## Quantum Dots

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## Introduction

Quantum dots are small devices that contain a tiny droplet of free electrons.

Typical dimensions are between nanometers to a few microns.

A quantum dot can have anything from a single electron to a collection of several thousands.

The size ,shape and number of electrons can be precisely controlled Just as in an atom, the energy levels are quantized due to the confinement of electrons.

■ The 3D spatial confinement is observed in the quantum dots.

In some quantum dots even if one electron leaves the structure there is a significant change in the properties.

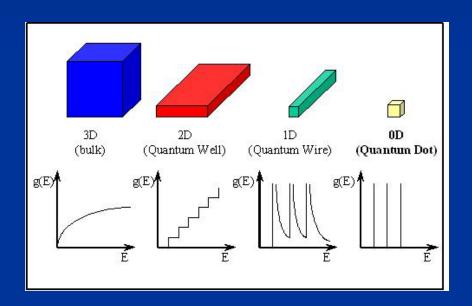
Unlike atoms however, quantum dots can be easily connected to electrodes and are therefore excellent tools to study atomic-like properties.....

The potential of nearby metal gate is changed.....

■ The atomic structure might behave as a lead one minute and gold next minute...

■ The fanciful idea of designer materials might be realized.....

### History



In the 1970s the first low dimensional structures
QW (Quantum Wells) were developed.

■ 1D (quantum wires) and 0D (quantum dots) were subsequently developed.

 In the quantum wells density of states is continuous,

 However in the Quantum Dots the density of states is discrete,

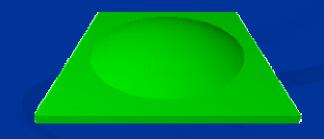
lithography, colloidal chemistry, and epitaxial growth....

#### **Formation**

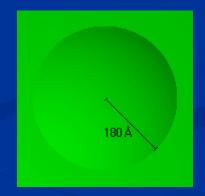
Quantum dots form when very thin semiconductor films buckle due to the stress of having lattice structures slightly different in size from those of the material upon which the films are grown



Just a few percent difference in lattice size creates stresses (or pressures) in a film that are ten times larger than those present in the deepest oceans of Earth.



These huge pressures, as new layers are deposited, force the initially flat film to separate into dots and then pop up into the third dimension to relieve stress, rather than continue to grow against resistance in two dimensions.



In terms of actual formation, the process characteristically went like this: ten atomic layers of film would form smoothly. As more layers were deposited, the film broke up into tiny pyramid-shaped islands. With more layers, the pyramids self-organized and coarsened, and then became dome-shaped islands.

 confining potential along the growth direction while the lateral confinement is provided by an electrostatically induced potential barrier

## Applications

optical and optoelectronic devices, quantum computing, and information storage.

 Semiconductors with QDs as Material for Cascade Lasers  Semiconductors with QDs as Material for IR Photodetectors

Injection Lasers with QDs

In a different approach to creating white light several researchers at the Department of Energy's (DOE) Sandia National Laboratories have developed the first solidstate white light-emitting device using quantum dots



 Color Coded Quantum Dots For Fast DNA Testing

 3-D Imaging Inside Living Organism, Using Quantum Dots

# Questions / Comments