Elucidation of the switching mechanism of atom switch based on electric measurement

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Redox-based RRAM such as atom switch is one of the most promising alternatives to current non-volatile memory. The atom switch consists of insulating thin oxide layer sandwiched between two metal electrodes. In the atom switch, metal atomic junction [1] is formed and broken in oxide layer, which causes the conductance switching between high (ON) and low (OFF) states. However, in situ observation of the metal filament inside oxide layer has not yet been reported. In this study, we used spectroscopic techniques to see metal atomic junction in the oxide layer for the purpose to elucidate the switching mechanism.

We put Ag_2S coated Ag wire on the Pt wire. Thin Ag_2S layer was sandwiched between Ag and Pt wire at the cross point. To measure spectrum of atom switch, we had to stop atomic motion of atom switch. The samples were, thus, cooled to cryogenic temperature. We measured Point Contact Spectroscopy (PCS) and Transition Voltage Spectroscopy (TVS) of the atom switch at ON and OFF states.

Figure1 shows d^2I/dV^2 spectrum and FN plot of atom switch at ON/OFF states respectively. In ON state, the energy of peaks in d^2I/dV^2 spectra was around 30meV. It was close to the silver phonon energy of bulk state. The FWHW of the peaks were proportional to samples' temperature. These results indicated that the peak in d^2I/dV^2 spectrum corresponded to silver phonon excitation. Therefore, PCS confirmed the formation of Ag atomic junction at high conductive state. In the case of OFF state, the peak positions of FN plots were around 0.53V. It means the potential barrier height was 0.53eV. This barrier height matched the half value of the bandgap of bulk Ag_2S, so TVS confirmed that Ag_2S was sandwiched between metal electrodes. The spectrum measurements determined the chemical species between metal electrodes of ON/OFF states, and the switching mechanism was confirmed to be forming and breaking at metal atomic contact.

References:
[1] Akira Aiba, Firuz Demir, Scientific Reports, **7**, 7949 (2017).

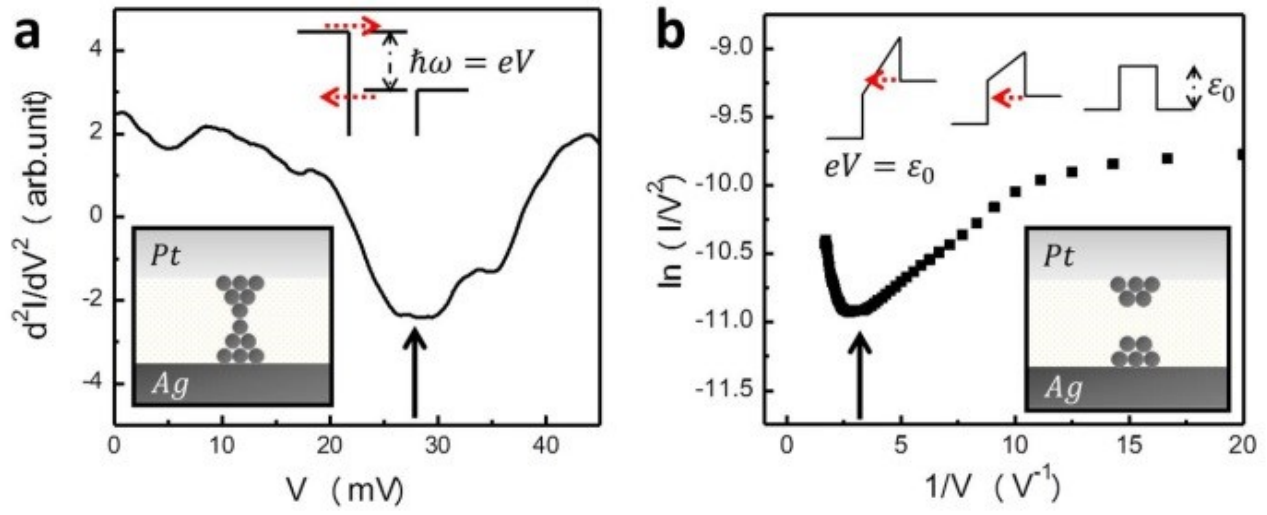

Figure 1 **a** d^2I/dV^2 spectrum of ON state **b** FN plot of OFF state.