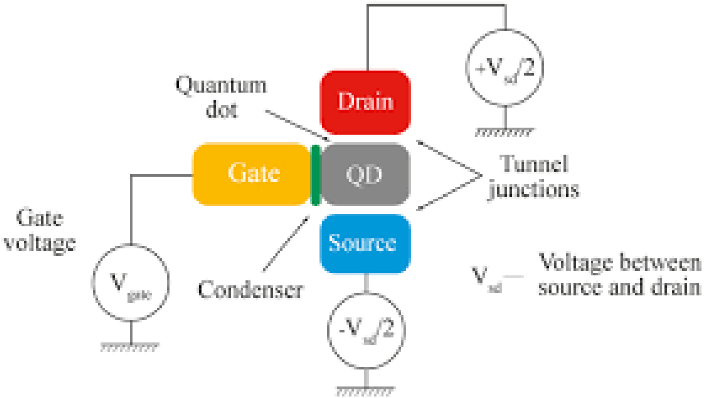
February 11, 2020

Single Electron Transistor (SET)



Single Electron Transistor (SET)

- The SET is made by placing two tunnel junctions in series.
- The two tunnel junctions create what is called "Coulomb Island" that electrons can enter only by tunneling through one of the insulators.
- This device has 3 terminals like a FET (one type of transistors).
- The third terminal is much thicker than these two tunnel junctions and therefore it does not add to the tunnel current.
- The probability of tunneling depends upon the thickness of the potential wall. Hence no current through this terminal.
- This is the gate terminal. It helps in manipulating or setting the electric charge in the coulomb island.

Concept of Quantum Tunneling

Let's understand what "Quantum Tunneling" is.

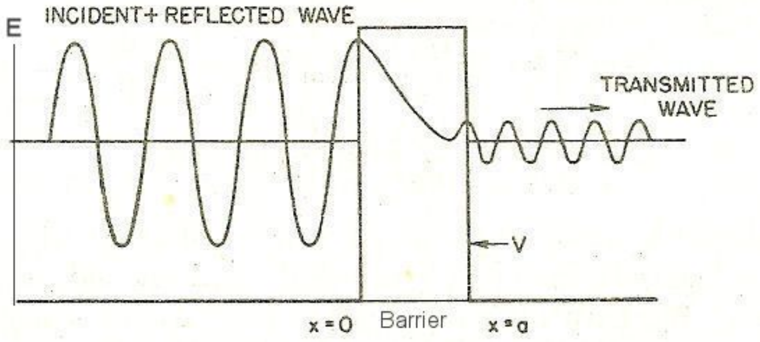


Figure: The particles having energy lesser than the potential barrier may appear in the Classically Forbidden Region.

Concept of Quantum Tunneling

- We know the parallel plate capacitance is given by $\epsilon A/d$.
- Similarly a spherical capacitor has capacitance $= 4\pi\epsilon a$, where a is the radius of the spherical capacitor.

The energy required to add one more electron in the configuration is given by E_C where,

$$E_C = \frac{e^2}{2C_{DOT}}. \tag{1}$$

Here $C_{DOT} = G\epsilon d$.

$$E_C \geq \Delta E \equiv \frac{h}{\Delta t} = \frac{h}{R_t C_{DOT}} \tag{2}$$

Here we have used the concept of rise time of a capacitor which is given by RC.

Concept of Quantum Tunneling

By combining the two, we get

$$\frac{e^2}{2C_{DOT}} >> \frac{h}{R_t C_{DOT}}. \tag{3}$$

This implies that

$$R_t >> \frac{h}{e^2}. \tag{4}$$