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ROOM TEMPERATURE HYDROGENATION IN FUNCTIONAL OXIDE NANOWIRES BY AN ELECTRIC FIELD VIA AIR NANOGAP

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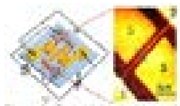
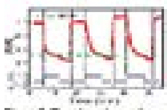
Large reversible changes of the electronic transport properties of solid-state oxide materials induced by electrochemical fields have received much attention as a new research avenue in iontronics. The action on time-dependence of conductive modulation is slower. Despite the slow modulation, the emergence of non-linear, plastic and/or memristive behaviors provides an opportunity to obtain new abilities in information processing, like signal flow in brain, in addition to sensing and energy devices. In this conference, dramatic transport changes in VO_2 nanowires were demonstrated by electric field-induced hydrogenation at room temperature. As a suitable device structure to perform transport modulation through electrochemical reactions, we proposed a planar-type field effect transistor with side gates and a nanowire channel separated by air nanogaps (denoted PG-FET), as illustrated in Figure 1. This unique structure allowed us to investigate hydrogen intercalation and diffusion behavior in VO_2 channels with respect to both time and space. Figure 2 shows the reversible, non-volatile resistance changes in a VO_2 nanowire channel with a width (w) of 500 nm obtained by applying positive and negative VG at 300 K under a humidity of around 50%. The normalized resistance (R/R0, where R and R0 are the measured resistance and resistance of the pristine device before applying a VG at 300 K, respectively) slowly decreased down to the saturation line at roughly R/R_0 = 0.75 during the application of VG = +100 V. This state was held after the removal of the VG. Namely, the device exhibited a non-volatile memory effect. The R/R_0 increased again with applying V_G = -100 V. Our results will contribute to further strategic researches to examine fundamental chemical and physical properties of devices and develop iontronic applications, as well as offering new directions to explore emerging functions for sensing, energy, and neuromorphologic devices combining ionic and electronic behaviors in solid-state materials.





Recent Publications

1. Manca N, Pellegrino L, Kanki T, Venstra W J, Mattoni G, Higuchi Y, Tanaka H, Caviglia A D and Marré D (2017) Selective high-frequency mechanical actuation driven by the VO_2 electronic instability. Advanced Materials 29, 1701618.
2. Wei T, Kanki T, Chikanari M, Uemura T, Sekitani T and Tanaka H (2017) Enhanced electronic-transport modulation in single-crystalline VO_2 nanowire-based solid-state field-effect transistor. Scientific Reports 7, 17215.
3. Kanki T and Tanaka H (2017) Nanoscale electrochemical transistors in correlated oxides. APL Materials 5, 042303.
4. Wei T, Kanki T, Fujiwara K, Chikanari M and Tanaka H (2016) Electric field-induced transport modulation in VO_2 FETs with high-k oxide/organic parylene-C hybrid gate dielectric. Applied Physical Letters 108, 053503.
5. Sasaki T, Ueda H, Kanki T and Tanaka H (2015) Electrochemicalgating-induced reversible and drastic resistance switching in VO_2 nanowires. Scientific Reports doi: 10.1038/srep17080.

Biography

Teruo Kanki has completed his PhD in Material Physics from Osaka University in 2004. After working as Visiting Researcher in IBM's Almaden Research Center from 2004 to 2006, he became a specially appointed Assistant Professor in Osaka University. Now he is an Associate Professor in Osaka University and works on novel and new concept oxide nano-electronics. He has published more than 80 papers in reputed journals.

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