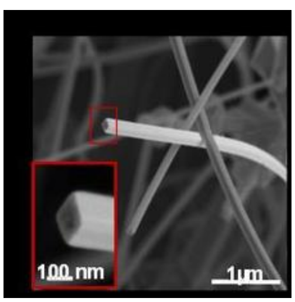
Nanowires Memorize by Changing Phase

Researchers can envision fabricating a memory device that can switch reversibly between crystalline and amorphous arrangements (phases) to store information. By applying short electrical pulses to a crystalline material, phase change to the amorphous state can occur resulting in higher electrical resistance (data writing process to produce data state=1), while another pulse can switch the amorphous state back to the crystalline state (data erase process to produce data state=0). The underlying mechanism of current-induced phase change is rapid material heating produced by current flow, and rapid cooling by the local environment. The memory is stored as higher resistance of the amorphous state, and the longevity of this amorphous state determines how long the information can be stored without loss of data. In theory, nanoscale materials are particularly suitable for such memory devices because they would require only small amounts of energy and because their data states would be stable.

Research by Ritesh Agarwal and students at the University of Pennsylvania has confirmed that nanoscale materials such as germanium antimony telluride (Ge2Sb2Te5) can be reversibly switched between amorphous and crystalline states and, in the form of nanowires, are promising for electronic memory device applications owing to their rapid read- and write-speeds, high storage density, and non-volatility. While conventional processing of materials such as Ge2Sb2Te5 into nanostructures often damages their useful properties, Agarwal's research group has demonstrated that an alternate approach, based on self-assembly of nanowires composed of Ge2Sb2Te5, yields materials with high potential for use in electronic memory applications. Their research also shows strong size-dependent phase change behavior that provides significant reduction of writing current as the memory cell thickness decreases. Their research results also demonstrate non-volatile data retention capabilities at 20-nanometer length scales with a timescale of more than 100,000 years at room temperature, suggesting that memory devices based on phase change nanoscale materials can provide both improved performance and storage density.



Nanowire phase change memory: electron microscopy image of Ge2Sb2Te5 self assembled nanowires. Credit: Ritesh Agarwal, University of Pennsylvania

NSF Award # 0706381 (www.nsf.gov/awardsearch/)

Patents and other steps toward commercialization:

Contributing Agency: NSF