

Functional Inorganic Nanostructures, New Opportunities for Future Electronics

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Silicon based semiconductor electronics have experienced enormous growth in the past several decades and are rapidly evolving into two extremes: highly integrated circuits with device size approaching single digit nanometer scale (nanoelectronics) and large area electronics with system size measured in square meters (macroelectronics). However, significant challenges are expected in both extremes. Functional inorganic nanostructures, with precisely controlled chemical composition, physical dimension and electronic properties, can offer unique opportunities to address these critical challenges. In this talk, I will discuss several examples to illustrate the potential of exploring functional inorganic nanostructures to address the emerging challenges in semiconductor electronics.

In the first example, I will describe a new concept of high performance thin film transistors (TFTs) exploiting assembled nanowire arrays for applications in large area electronics such as flat panel displays. These TFTs have conducting channels formed by multiple parallel single-crystal nanowire paths, in which charges travel from source to drain with ensured high carrier mobility. Moreover, this TFT fabrication approach dissociates the high temperature processes required to produce high quality semiconductor materials from device substrates, and thus enables a general platform for preparation of high performance semiconductor devices on various substrates including plastics.

In a second example, I will briefly discuss using self-assembled nanodots as distributed charge storage elements in floating gate memory devices for high density information storage. The use of nanodot floating gate with controlled dot size, density and inter-dot distance can lead to improved charge retention, increased memory window and lower operating voltage, and enables continued downscaling in flash memory.

Lastly, the continued improvement in device speed through the evolutionary miniaturization of silicon based electronics will soon reach the technological limit. Additional advancement in electronics calls for fundamentally new materials or new device operation mechanism. Graphene has emerged as an interesting alternative due to its exceptional electronic characteristics. However, two-dimensional graphene is a semimetal with a zero bandgap, and therefore can not be used for field-effect transistors (FETs) at room temperature. The formation of sub-10 nanometer graphene nanostructures with lateral quantum confinement can open up a sufficient band gap for room temperature transistor operation. In the third example, I will discuss our recently effort in exploring chemical nanotemplates to prepare a wide range of graphene nanostructures that can enable a new generation of electronics, and impact broadly from highly integrated circuits to high performance flexible electronics.