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Transport Properties of Anodic Porous Alumina for ReRAM

S. Kato, S. Nigo, ***J. W. Lee****, M. Mihalik, H. Kitazawa and* ***G. Kido***

National Institute for Materials Science, 1-2-1 Sengen, Tsukuba, Ibaraki, 305-0047, Japan

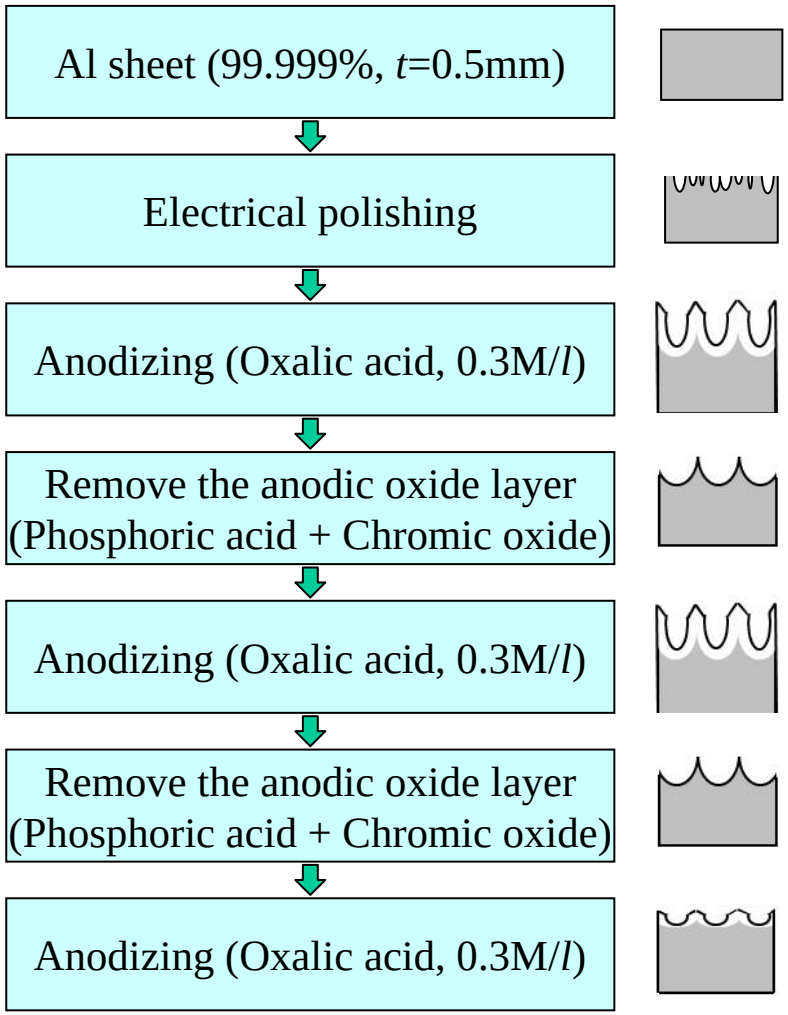
Abstract.

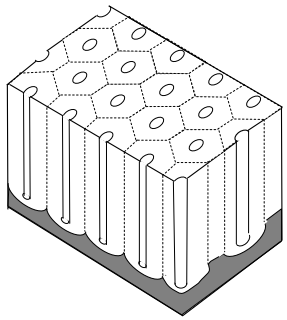
A voltage-induced bistable switching effect was studied for an Al/AlOx/Al device made of the anodic porous alumina with the top electrode of silver. The resistance state of memory is switched between OFF state (high resistance) and ON state (low resistance), where the resistance ratio is order of 10^4. We are developing the next generation memory (ReRAM) using this switching phenomenon.

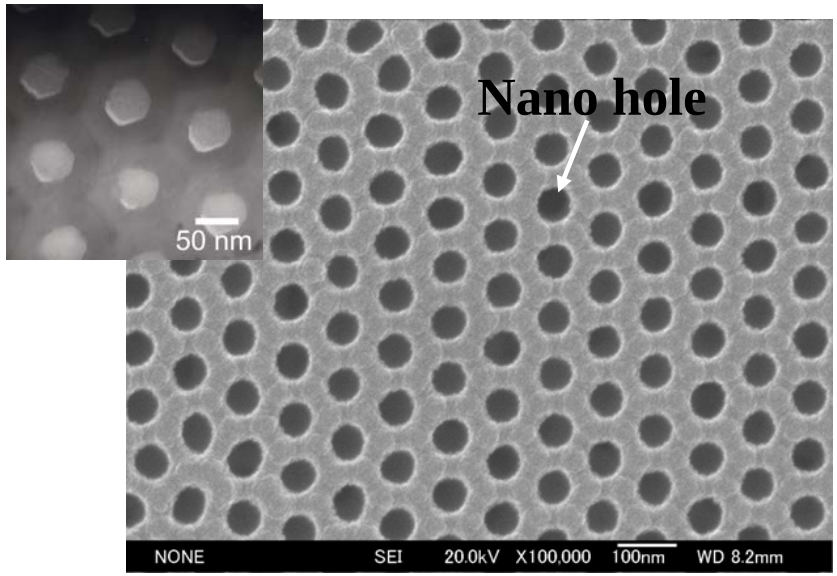
In the thermally stimulated current (TSC) measurement, a narrow band was observed around 280 K and it is indicated that a conduction mechanism comes from a kind of impurity band in the energy gap. The abnormal phenomenon was also observed in the temperature dependence of the resistance at the low resistance state.

Fabrication of Anodic Porous Alumina

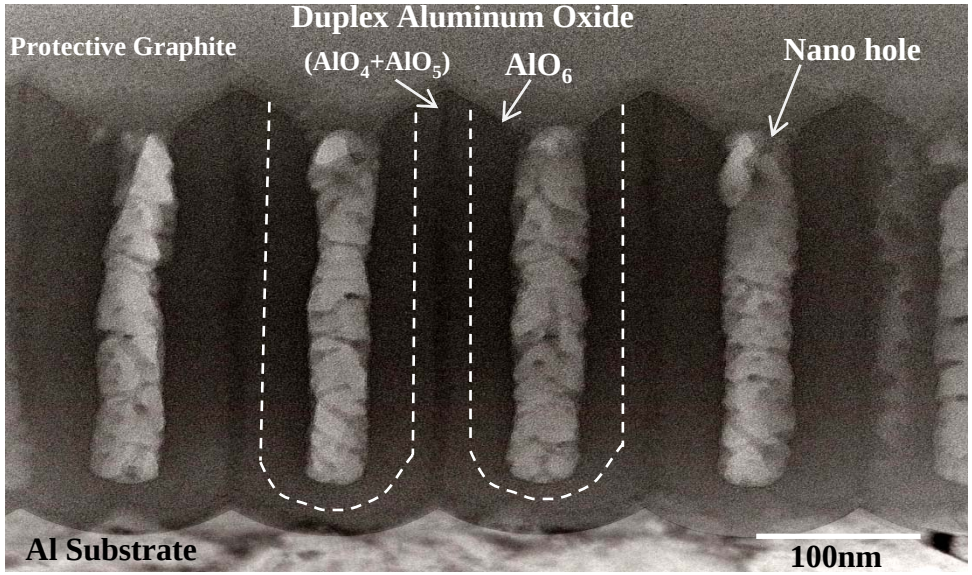
2-step anodizing process





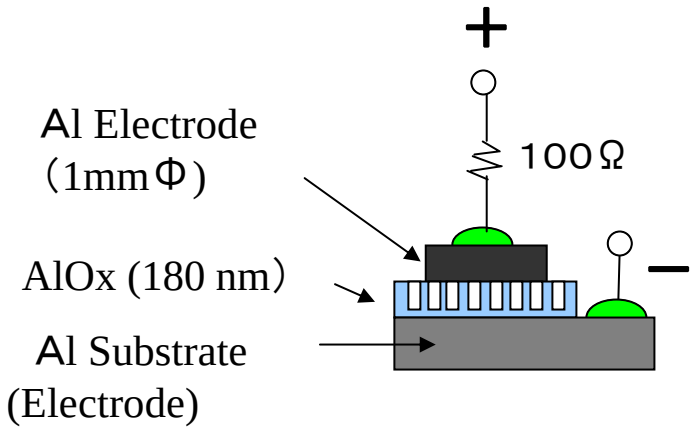


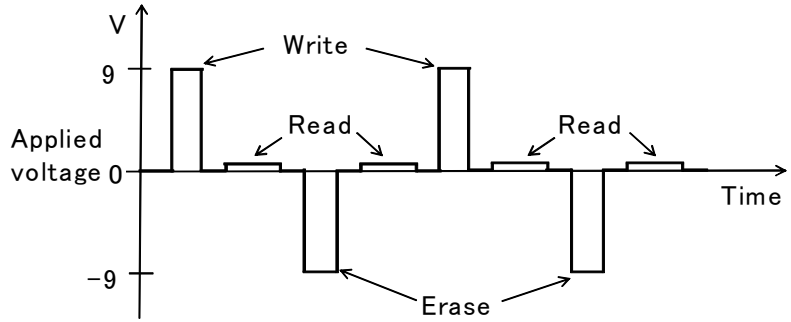
SEM image of surface with a nano-hole honeycomb array (Insert is TEM image)

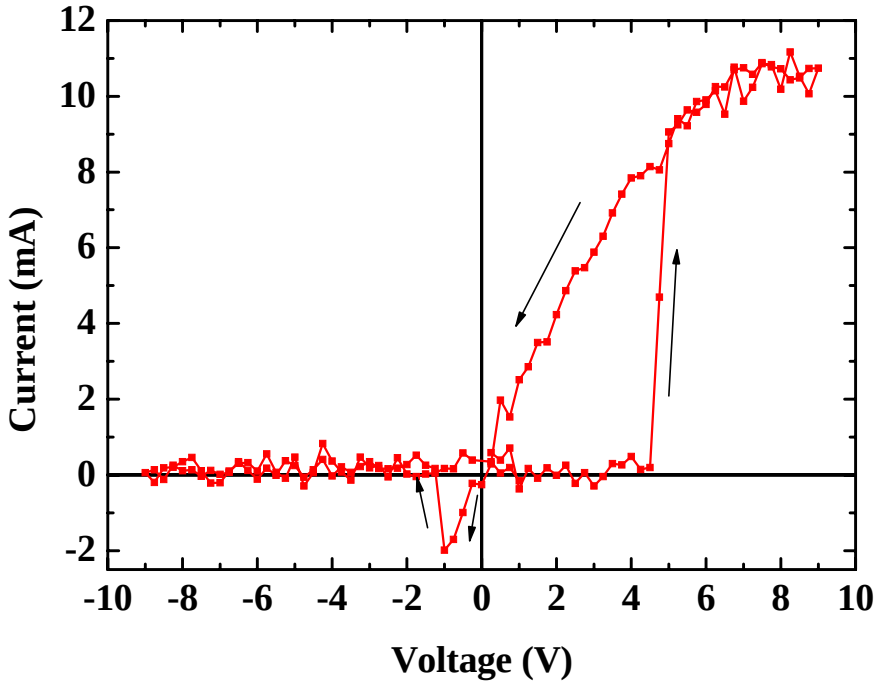


Cross-sectional TEM image

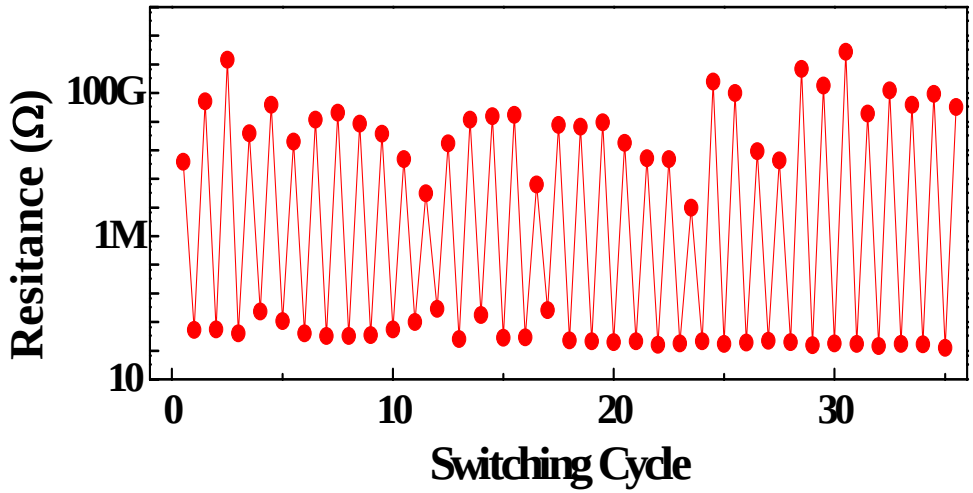
Memory Properties of AlOx-ReRAM







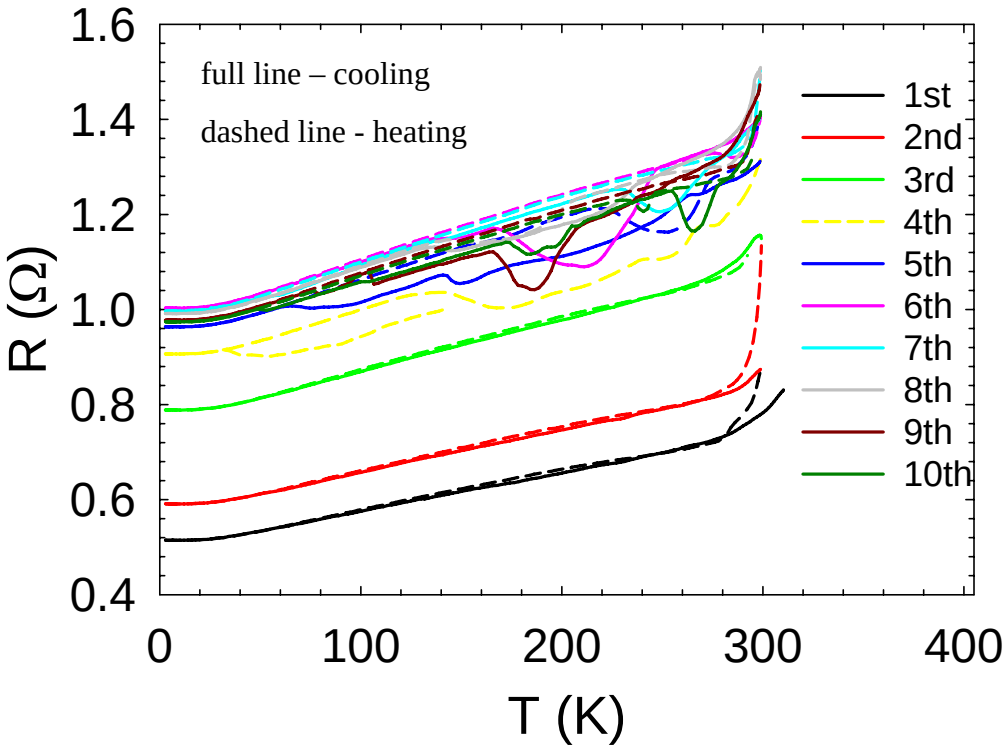
I-V property of AlOx-ReRAM



Resistance switching of AlOx-ReRAM

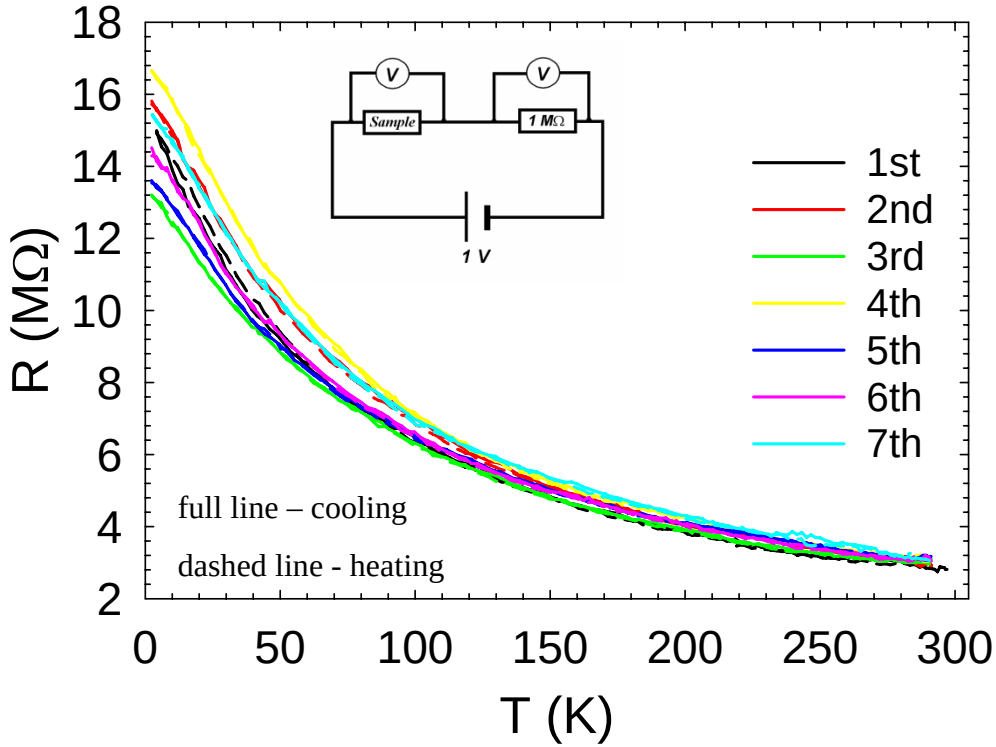
Temperature Dependence of Resistance in ON and OFF state

ON state (low resistance**)**



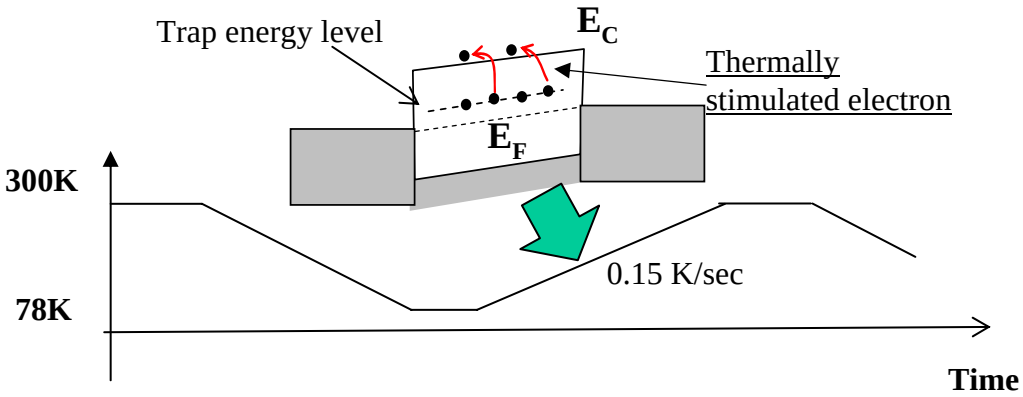
Metallic behavior

OFF state (high resistance**)**



Semiconductor-like behavior

Thermally Stimulated Current (TSC)



TSC Measurement pattern

Activation energy for thermally stimulated electron

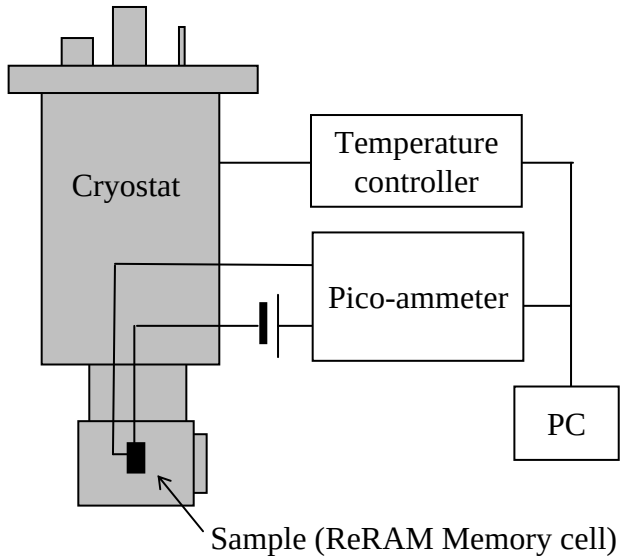
$E_t = kT_m \cdot \ln(T_m^4/\beta)$

k : Boltzman constant

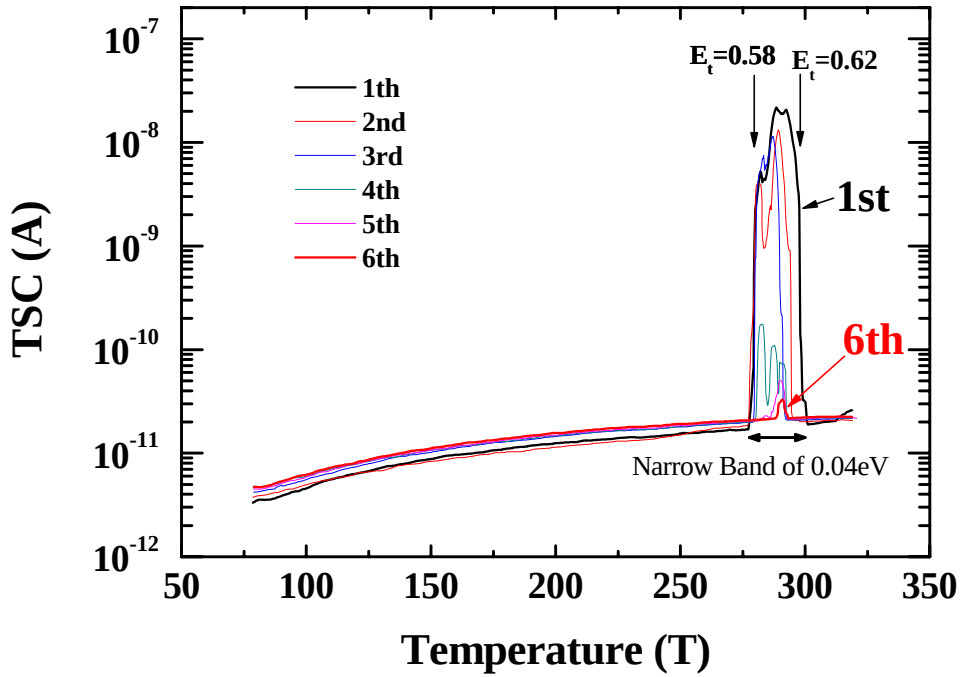
T_m : Peak temperature (K)

β : Temperature rise speed = 0.15 K/sec

R. H. Bube, *Photoconductivity of Solids*, John Wiley, New York (1960), p. 292

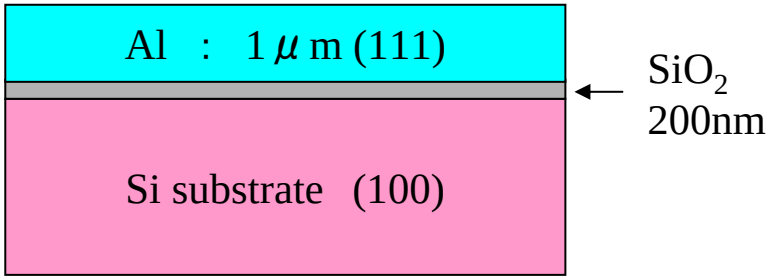


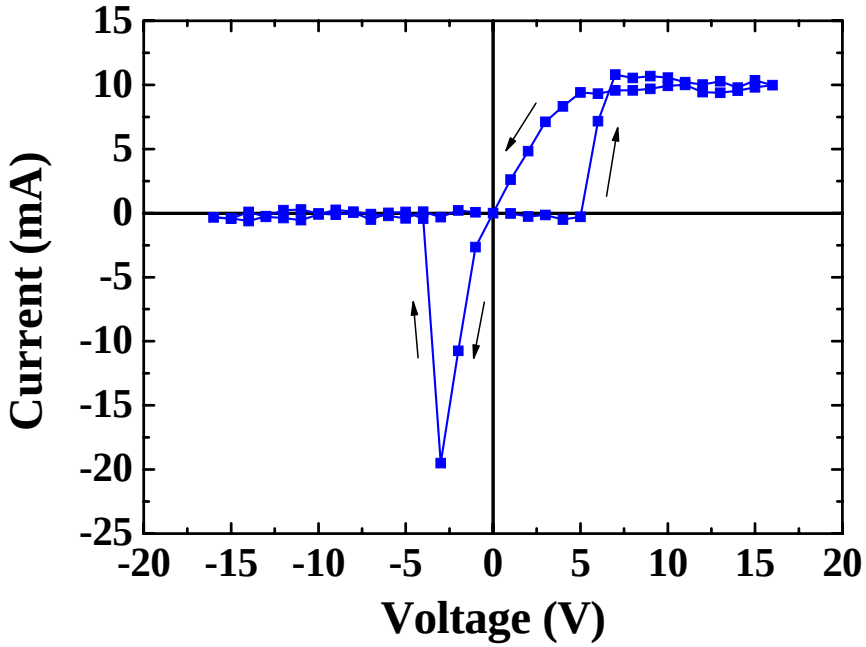
Schematic diagram of TSC measurement system
(KOBELCO RESEARCH INSTITUTE INC.)



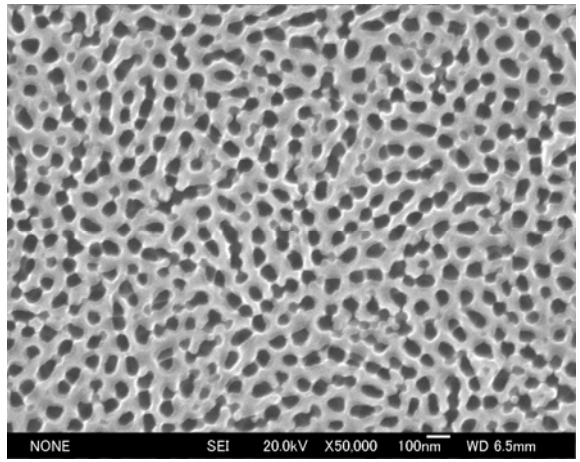
TSC curves of AlOx-ReRAM in OFF state

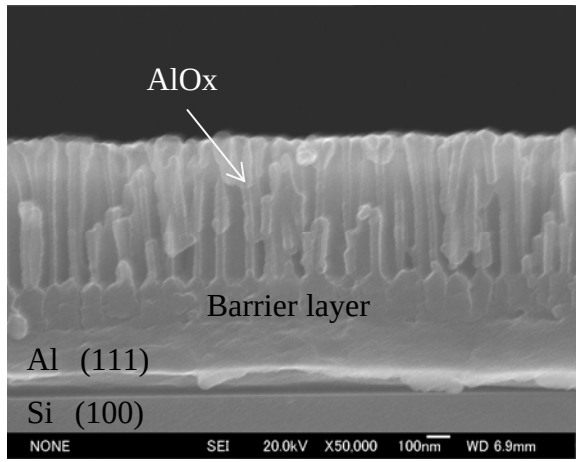
Anodic Porous Alumina on SiO_2/Si substrate





I-V property of AlOx on SiO_2/Si substrate





SEM image of surface and cross-section after anodizing process

Conclusion

- **The switching characteristic of ReRAM cell using the anodic porous alumina.**

  We confirmed the preliminary properties of nonvolatile memory.

- **The transport properties and thermally stimulated current (TSC).**

  Temperature dependence of resistance in ON and OFF state;

  ON state ⇒ metallic behavior

  OFF state ⇒ semiconductor-like behavior

  TSC measurement;

  TSC peaks are observed around 290K. ⇒ releasing of trapped carriers

  The intensity of the peak are decreased with cycles.

  The conductivity is originated by trapped carrier.

- **We also succeed in fabricating ReRAM cell using anodic porous alumina on SiO_2/Si substrate.**