# Fundamental Study on Interface Electrical Properties of Single Crystalline Metal Oxide Nanowires

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（単結晶金属酸化物ナノワイヤの界面電子物性に関する基礎的研究）

区　　分　　：甲

論　文　内　容　の　要　旨

Electronics based on metal oxide nanowires have attracted great attention due to their unique physical and chemical properties, such as sensitivity to chemical species, surface redox reactions and ambient stability. In typical 2 terminal electrical devices, the charge will be injected into an active material channel through an electrical contact between channel and electrodes. This contact, or interface, play a crucial role on the electrical properties of nanowire devices due to their deeply scaled surface-to-volume ratio and nanoscale effects. In addition to the contacts, interaction between nanowire surface and molecules in ambient air also affects the electrical properties of nanowire devices. Therefore, understanding and controlling the effects of surface molecules and contacts on electrical properties of nanowire devices are essential to achieve practical applications of metal oxide nanowires. This thesis mainly focuses on the fundamental study of the interface electrical properties between contact material and single crystalline metal oxide nanowires.

First, a rational method to improve electrical characteristics of oxide nanowire field-effect transistors (FET) performance is proposed. Octadecylphosphonic acid (ODPA) was utilized as the self-assembled monolayer (SAM) because of its chemical reaction with oxide surface which removes -OH groups from the channel surface of FETs. The long alkyl chain of ODPA SAM is also effective to prevent adsorption of H2O molecules on oxide nanowire surfaces. By utilizing ODPA SAM modification, the drain current versus gate voltage characteristics of back-gate hydrothermally grown ZnO nanowire FETs are improved: reduction of hysteresis in vacuum condition and improved switching characteristics in atmospheric condition. Second, a rational concept to achieve a long-term electrical stability of metal oxide nanowire sensors with heavily-doped metal oxide contact layer is presented. Antimony-doped SnO2 (ATO) contacts on SnO2 nanowires show much stable and lower electrical contact resistances than conventional Ti contacts for high temperature (200 oC) conditions, which are required to operate chemical sensors. The stable and low contact resistance of ATO was confirmed for at least 1960 hours under 200 oC in open air. This heavily-doped oxide contact enables to realize the long-term stability of SnO2 nanowire sensors with keeping the sensitivity for both NO2 gas and light (photo) detections. Finally, an anomalous resistive switching behavior at the interface of two metallic metal oxides is reported. Atmosphere-controlled annealing experiments revealed that atmospheric oxygen molecules reproducibly deactivate electron dopants within the ITO electrodes. This anomalous, oxygen-triggered resistive switching is not observable at the interface between the same polycrystalline ITO electrodes and lithography-defined polycrystalline oxide nanowires. The effects of specific metal cation species and channel crystallinity on the resistive switching capability were thoroughly investigated, and the anomalous interface resistive switching was found to occur only for the combination of ITO electrodes and single-crystalline oxide channels.