Title: Oxide Electronics and Recent Progress in Bipolar Applications

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The discovery of oxide electronics is of increasing importance today as one of the most promising new technologies and manufacturing processes for a variety of electronic and optoelectronic applications such as next-generation displays, batteries, solar cells, memory devices, and photodetectors[1]. The high potential use seen in oxide electronics is due primarily to their high carrier mobilities and their ability to be fabricated at low temperatures[2]. However, since the majority of oxide semiconductors are n-type oxides, current applications are limited to unipolar devices, eventually developing oxide-based bipolar devices such as p-n diodes and complementary metal-oxide semiconductors.

We have contributed to a wide range of oxide semiconductors and their electronics and optoelectronic device applications. Particularly, we have demonstrated n-type oxide-based thin film transistors (TFT), integrating In_2O_3-based n-type oxide semiconductors from binary cation materials to ternary cation species including InZnO, InGaZnO (IGZO), and InAlZnO. We have suggested channel/metallization contact strategies to achieve stable and high TFT performance[3, 4], identified vacancy-based native defect doping mechanisms[5], suggested interfacial buffer layers to promote charge injection capability[6], and established the role of third cation species on the carrier generation and carrier transport[7].

More recently, we have reported facile manufacturing of p-type SnOx through reactive magnetron sputtering from a Sn metal target[8]. The fabricated p-SnOx was found to be devoid of metallic phase of Sn from x-ray photoelectron spectroscopy and demonstrated stable performance in a fully oxide-based p-n heterojunction together with n-InGaZnO. The oxide-based p-n junctions exhibited a high rectification ratio greater than 10^3 at ±3 V, a low saturation current of ~$2x10^{-10}$, and a small turn-on voltage of -0.5 V.

In this presentation, we review recent achievements and still remaining issues in transition metal oxide semiconductors and their device applications, in particular, bipolar applications including p-n heterostructures and complementary metal-oxide-semiconductor devices as well as single polarity devices such as TFTs and memristors. In addition, the fundamental mechanisms of carrier transport behaviors and doping mechanisms that govern the performance of these oxide-based devices will also be discussed.

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