THZ SPECTRAL SENSING WITH NANOTECHNOLOGY: AN OVERVIEW

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ABSTRACT

Over the past 20 years, extensive research has been performed by the device physics community on the ultimate limits of scaling as electronic devices sizes approach the nanoscale. Based on this vast experimental and theoretical work, there is now a solid fundamental understanding of electronic properties of nanoscale devices, be they nanowires, nanotubes, quantum dots, or even molecular scale components. In addition, while not always economical, a myriad of fabrication techniques have been demonstrated, from top-down advanced lithography, to bottom-up self assembly.

All told there are two over-arching themes of such research: First, individual electrons can be manipulated and measured, one at a time. Second, the confinement of *electrons to small geometries gives rise to quantum states (energy levels) which behave as artificial atoms,* also called quantum dots.

The spacing between energy levels in "real" atoms is typically of order 1 eV, so that spectral properties in the IR/visible/UV region are dominated by energy level quantization. This gives rise to the colors we experience in our everyday lives. In contrast, in artificial atoms, the typical energy level spacings are in the 1-10 meV range. Therefore, the natural spectroscopic frequency range of interest for nanotechnology based electronic devices is in the THz frequency range. This gives rise then to a large class of spectral sensors based on nanotechnology, which can directly transduce THz signals *spectrally* into electronic currents and voltages.

In this work, we present an overview of the fabrication technologies and demonstrated THz spectral sensing techniques of the various materials approaches to quantum dot fabrication and electronic readout. Specifically, quantum dots with controllable # of electrons (0,1,2,3,…) have been demonstrated in three technologies: lateral dots, vertical dots, nanotube dots. For each technology, there are invasive and non-invasive techniques to readout the # of electrons on each dot. The invasive technologies act in a sense as THz photomultipliers: Absorption of a THz photon causes an electron to be ejected from a quantum dot, and this leads to a cascade of current. Non-invasive technologies use capacitively coupled single electron transistors to sense the number of electrons on a quantum dot.

The focus of this talk will be to review the various fabrication and readout approaches, which have been developed by the device physics community to understand potential applications in quantum computing and single electron classical computing. We argue that, because of the THz spectral properties of such electronic devices, that this vast nanotechnology developed for computing applications can be leveraged for potentially single photon[1], electronically tunable, nano-scale spatial resolution[2] THz spectroscopy.

REFERENCES

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