Ionic memory and the future of the semiconductor industry

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It is generally accepted that the adoption of novel materials and device structures will be required to overcome the limitations of charge-storage memory elements as we pass beyond the 22 nm node of the International Technology Roadmap for Semiconductors (ITRS).[1] This is particularly true in the case of non-volatile memory (NVM), where both NOR and NAND Flash will struggle to meet the requirements of next generation memory and storage. One solution to this problem involves devices that can be switched between two or more non-volatile resistance states. One of the most promising resistance-change variants involves devices based on solid electrolytes. A thin (<50 nm) ion conducting film is placed between two electrodes to form a device which may be switched from high- to low-resistance states by the rapid formation of a nanoscale conducting pathway created by ion transport and redox reactions.[2] The resistance is returned to a high level via the application of a reverse bias which results in the dissolution of the conducting filament. Ionic memory technology would appear to have all the necessary attributes for applications in high density non-volatile arrays and data storage. The memory cells are both physically and electrically scalable and may be operated at low voltage and current, thereby minimizing power dissipation in high density integrated systems. Both transistor-based multi-level cell (MLC) active and diode-isolated passive cells have been successfully demonstrated and small NOR-functionality devices have already been commercialized. However, we believe that NVM might just be the initial application of ionic technology and that others will soon follow.

This talk will cover the state-of-the-art in nanoionic memory and will also highlight emergent applications of the technology. Since ionic devices exhibit large changes in electrical resistance in a compact structure, applications in a variety of switching functions are possible. We will show how cation-based devices, using Ag and Cu as the ionic component, can be used in reconfigurable systems and interconnect.

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[1] http://www.itrs.net/

[2] I. Valov, R. Waser, J.R. Jameson and M.N. Kozicki, "Electrochemical metallization memories—fundamentals, applications, prospects," Nanotechnology, vol. 22, doi:10.1088/0957-4484/22/25/254003 (2011).