SPICE compact model of the IGZO memristor considering both the metal electrode and the process sequence of the deposition of metal and IGZO film

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The In-Ga-Zn-O (IGZO) memristor is a promising device as the building block for the wearable neuromorphic computing system, the analog memory operation of which is based on the oxygen ion/vacancy-based redox reaction [1]. However, its dependence of either the metal electrode or the process sequence of the deposition of metal and IGZO resistive switching film has been rarely investigated. On the other hand, the SPICE compact model of the metal-oxide memristor is indispensable for the design of circuits and systems. In this work, the dependence of either the kind of metal electrode or the deposition sequence on the IGZO memristor characteristic is investigated and incorporated into the SPICE compact model.

Two kinds of memristors, i.e., the sample A (Pd/IGZO/Mo) with the deposition sequence of Mo evaporation, IGZO sputtering, and Pd evaporation and the sample B (Mo/IGZO/Pd) with the deposition sequence of Pd, IGZO, and Mo, were used. Although the polarity of applied voltage which is defined by a higher potential at top electrode (TE) than bottom electrode (BE) is changed, the SET occurs in a positive bias (symbols in Fig.1 (a) and (b)). It is well known that the metal with low work function has a low formation energy with oxygen so it is highly likely to form an interfacial oxide layer between metal and oxide [2] and this oxygen vacancy-rich interfacial layer would act as the electron capture/emission trap and be located in the Mo/IGZO interface rather than in the Pd/IGZO interface. Then, the Schottky barrier height (SBH) in the Mo/IGZO interface can be modulated by the change of charge induced by electron trapping/detrapping and be followed by SET(potentiation)/RESET(depression) synaptic operation. However, this model cannot explain the result in Fig.1 (a) and (b). Thus, we deduce that the concentration of oxygen vacancies would be higher in the IGZO/BE interface rather than in the IGZO/TE interface due to the effect of Ar ion bombardment during sputtering [3]. Therefore, in the sample A, the ϕ_{B2} is lower than ϕ_{B1} but dominantly modulates SBH while both ϕ_{B1} and ϕ_{B2} affect comparably to the SBH modulation in sample B (insets of Fig.1 (a) and (b)), which explains successfully the influences of metal electrode as well as of the deposition sequence. The proposed model is implemented into SPICE compact model (Fig. 1 (c) and (d)) and the simulation result reproduces the measured characteristic very well (lines in Fig. 1 (a) and (b)). Our result is potentially useful for the process-material-circuit co-design of IGZO-based neuromorphic system.

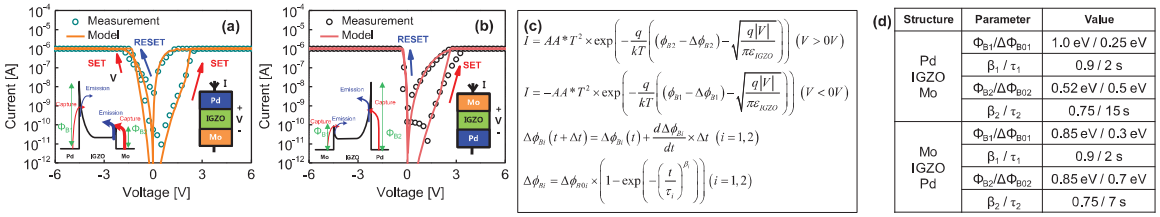

Fig 1. Measured I-V characteristics compared with the proposed model of (a) sample A (Pd/IGZO/Mo) and (b) sample B (Mo/IGZO/Pd). (c) SPICE compact model and (d) the used parameters.

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