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Photodiodes from Hetero Junctions of Intrinsic Nano-GaAs and Si Semiconductor Materials

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Abstract:
Hetero junction photodiodes as a light-activated switch or a photo detector in the visible range are proposed in this short communication. The hetero junction can be formed with intrinsic GaAs as nanoparticles and intrinsic Si (100) surface. The nanoparticles of intrinsic GaAs can provide bandgaps in the range of 1.65 to 3.26 eV visible range of electromagnetic spectrum. Other semiconductors can also be thought of in place of nano-GaAs for different wavelengths of radiations including infrared and ultraviolet.

Keywords: Hetero junctions, intrinsic semiconductors, nano-GaAs, Silicon.

A SHORT COMMUNICATION

It has been shown that the universal mass-energy equivalence relation dE/E = dm/m applicable to semiconductors can lead to the determination of their intrinsic Fermi energy levels E_i below the semiconductor conduction bands. Here, dE is the differential potential energy of electrons from the intrinsic Fermi energy level E_i to the semiconductor conduction band, E is the semiconductor bandgap as the total potential energy of electrons, dm is the differential mass as the longitudinal electron effective mass in the semiconductor, and m is the free electron mass [1-2]. The relative longitudinal electron effective mass in GaAs (100) having a bandgap in the X<100> direction as 1.90 eV is 0.41m. dm/m is thus 0.41m and the bandgap E is 1.90 eV. Substituting these in the universal mass-energy relation will give dE in GaAs as 0.41 x 1.90 = 0.78 eV as the position of E_i below the conduction band of GaAs (100). The E_i in nano-GaAs is not expected to change much from that of GaAs (100) because the bandgap will increase but the longitudinal electron mass may decrease, giving nearly the same E_i energy position. For intrinsic Silicon, the relative longitudinal electron effective mass in the Si [100] direction is 0.49 for one conduction valley and the bandgap of Si at 300K is 1.12 eV. These when substituted in the universal mass-energy relation gives dE = 0.49 x 1.12 = 0.55 eV below the Si conduction band. The hetero junction formed out of nano-GaAs and Silicon will align the intrinsic Fermi energy levels due to charge neutrality giving depletion of electrons in Silicon having a built-in voltage of 0.78-0.55 = 0.23V, with Silicon being positive. Since the semiconductor materials are intrinsic, their intrinsic carrier densities are very small with about 10^{-4} /cm^3 to 10^{-8} /cm^3 in nano-GaAs and 10^{10}/cm^3 in Silicon at 300K temperature. The dark current with these carrier densities will be very small. When light impinges on nano-GaAs, it will generate electron-hole pairs (EHPs) in nano-GaAs. Due to the existing electric field from Si to nano-GaAs, the electrons generated in nano-GaAs will flow towards Silicon forming a current in the junction device with the conventional current direction from Silicon to nano-GaAs. The photodiode can thus act as a light-activated switch or as a sensitive photo detector with visible light impinging on the nano-GaAs. Other semiconductor materials such as 6H-or 4H-SiC, ZnO or GaN can replace nano-GaAs for photodiodes that work at ultraviolet wavelengths of electromagnetic radiation.

REFERENCES

[1]. R.K. Chanana, *Theoretical finding of the properties of a Si (100) MOS device*, IOSR-J. Applied Physics, 14(3), 5-6 (2022).

[2]. R.K. Chanana, *N-channel 4H-SiC MOSFET device on (11$\bar{2}$0) oriented epitaxial surface*. IOSR-J. Electrical and Electronics Engineering, 17(3), 20-22 (2022).