

電界放射電流誘起型EMにおける新たな通電手法の検討

Control of Resistances by Field-Emission-Induced Electromigration Using Current Source Mode



滝谷 和聡、友田 悠介、久米 彌、上野 俊介、花田 道庸、白樫 淳一
 国立大学法人 東京農工大学 大学院共生科学技術研究院



Introduction

Field-Emission-Induced Electromigration (so-called "Activation")

Activation process is based on moving atoms induced by **Fowler-Nordheim (F-N) field emission current**.

The motion of moving atoms is completely controlled by the **field emission current** at nanogaps.

Conventional Activation Scheme: **Field Emission Current** Induced by **Voltage Source (V_{source})**

Advantages: Wide-Range Control of Tunnel Resistance of Nanogaps^[1-3]

Magnetoresistance Properties of Ni/Vacuum/Ni System^[4-5]

Disadvantage: **Relatively Long Process Time for Activation**

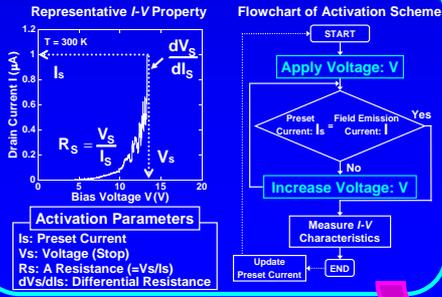
Newly Proposed Activation Scheme: **Field Emission Current** Generated by **Current Source (I_{source})**

Continuous current flow may shorten the process time for activation due to directly applying to the nanogaps.

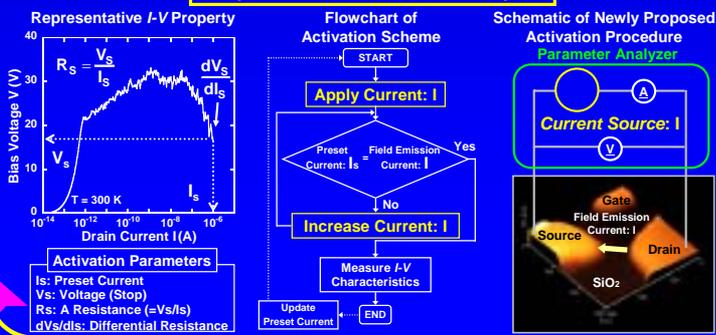
[1] S. Kayashima et al., Jpn. J. Appl. Phys. 46 (2007) L907.
 [2] S. Kayashima et al., J. Phys. Conf. Ser. 100 (2008) 052022.
 [3] Y. Tomoda et al., J. Vac. Sci. & Technol. B 27 (2009) 813.
 [4] Y. Tomoda et al., IEEE Trans. Mag. 45 (2009) 3480.
 [5] Y. Tomoda et al., J. Phys. Conf. Ser. 200 (2010) 062035.

Activation Methods: Voltage Source Mode vs. Current Source Mode

Conventional Activation (Voltage Source Mode)



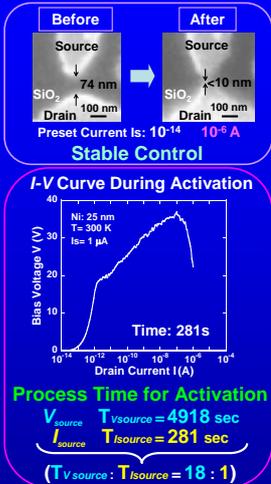
Newly-Proposed Activation (Current Source Mode)



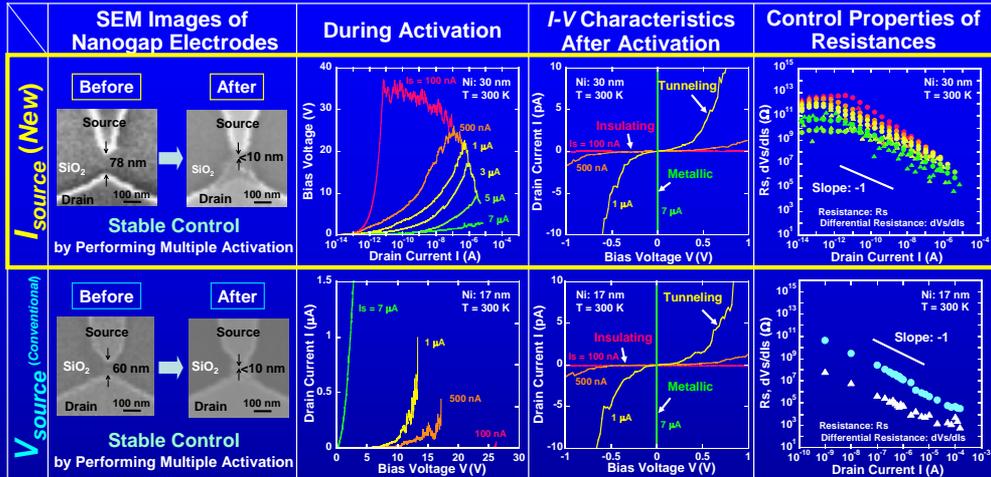
In order to improve the process efficiency of activation ...

Resistance Control of Nanogaps Using Activation with Current Source Mode

Single Activation



Multiple Activation



Conclusions

We proposed a newly investigated activation method using **Current Source Mode (I_{source})**.

Single Activation Procedure: Process time was about 18-20 times shorter than that of V_{source} .

• Activation @ $I_s = 10^{-14}$ A to 10^{-6} A Gap Width: 78 nm to <10 nm

Multiple Activation Procedure: Electrical properties during and after activation were similar to those of V_{source} .

• Decrease of Resistances: A Linear Relation with a Slope of -1

• Transition of I-V Characteristics: Insulating Tunneling Metallic

These results indicate that **Current Source Mode** is suitable for activation procedure.