Investigation of the scalability limit and thermal stability of low current consuming, nanowire phase change memory cells for high density commercial applications

B. Gholipour, D.W. Hewak, C.C. Huang, F.Al-Saab
Optoelectronics Research Centre, University of Southampton, Southampton, SO17 1BJ, United Kingdom
Contact email: [Behrad Gholipour] bg305@orc.soton.ac.uk

A. Anastasopoulos*[+], S. Guerin, B. Hayden*[+] and G. Purdy
**School of Chemistry, University of Southampton, Southampton, SO17 1BJ, United Kingdom*
[+]Ilika Technologies Ltd, Kenneth Dibben House, Chilworth, Southampton, SO16 7NS, United Kingdom
Contact email: [Brian Hayden] brian.hayden@ilika.com

Phase change memory which has been responsible for rewriteable optical disks and widely regarded as the electronic successor to the standard FLASH memory in the form of PCRAM, has a great deal of advantages, including high speed and cycling endurance and physical scaling. However, most forms of PCRAM make use of the germanium antimony telluride alloy, which has issues with high current consumption and poor thermal stability; as a consequence the technology finds itself hitting a road block in terms of the operational scalability and integration with standard CMOS. In this investigation highly scaled nanowire PCRAM cells from a wider range of chalcogenide alloys are investigated for low current consumption high density applications.

This project involves the synthesis and characterization of a range of nanowire memory cells using gallium lanthanum sulphide (GLS), germanium antimony (GeSb) as well as the conventional germanium antimony telluride (GST) as a standard to compare the more novel phase change materials against. The GLS and GST family of glasses were deposited by sputtering whilst the Ge:Sb family of materials were deposited by chemical vapour deposition. Memory cells were created using a combination of photolithography and ion beam milling techniques.

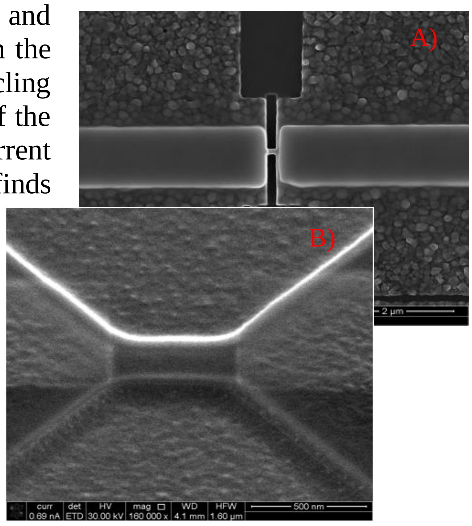

Figure 1. Scanning electron microscope images of phase change nanowire memory cells fabricated using the alloys A) GeSb and B) GLS.

For the Ga:La:S family of glasses, we show that they offer vastly higher thermal stability and lower current consumption than conventional GST. The full ternary was deposited by physical vapour deposition and all compositions on the phase diagram were screened using high throughput techniques and nanowire memory cells were fabricated across all compositions giving us the ability to investigate the change threshold voltage, set and reset currents as well as other relevant parameters for phase change memory across the full compositional range.

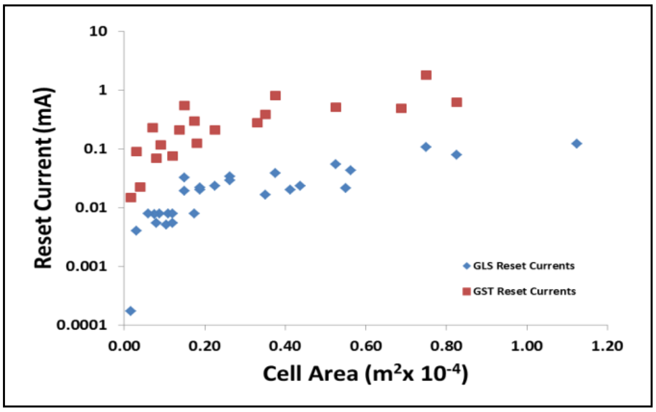

Figure 2. Reset Currents of various nanowire memory cells utilizing the alloys GST and GLS across a range of different size active areas.

Nanowire (NW) memory cells were fabricated and characterized in order to investigate the current consumption and threshold voltages in both on and off states of the cell for each alloy and composition. This includes the crucial set and reset currents and Ron/Roff ratio of each type of cell. NW memory cells from the respective alloys and compositions were also characterized at elevated temperatures and relevant parameters were extracted as a function of temperature, composition and device geometry. This allows an assessment of the thermal stability and suitability of each alloy and composition for commercial applications.

REFERENCES

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Biographies

Behrad Gholipour graduated from the School of Electronics and Computer Sciences at the University of Southampton with a BEng in Electronics and an MSc with Distinction in Nanoelectronics. He is currently a PhD research student within the Novel Glass group at the Optoelectronics Research Centre at the University of Southampton. His research involves the development of next generation optoelectronic devices using chalcogenide thin films and nanowires for data storage, optical and electro-optical switches and novel computing purposes. He is a recent recipient of a UK EPSRC ICT Pioneer Award for this research.