Nanoionics: Applications in Information Technology

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The electronics industry has relied for many years on critical dimension scaling to provide increases in the functionality of integrated circuits and systems while reducing the cost per function. Scaling has taken us from the microelectronics to the nanoelectronics regime, as critical device dimensions within commercially available chips are now measured in tens of nm. However, it has become abundantly clear that performance can no longer be driven solely by feature size reduction as nanoscale versions of traditional electronic devices do not necessarily possess the characteristics that made their forebears so desirable. It is therefore universally agreed that the adoption of new material paradigms will be necessary to allow us to break through to the "terabit regime". One such paradigm goes by the name *nanoionics*. Whereas nanoelectronics involves the movement of electrons within their nanostructured settings, nanoionics concerns materials and devices that rely on ion transport and chemical change at the nanoscale. Rising interest in nanioionics has been fuelled by the wide range of demonstrated and potential applications so that the field has been equated in significance by some with nanoelectronics.

This presentation will cover the basic electrochemistry, materials science, and key applications in information technology of devices based on solid electrolytes and nanoionic principles. Electrodeposition of even nanoscale quantities of a noble metal such as silver can produce localized *persistent* but *reversible* changes to macroscopic physical or chemical characteristics; such changes can be used to control behavior in applications that go well beyond purely electronic systems. For example, movement of mass can be used to control the mechanical properties of a vibrating element in microelectromechanical system (MEMS) device. Of course, electrical resistance will change radically when a low resistivity electrodeposit (e.g., in the tens of $\mu\Omega$.cm or lower) is deposited on or in a solid electrolyte surface which has a resistivity some eight orders of magnitude higher. This leads to a variety of applications in memory and logic.

The presentation will focus on some of the advances in non-volatile "resistance-change" devices and will show that solid electrolyte memory is a realistic candidate for future high-density solid state memory and mass storage applications. In this regard, multi-Mb test arrays have already been produced in CMOS integrated circuits and scaling below 20 nm has been demonstrated. It will also include switching applications of the technology such as reconfigurable logic and RF routing for phase shifters. The results from work concerning alternative applications in microelectromechanical systems, specifically MEMS resonators and microphones, will also be presented.

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