

Charge transport mechanism in tantalum oxide TaO_x

A.A. Gismatulin,^{1,*} V.A. Voronkovsky,¹ T. V. Perevalov,^{1,2} V. A. Gritsenko,^{1,2,3} V. Sh. Aliev¹

¹A.V. Rzhanov Institute of Semiconductor Physics of SB RAS, 13 Lavrentieva Ave, 630090, Novosibirsk, Russia, ²Novosibirsk National Research University, 2 Pirogova Str., 630090 Novosibirsk, Russia, ³Novosibirsk State Technical University, 20 K. Marksa ave., 630073, Novosibirsk, Russia

Tantalum oxide is used as a storage medium instead of silicon nitride in flash memory elements. Tantalum oxide is one of the promising materials for ReRAM. The aim of this work is to study the mechanism of electron transport in tantalum oxide. The TaO_x (x<5/2) films were produced using ion beam sputtering deposition.

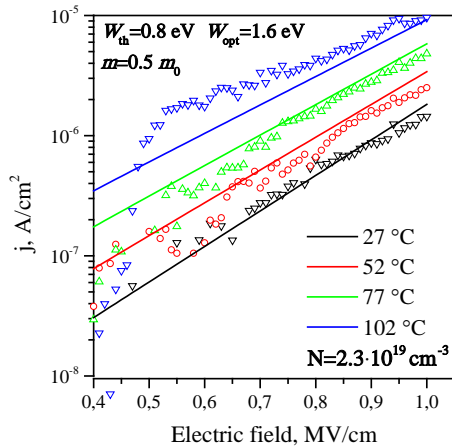


Fig.1 Experimental (symbols) and calculated (lines) current-voltage characteristics of the TaO_x at different temperatures.

Fig 1 shows the current-voltage characteristics of Ta₂O₅ at different temperatures. Experiment well described by trap assisted tunneling between traps [1].

$$J = veN^{2/3},$$

$$v = \frac{\sqrt{\pi} \hbar W_T}{m^* D^2 Q_0 \sqrt{kT}} \exp\left(-\frac{W_{opt} - W_T}{2kT}\right) \times$$

$$\times \exp\left(-\frac{2D\sqrt{2m^* W_T}}{\hbar}\right) \exp\left(-\frac{eFD}{2kT}\right)$$

Here J is current density, F-electric field, N-trap density, W_t and W_{opt} thermal and optical trap energy. From experiment we obtained W_t=0.8 eV, W_{opt}=1.6 eV, N=2.3·10¹⁹ cm⁻³.

Exponential big increasing of current in TaO_x is related to increasing of trap density at the same trap energies.

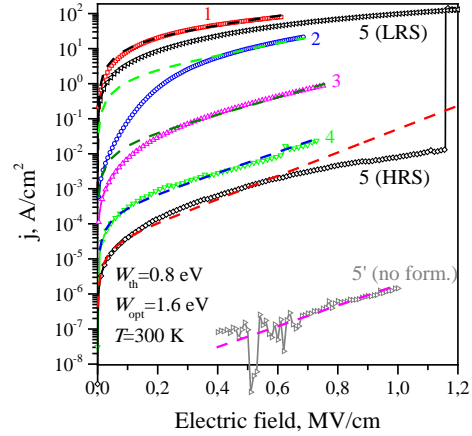


Fig. 2 Shows J-V characteristics of TaO_x of different composition. Model calculation of trap density (1) N=39.0 · 10¹⁹ cm⁻³, (2) N=17.6 · 10¹⁹ cm⁻³, (3) N=5.4 · 10¹⁹ cm⁻³, (4) N=2.25 · 10¹⁹ cm⁻³, (5) N=1.58 · 10¹⁹ cm⁻³, (5') N=2.3 · 10¹⁹ cm⁻³.

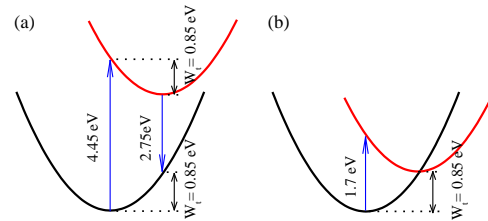


Fig.3 Configuration diagrams: (a) a neutral oxygen vacancy, (b) a neutral electron trap. Black lines are the ground filled state; red lines are an excited state

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* Email: aagismatulin@isp.nsc.ru