref. 1 is not reliable, and $SrTiO_3$ is not an appropriate substrate for electrical measurement of Nb-doped TiO_2 films. The measured resistivity of Nb-doped TiO_2 on (0001) sapphire substrate is reliable because sapphire is very stable at 820 K and it keeps insulating after film deposition.

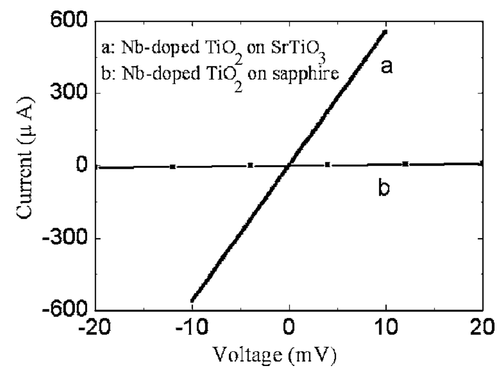

FIG. 1. Room temperature current-voltage curves of the Nb-doped TiO_2 films deposited on (100) $SrTiO_3$ and (0001) sapphire substrates.

In summary, the resistivity of Nb-doped TiO_2 film on (0001) sapphire substrate was found to be much higher than that of the film on (100) $SrTiO_3$ substrate. $SrTiO_3$ is not an appropriate substrate in the case of electrical measurement of Nb-doped TiO_2 films due to the Nb diffusion into the $SrTiO_3$ at high temperature.

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[1]Y. Furubayashi, T. Hitosugi, Y. Yamamoto, K. Inaba, G. Kinoda, Y. Hirose, T. Shimada, and T. Hasegawa, Appl. Phys. Lett. **86**, 252101 (2005).
[2]T. Tomio, H. Miki, H. Tabata, T. Kawai, and S. Kawai, J. Appl. Phys. **76**, 5886 (1994).
[3]T. Zhao, H. B. Lu, F. Chen, S. Y. Dai, G. Z. Yang, and Z. H. Chen, J. Cryst. Growth **212**, 451 (2000).

0003-6951/2006/88(22)/226102/1/$23.00