NANO HIGHLIGHT
Collective Computation with Self Assembled Quantum Dots, Nanodiodes and Nanowires: A Novel Paradigm for Nanoelectronics

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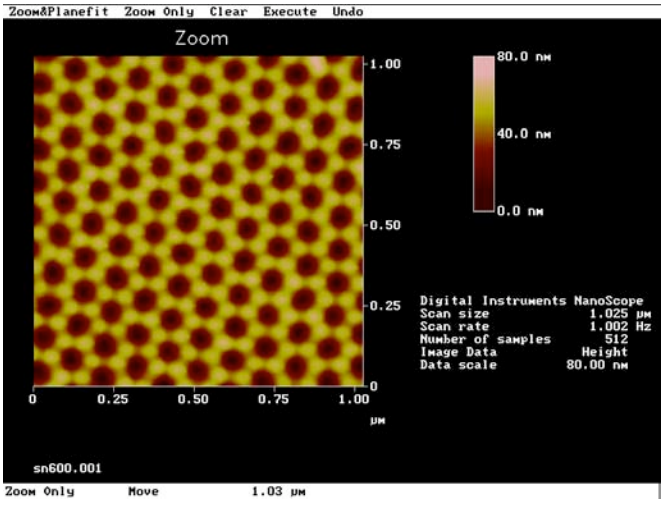
The workhorse of modern electronic circuits is the celebrated "transistor" that performs all the switching and other functions necessary for computation and signal processing. However, relentless downscaling is making it increasingly difficult to shrink transistor size while retaining all its wonderful functionalities. Consequently, we have embarked on a search for alternate circuit models that forego the transistor. We are specifically focusing on eliciting collective computation from interacting self assembled 2-terminal devices such as quantum dots and nanowires, which are considerably easier to fabricate than transistors and can be produced using inexpensive self assembly techniques. Roughly 8 years ago, it was shown theoretically that a 2-dimensional array of nanowires, each exhibiting a negative differential resistance, can behave as an associative memory, mimic logic gates and perform signal processing functions with amazing speed and density. Our efforts have been geared towards the realization of this model.

Since the inception of this grant, we have synthesized a 2-dimensional array of nanowires by electrodepositing a semiconductor within the pores of a self assembled nanoporous film of alumina (Fig. 1(a)). The nanowire conduction characteristics exhibit a strong S-type negative differential resistance with a peak to valley ratio of 19:1 at room temperature, which is more than adequate for many image processing functions such as edge detection. The negative differential resistance is "optically sensitive"; the peak current can be modulated by a factor of ~ 5 using infrared light. This opens up the intriguing possibility of programming these networks with light. The combination of two functions – negative differential resistance and infrared photodetection – may also make it possible to embed both sensing and processing functions in the same chip, which has been a dream of circuit designers.



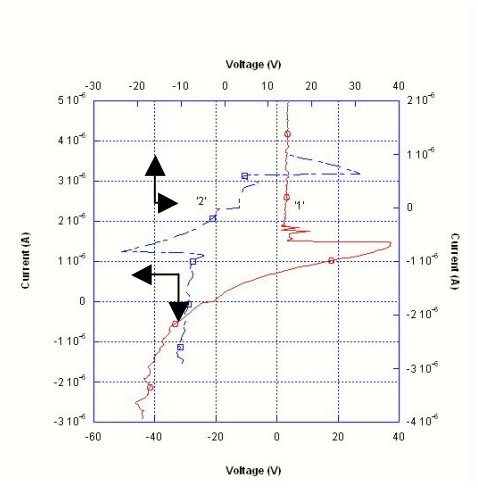


Fig. 1: (a) Atomic force micrograph of self assembled porous alumina film containing a regimented array of 50-nm diameter pores. (b) Room temperature current-voltage characteristic of nanowires produced by electrodepositing semiconductors within the pores.