Influence of Feedback Parameters on Resistance Control of Metal Nanowires by Stepwise Feedback-Controlled Electromigration

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➢ Introduction

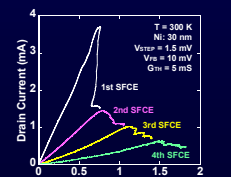
- Fast Progress and Development of Nanoelectronics
  - ➔ Intensive Studies in Fundamental Physical Properties of Metallic Nanogaps [1]
- Electromigration Method for the Fabrication of Nanogaps
  - ➔ Simple Method Achieved by Only Passing a Current Through a Metal Nanowire [2]
  - ➔ Feedback-Controlled Electromigration (FCE) [3,4]

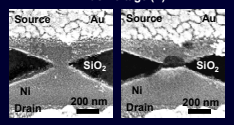
[1] K. I. Bolotin, et al., Nano Lett. 5 1685 (2005).
[2] H. Park, et al., Appl. Phys. Lett. 75 301(1999).
[3] D. R. Strachan, et al., Appl. Phys. Lett. 86 43109 (2005).
[4] K. Takahashi, et al., J. Vac. Sci. Technol. B 27 805 (2009).

A New Approach to Control The Resistance of Metal Nanowires @ Room Temperature

➢ Resistance Control by Stepwise Feedback-Controlled Electromigration (SFCE)

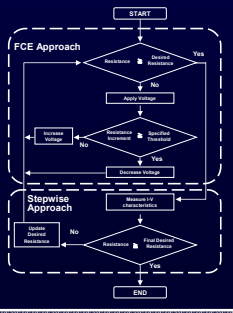
SFCE Scheme





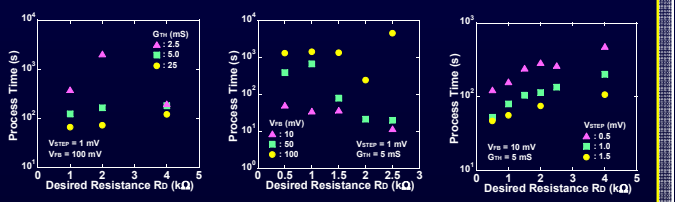
Before SFCE After SFCE

SFCE Procedure



Optimization of Feedback Parameters

Threshold Differential Conductance G_{TH} | Feedback Voltage V_{FB} | Voltage Step V_{STEP}

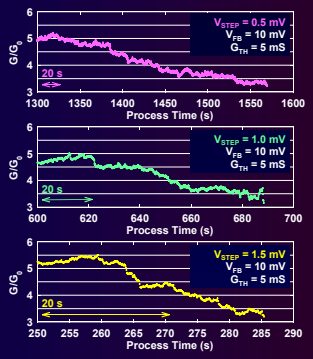


Decrease of Process Time

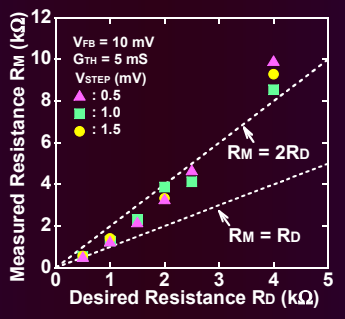
Resistance Control Using SFCE with Optimized Feedback Parameters

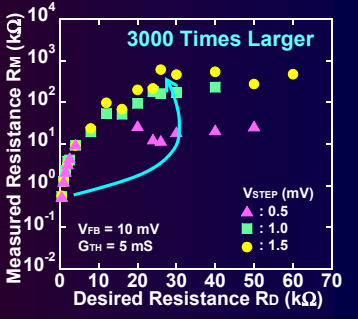
Conductance Trace | Controllability of SFCE | Control Range of SFCE

Decrease of Process Time



Stable Formation of QPC (Quantum Point Contact)





R_D < 20 kΩ: No Influence of V_{STEP} on the Channel Resistance
R_D ≥ 20 kΩ: Formation of Tunnel Junction

High-Speed, Stable, and Wide-Range Control of Channel Resistance Using SFCE

➢ Conclusions

- Control of Channel Resistance of Metal Nanowires Using SFCE Process
  - ➔ Successful Resistance Control by Suppression of Excess Heating During Electromigration
- Optimization of Feedback Parameters of SFCE Scheme
  - ➔ Considerable Decrease of the Process Time of the SFCE Procedure
- Resistance Control Using SFCE with Optimized Feedback Parameters
  - ➔ No Degradation of the Controllability of the SFCE by Increase of V_{STEP}
  - ➔ Decrease of Process Time of SFCE Procedure in QPC Regime
  - ➔ Resistance Control from 200 Ω (Metallic Regime) to 600 kΩ (Tunneling Regime) for 20 Min