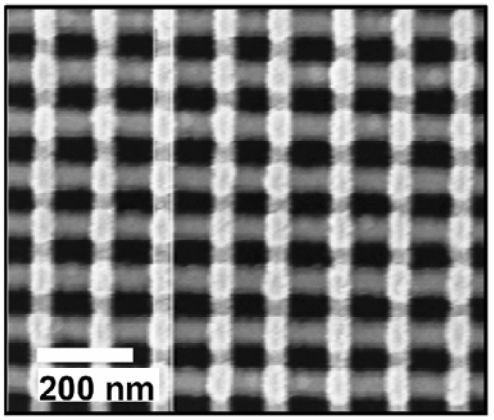
Memory Cell Selection Device Enabling High Density Memory



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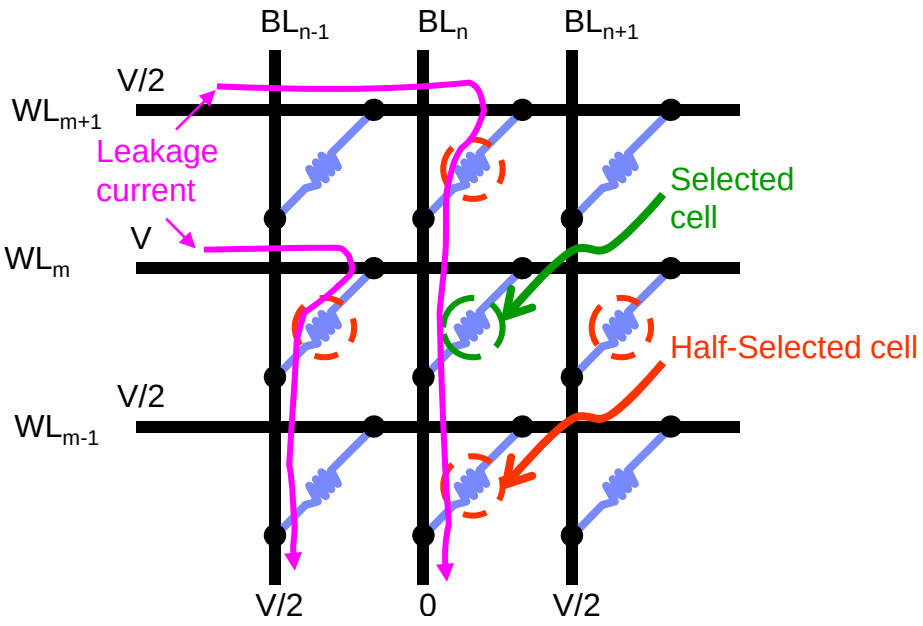
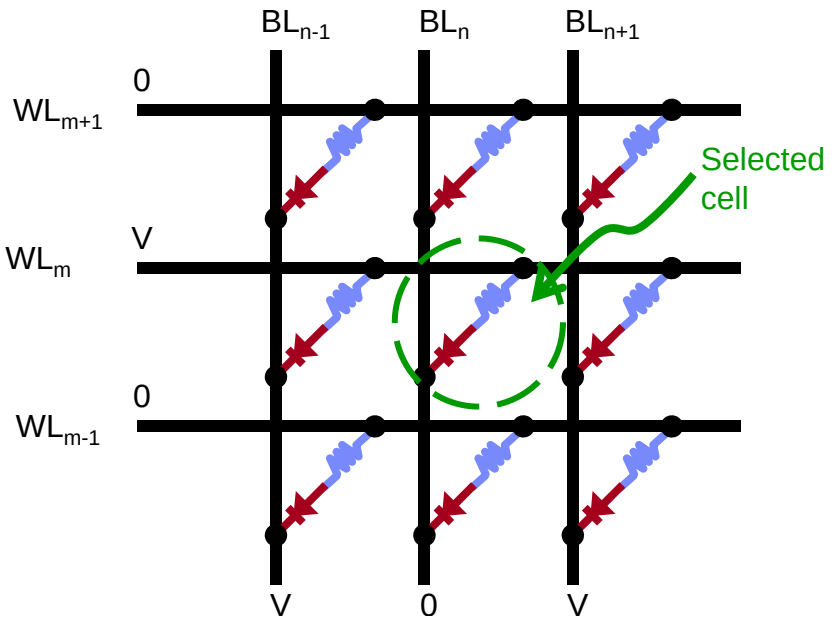
Cross-Point Memory Cell Selection Device

Required for:

- **Read signal to noise margin**
- **Write-ability**
- **Power dissipation**

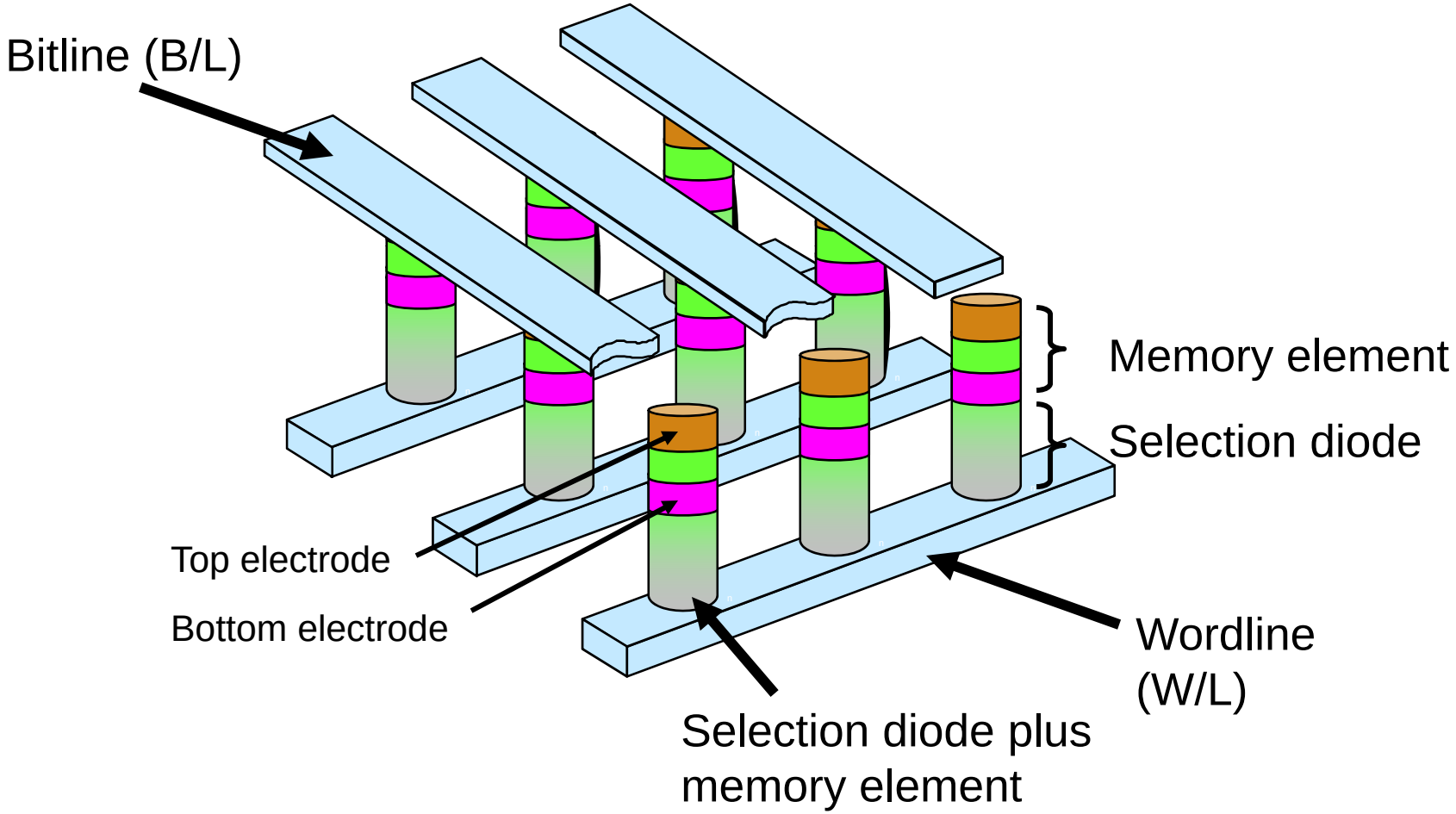


Without Diode



With Diode

Cross-Point Memory Array with Selection Diode

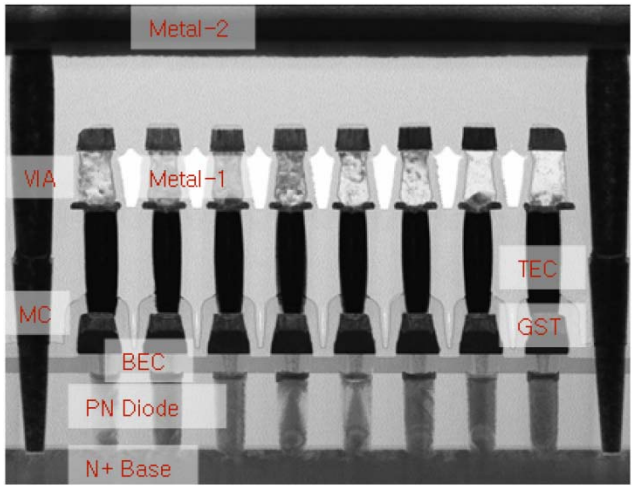


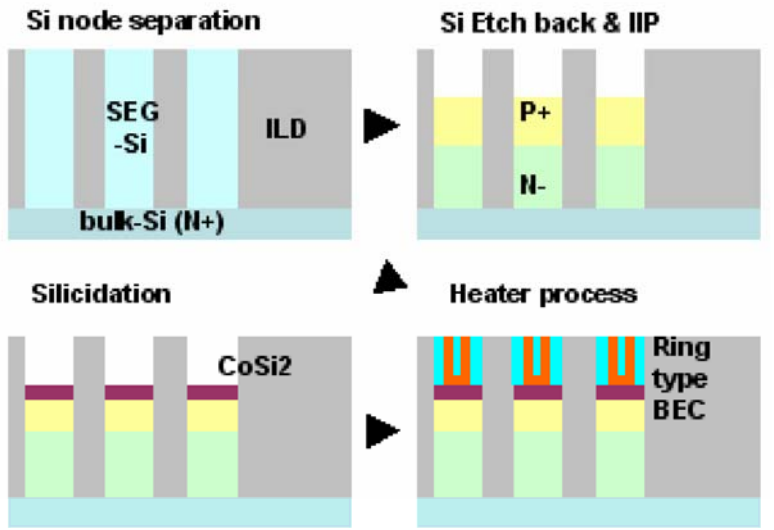
Memory Cell Selection Diode Specifications

- **Small size (scalable as $4F^2$)**
- **Large current density**
- **Large I_{on}/I_{off} ratio, > 10^4**
- **Low temperature process**
  - Integration with Si CMOS
  - 3D structure for embedded system

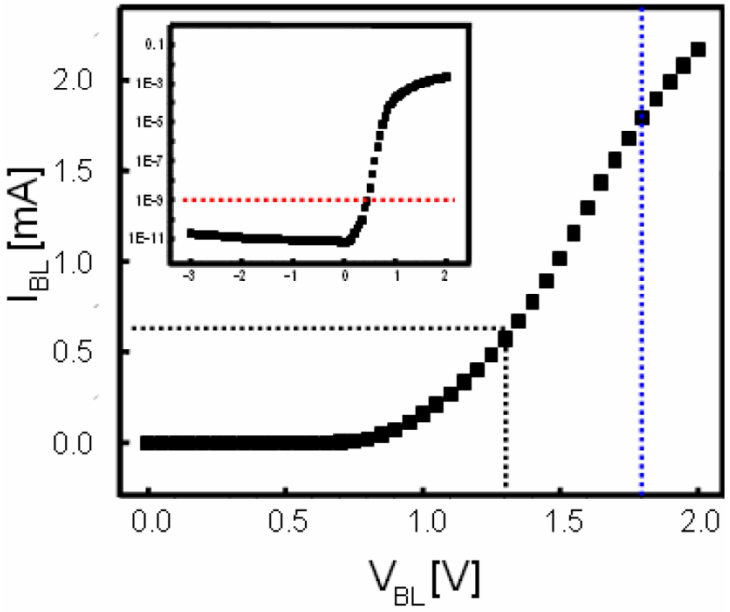
Diode Example: Epi Si

- **512 Mb PRAM with 0.047μm²(5.8F²) cell, 90nm diode technology**
- **Current density 26 MA/cm² at 2V**
- **Single crystalline Si vertical diode by selective-epitaxial-growth**



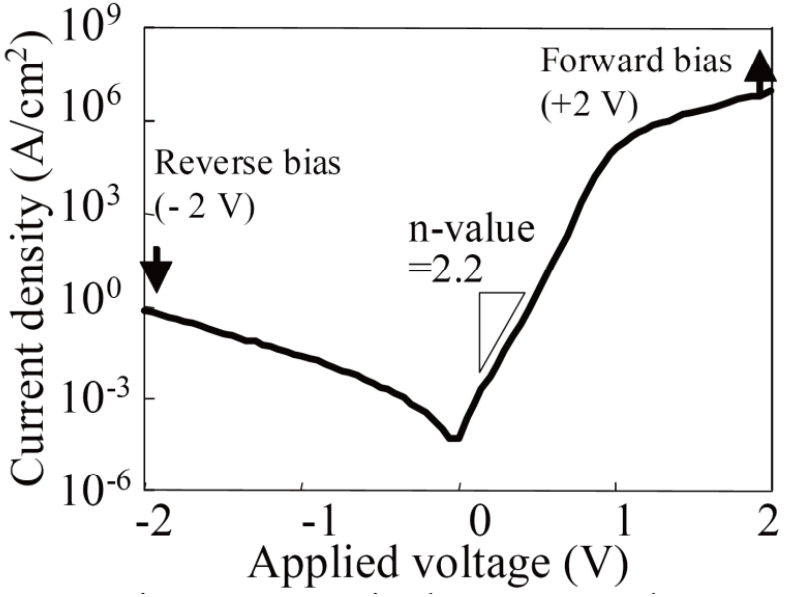


J.H. Oh et al., IEDM, p. 49, 2006. (Samsung)

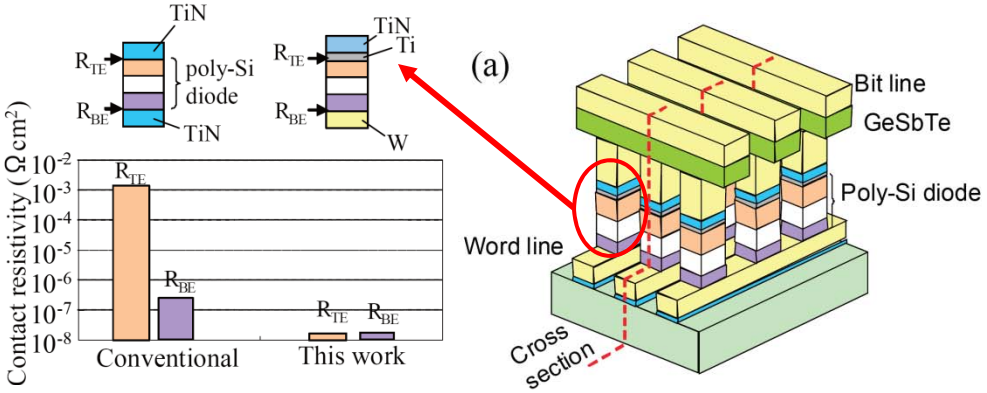


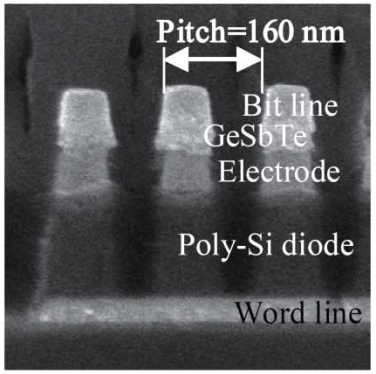
Diode Example: Poly-Si

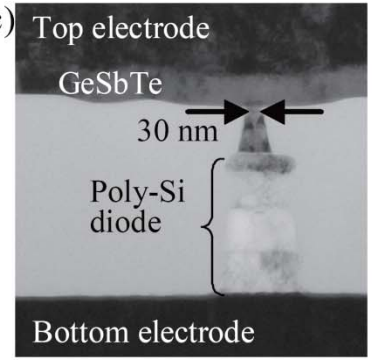
- **High on current: 8MA/cm²**
- **Low off current: 100A/cm²**
- **Low contact resistivity and low temperature budget poly-Si p-i-n structure**



Insert Ti between TiN and Si to reduce $R_{contact}$



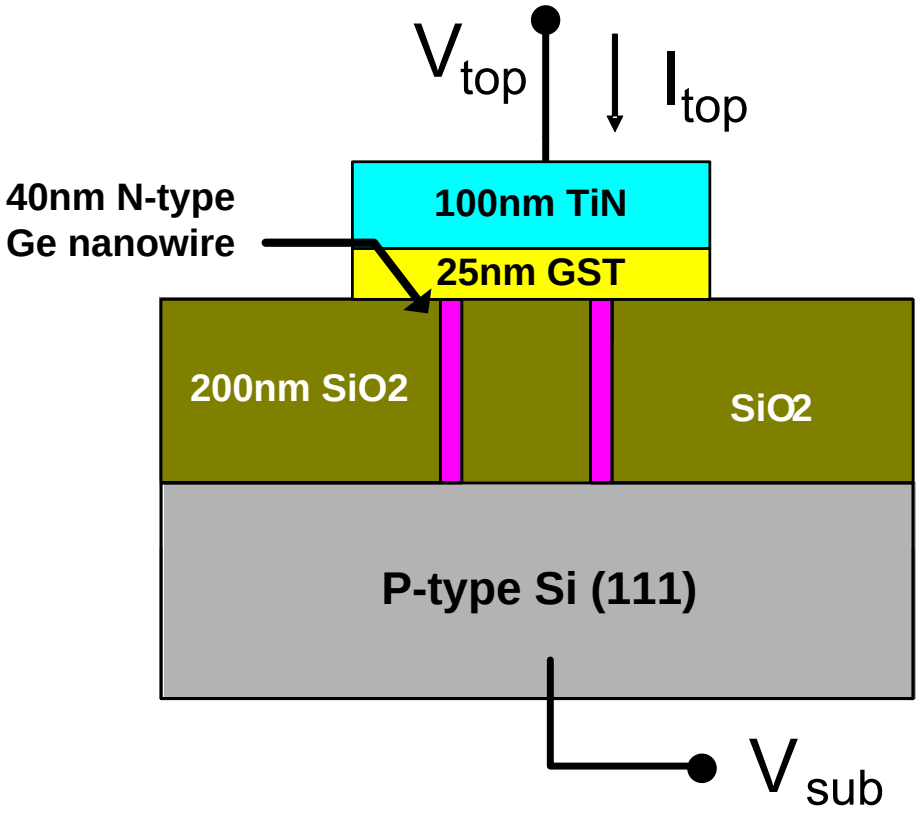


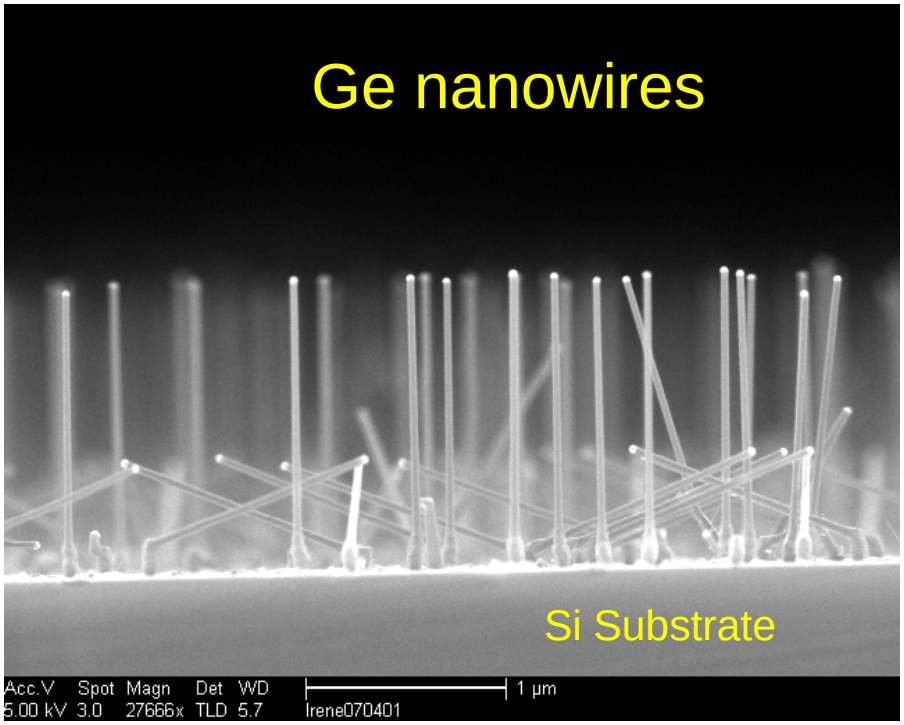


Y.Sasago et al., Symp. VLSI Technology, p. 24, 2009. (Hitachi)

Diode Example: Ge Nanowire

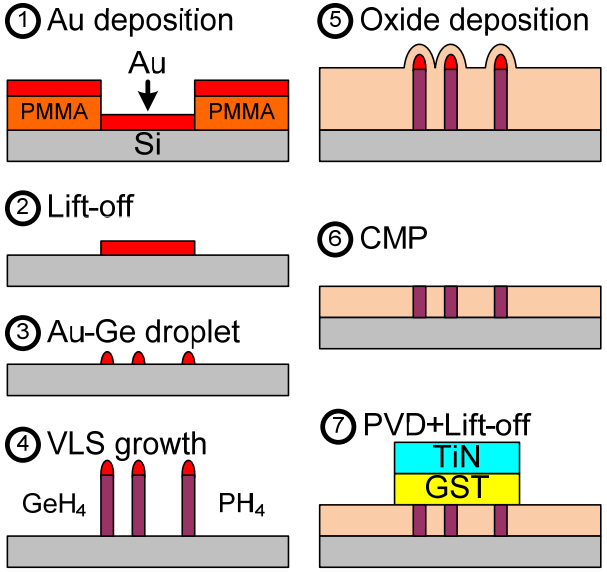
- **Small diameter electrode, reduces programming current**
- **Route to pn-junction diode selection device**
- **Low-temperature (<350C) nanowire synthesis**

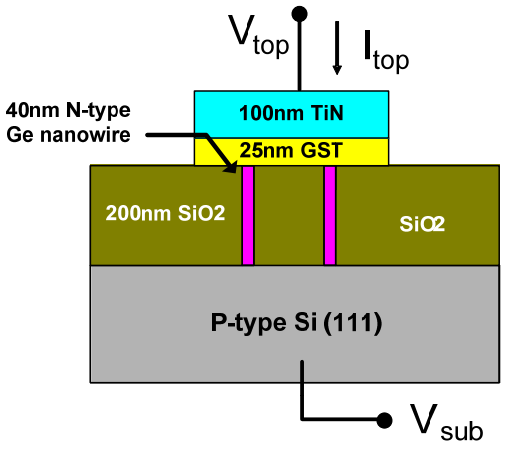


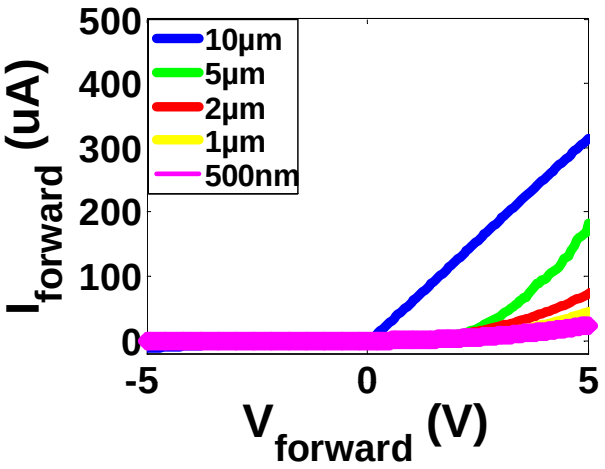


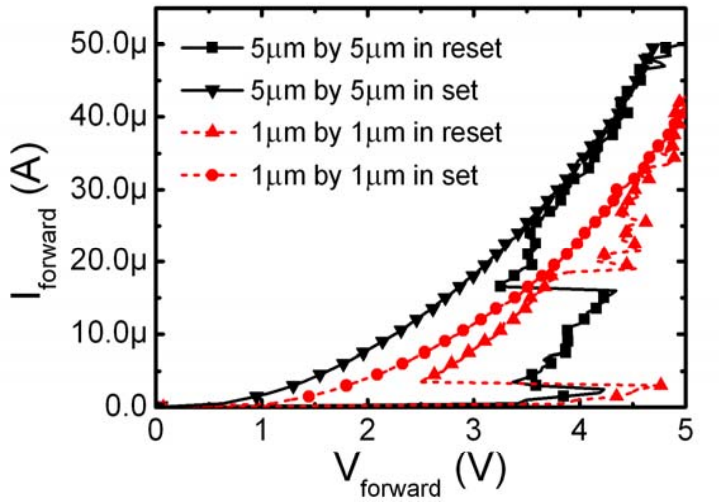
Y. Zhang, S. Kim, J.P. McVittie, H. Jagannathan, J.B. Ratchford, C.E.D. Chidsey, Y. Nishi, and H.-S. P. Wong, "An Integrated Phase Change Memory Cell With Ge Nanowire Diode For Cross-Point Memory," Symp. VLSI Technology, pp. 98 – 99, June 12 – 14, 2007, Kyoto, Japan. (Stanford)

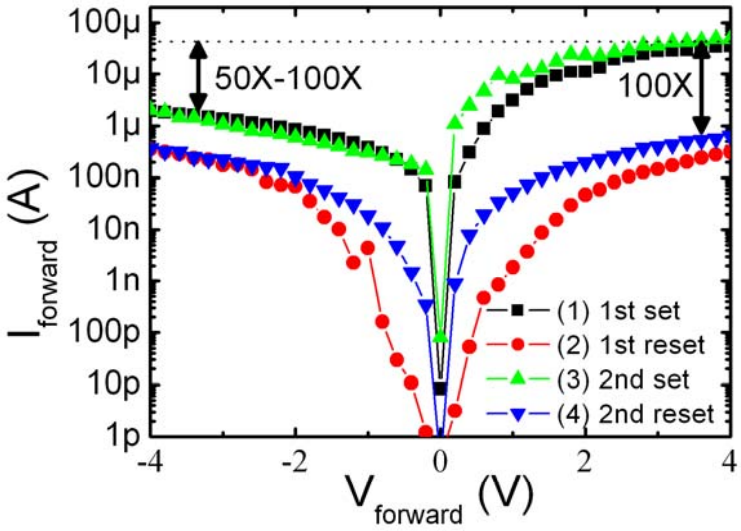
Nanowire Diode + Phase Change Memory











S. Kim, Y. Zhang, J. McVittie, H. Jagannathan, Y. Nishi, H.-S. P. Wong, "Integrating Phase Change Memory Cell with Ge Nanowire Diode for Cross-Point Memory – Experimental Demonstration and Analysis," *IEEE Trans. Electron Devices*, vol. 55, No. 9, pp. 2307 – 2313, September, 2008. (Stanford)

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