Electrochemical self assembly of structures for single electronics

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Cylindrical CdS quantum dots of diameter 8 nm and height 3-9 nm, as well as cylindrical ZnSe quantum wires of diameter 50 nm and height 0.5 - 1 μm were self assembled by electrodepositing the constituent compounds into the pores of an anodic alumina film. The varying heights of the nanostructures enable us to actually contact just a few of the nanostructures (10-100) by large area contacts delineated by standard photolithography (the contact pads cover about 10-100 million dots, but only about one in a million is electrically contacted on the average). The net capacitance between the contacts is therefore small enough to manifest distinct Coulomb blockade effects in the current voltage characteristic at room temperature. We have observed Coulom blockade in the CdS dots in the past, and recently we observed Coulomb staircase in the ZSnSe wires at room temperature. High resolution TEM has shown that the ZnSe wires are composed of 5-nm sized crystalline grains, separated by about 5 nm of amorphous regions. Since the resistivity of amorphous ZnSe is much larger than that of crystalline ZnSe, the amorphous regions act as weak links between the crystalline grains. Transport takes place by tunneling between successive grains via the amorphous weak links. The structure thus behaves as a linear array of tunnel junctions which are known to exhibit Coulomb staircase when the junctions are inhomogeneous (meaning the tunnel resistances are different from one junction to the next). We found these junctions also exhibit the Coulomb blockade, but more interestingly, they exhibit the Coulomb staircase *if they are exposed to infra-red radiation* (the staircase does not appear in the dark). This peculiar phenomenon may be due to modification of tunnel rates via the introduction of photon assisted tunneling, or re-arrangement of background charges owing to real space transfer in these structures[1]

The utility of this work is in demonstrating that inexpensive electrochemical self assembly can produce structures for room temperature single electronics, which makes single electronic devices much more accessible.

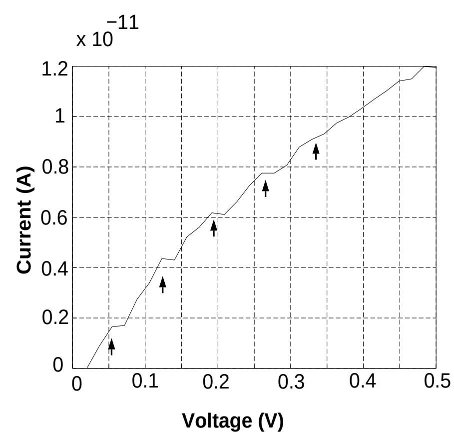

Figure 1: The current voltage characteristic of ZnSe quantum wires, consisting of a linear array of tunnel junctions, showing Coulomb staircase at room temperature.

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[1]N. Kouklin, et.l al., *Appl. Phys. Lett.*, **79**, 4423 (2001).