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UNIT - 1

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Introduction

Nano the Beginning:-

The greek word of 'Nano' ie, "DWARF". it is a very small & thousand millions of the metre ie, 10^{-9} metre. Nano science is the study of structure & molecules on the scales of Nanometres. the Ranging b/w '1' & '100' nm, & this type of technology will utilizes in practical applications such as a device is called as "Nano technology".

It is one of the most promissering technology of the 21st century. It is an ability to convert the nano science theory for different applications while measuring, manuplating, assembling at the nanometer scale. AS per the 'NNI' (National Nano technology Initiative centre) in USA. for development of science & Engineering technology at 10^{-9} nm. let us distinguish b/w the Nano science & technology. ie,

① Nano science is a convergency of physical materials, science & biology, which will deals with the materials at the molecular scales.

② while coming to the Nano technology it is the ability to observe & Measure & also to assemble at the nano scale.

Nano Electronics:-

It is a art & science of Manuplating matter at the nano scale. It is the one of the major technology in nano. Technology in the field of engineering & electronics for developing the Nano machines.

The Main target of the electronics is reduce the size, risk factors & surface areas of the materials & molecules. The first concept was Introduced in 1959 by the famous professor in physics "Dr. Richard Feynman". He discovered the Emergency of Nano technology.

Microscopes:-

A Microscope is an Instrument used to form enlarged Images. the word 'microscope' is derived from two Greek words, "micros" meaning 'small', & "skopos" meaning 'to look at' we use microscopy in order to see objects in more details. all forms of microscopy are aimed at Improving our capacity to see. the advantage of a microscope is that it effectively brings the object closer to the eye. this allows us to see a magnified Image with greater details.

several forms of Microscopy are available for studying nano-materials. these can be broadly grouped under the following categories.

① optical Microscopes

② Electron Microscopes.

③ scanning probe Microscopes.

④ others.

Resolution :- A Measure of the capacity of the Instrument to distinguish two closely spaced points as separate points, given in terms of distance.

Resolving Power:- the Resolving power is a property of the Instrument & is a quantity that may be estimated.

two kinds of Microscopes Exist:

① Transmitting:- the probe beam passed through the specimen in differentially refracted & absorbed.

② Scanning:- the probe beam is scanned over the surface. the Image is created point-by-point.

Electron Microscopies:-

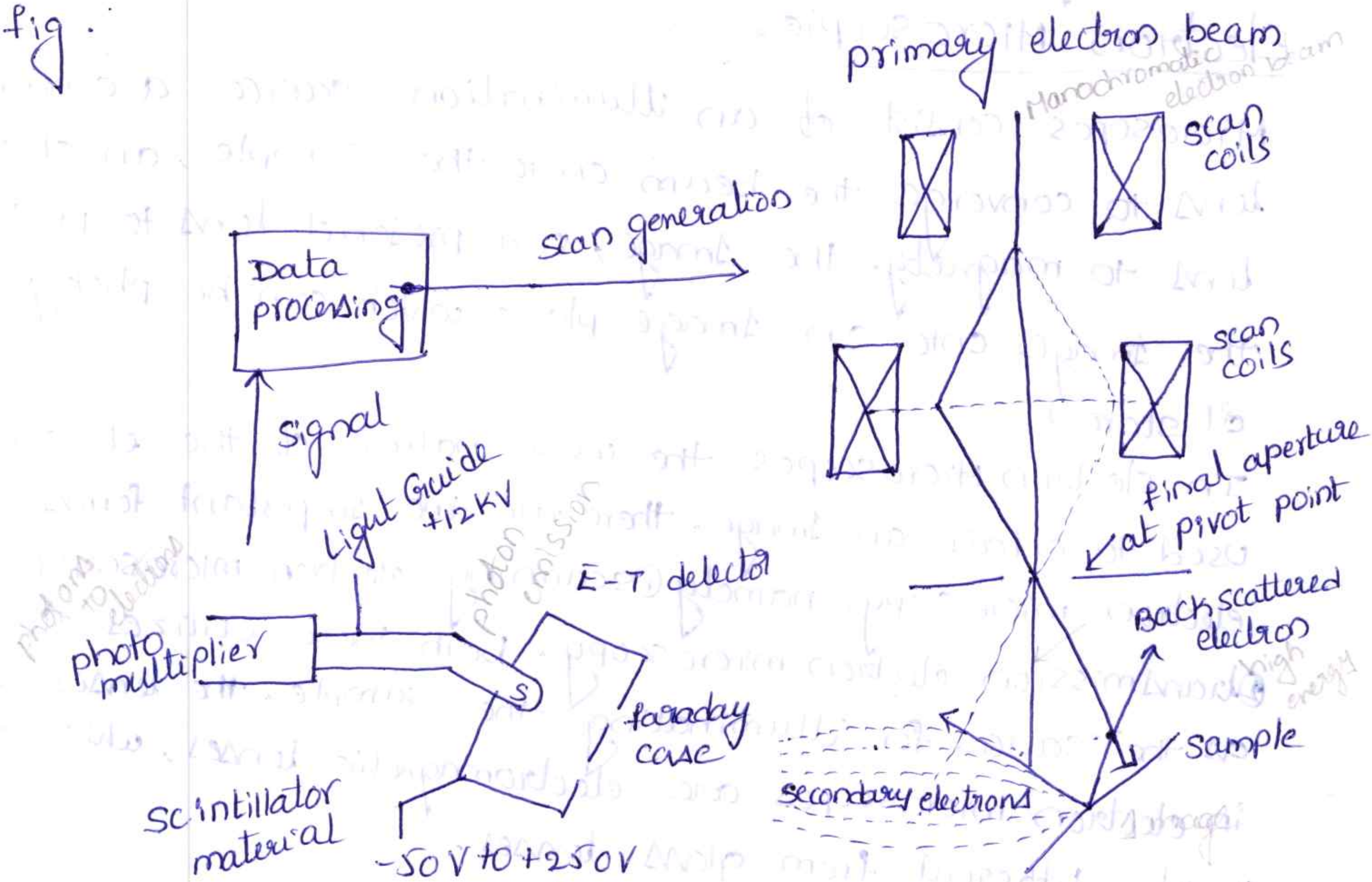
Microsopes consist of an illumination source, a condenser lens to converge the beam on to the sample, an objective lens to magnify the Image, & a projector lens to project the Image onto an Image plane which can be photographed or stored.

In Electron Microscopes, the wave nature of the electron is used to obtain an Image. there are two Important forms of electron microscopy, namely ① scanning electron microscopy & ② transmission electron microscopy. both these utilizes electrons as the source for 'illuminating the sample. the lenses used in electron microscopes are electromagnetic lenses, which are widely different from glass lenses.

① Scanning Electron Microscopy (SEM):- In this, a Monochromatic electron beam is passed over the surface of the specimen which Induces various changes in the sample. the resulting particles from the sample are used to create an Image of the specimen. the Information is derived from the surface of the sample.

→ the most Important advantage of SEM is its large depth of field. Although the Images appear to be three-dimensional, a true three dimensional Image is obtained only by using a combination of two pictures.

→ there are two kinds of electrons coming out from the sample in an SEM, the backscattered electrons, with high energies being larger or lower than the primary beam energy, & the secondary electrons which have energies of a few eV, or less than a few tens of ev. the most common kind of detector used in SEM is the Everhart - thornley (E-T) detector as shown in the fig.



Schematic of an SEM.

→ In this, a scintillator material is enposed to the electrons, energetic electrons, upon Impact with the material result in photon emission. the photons are transmitted through a light pipe. this is a glass rod or a piece of plastic.

→ At the other end of the light pipe, a photomultipler is placed, which converts the photons to electrons through photo emission. the detector has a high Bandwidth, which means it responds to a rapidly varying signal.

→ In the practical operation of the detector, a thin metal coating is applied on the surbace of the scintillator. A high positive potential is applied to the metal surbace so that all electrons, Including the low energy secondary electrons, are accelerated to it so as to generate photons.

→ the high voltage should not affect the primary beam & for this reason, a faraday cage is kept over the scintillator, which is electrically insulated. by applying a desired potential in the range of -50 to +250V to the faraday cage, a complete rejection & collection of secondary electrons becomes possible.

→ the next part of the SEM consists of the scan coils. In SEM, the scanned image is formed point by point & the scan is achieved by the scan coils. there are two pairs of coils, one each for the x & y axes.

→ the scan is made as follows. the electron beam is swept across the sample. the pattern over the sample is synchronous with that observed in the CRT. the secondary electrons produced by the sample & detector. the intensity of the signal at the CRT is proportional to the secondary electrons.

→ An intense signal can illuminate several dots on the screen, while a weak signal would mean that no dots will illuminated by the electron gun. In this way the image on the CRT is built-up point by point to match what is happening on the surface of the sample.

→ An electromagnetic lens used in electron microscope. An electron microscope contains two kinds of lenses. the condenser lens has a large bore giving a long focal length, while the objective lens has a strong field of short axial extent giving a short focal length, resulting in high magnification.

② Transmission Electron Microscopy (TEM) :—

In TEM, the transmitted electrons are used to create an image of the sample. scattering occurs when the electron beam interacts with matter. scattering can be elastic (no energy change) & inelastic (energy change). Elastic scattering can be both coherent & incoherent (with & without phase relationship).

→ Elastic scattering occurring from well-ordered arrangements of atoms as in a crystal, results in coherent scattering, giving spot patterns.

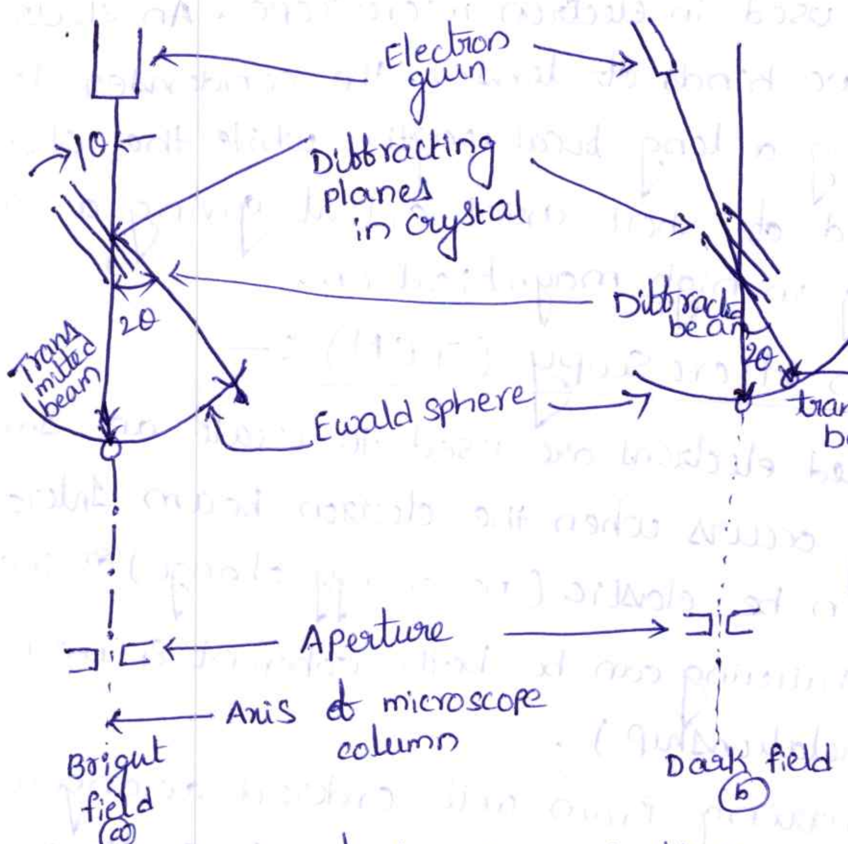
→ there are two main mechanisms of contrast in an image. the transmitted & scattered beams can be recombined at the image plane, thus preserving their amplitudes & phase. this results in the phase contrast image of the object.

→ An Amplitude contrast image can be obtained by eliminating the diffracted beams. this is achieved by placing suitable apertures below the back focal plane of the objective lens. this image is called the bright field image. one can also exclude all other beams except the particular diffracted beam of interest. the image using this is called the dark field image.

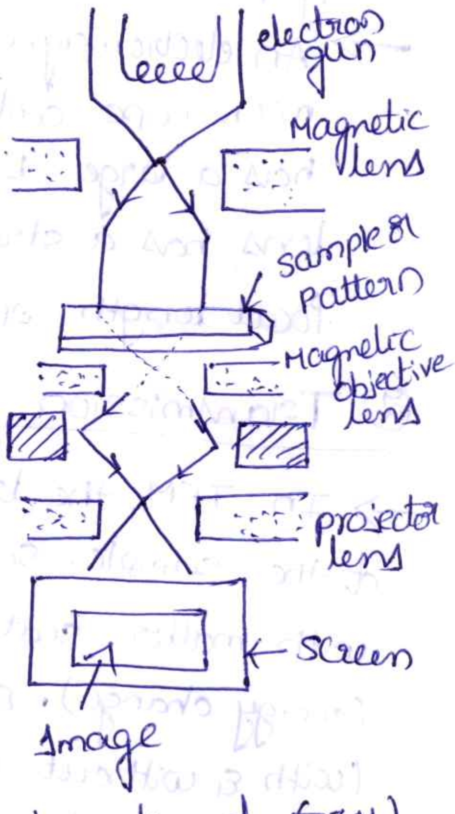
→ the function modulates the amplitudes & phases of the electron diffraction pattern formed in the back focal plane of the objective lens. the function is given as

$$T(K) = -\sin\left[\frac{\pi}{2} C_s \lambda^3 K^4 + \pi \Delta f \lambda K^2\right]$$

→ where C_s is the spherical aberration coefficient, λ - wavelength of the beam, Δf the defocus value, K is spatial frequency.



Two Kinds of Image collection
(a) Bright field (b) Dark field.



Schematic of TEM)

③ Scanning Transmission Electron Microscope (STEM) :-

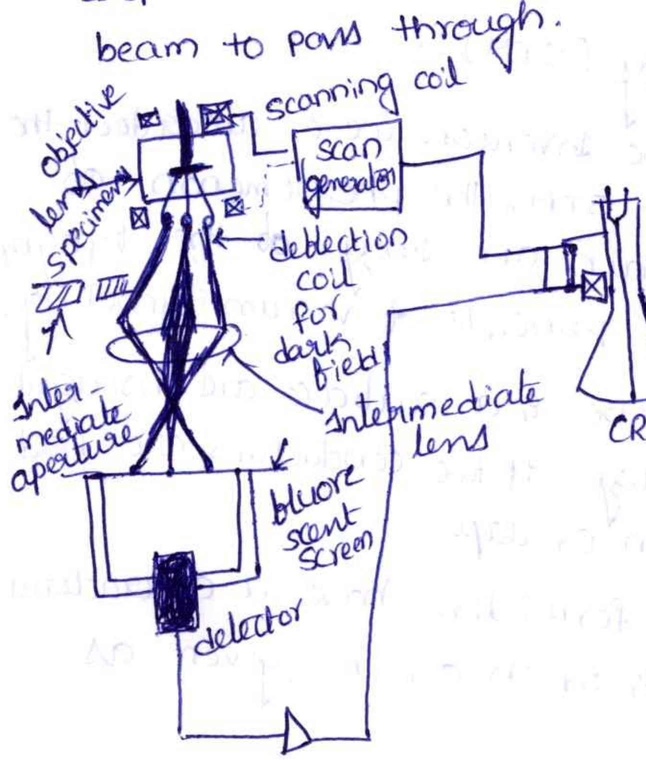
→ STEM is a hybrid Instrument with the features of both SEM & TEM. the same probe beam in TEM can be demagnified & used as a probe beam, which can be scanned over the sample. the principal components of STEM is shown in fig.

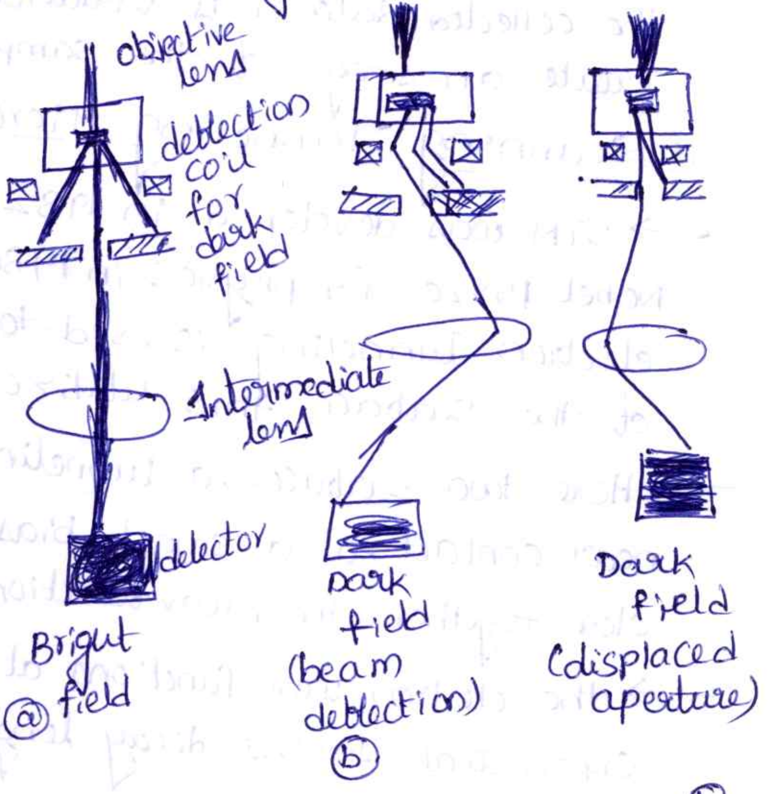
→ the beam coming off the gun is demagnified by the objective lens. A set of condenser lens is placed above the objective lens to add flexibility to the beam parameters.

→ the scanning coils are Incorporated into the objective lens itself.. the beam falling on the sample produces a diffraction pattern. the pattern is a convergent beam electron diffraction & is also called electron nano diffraction. the beam size is close to the resolution limit of the Instrument.

→ the observation screen may have an aperture & some part of the transmitted beam is used for electron energy loss spectroscopy (EELS). this analysis is usually done with the central part of the beam.

→ the Dark field Images may be formed either by the deflection of the diffracted beam into a centrally placed objective aperture, or by the displacement of the aperture which allows only a specific diffracted beam to pass through.





→ the measurement may correspond to either the EEL spectrum or an image using electrons with characteristic energy loss. the normal bright field image is made with no-loss electrons from the central beam.

→ Dark field images are made with electrons deflected from the beam axis with or without energy loss. common dark field STEM images are collected by imaging part of the diffraction pattern outside the central beam spot.

→ there are numerous areas where STEM can be of use in nanotechnology. with the current instrumental resolution of the order of 0.1nm, complete characterization of materials upto 1nm is possible.

Scanning probe Microscopies (SPM) :-

→ there are broadly two kinds of SPM techniques, namely scanning tunneling microscopy (STM) & atomic force microscopy (AFM). In a SPM technique, a probe of nanometer dimensions is used to investigate a material. the investigation is conducted on the surface of the material.

→ this is done by keeping the tip stationary and moving the sample or vice versa. the information that is collected by moving the sample can be of several kinds which differ from technique to technique. the collected data & its variation across the sample are used to create an image of the sample.

① Scanning Tunneling Microscopy (STM) :-

→ STM was developed in 1982 & the inventors were awarded the Nobel prize for physics in 1986. In STM, the phenomenon of electron tunneling is used to obtain an image of the topography of the surface. this utilizes the principle of vaccum tunneling.

→ Here two surfaces, a tunneling probe & a surface are brought near contact, at a small bias voltage. if two conductors are held close together, their wavefunctions can overlap.

→ the electron wave functions at the fermi level have a characteristic exponential inverse decay length, k which can be given as

$K = \sqrt{(2m\varphi)}/\hbar$, where m is mass of electron,
φ is the local tunneling barrier height

→ when a small bias voltage, V is applied b/w the tip & the sample the overlapped electron wave function permits quantum mechanical tunneling & a current, I to flow through.

→ the tunneling current, I decays exponentially with a distance of separation as $I \propto V e^{-\sqrt{(2m\varphi)}/\hbar 2d}$, where d is the distance b/w the tip & the sample & φ is the work function of the tip.

→ the tunneling current is a result of the overlap of electronic wave functions of the tip & the sample.

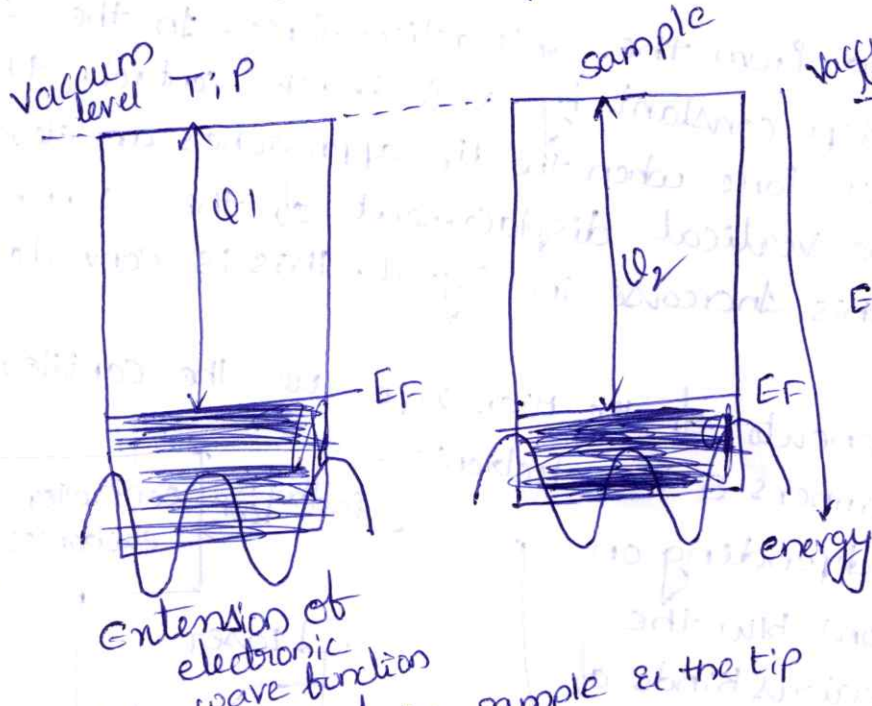


fig: Electron energy of the sample & the tip before bias

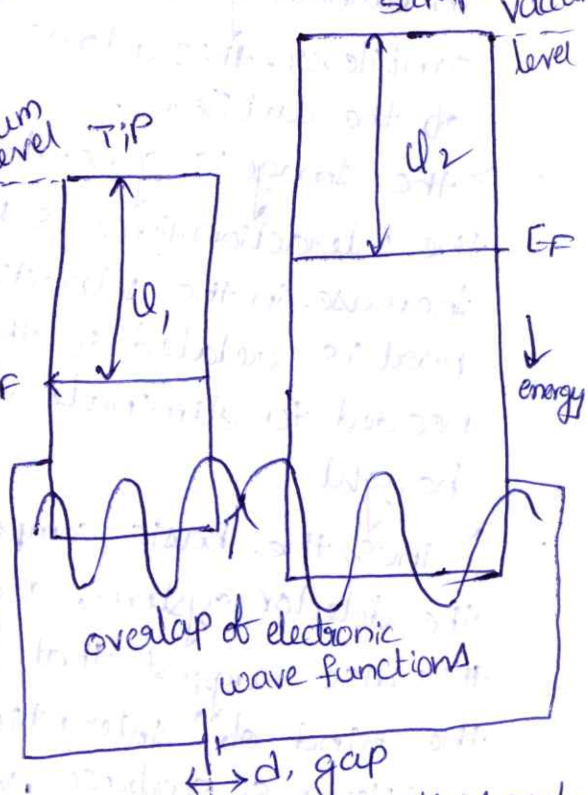


fig:- electronic wavefunctions overlap at lower seperations & a tunneling current is observed.

→ As shown in the fig, a tip is brought close to the sample so that the electrons can tunnel through the vaccum barrier. the position of the tip is adjusted by two piezoelectric scanners, with x & y control. the z-axis position is continously adjusted, taking feed-back from the tunneling current so that a constant tunneling current is maintained.

→ the other mode of imaging is by modulating the tip at some freq & measuring the resulting current modulation. STM provides information on the local density of states. the Density of states (DOS) represents the quantity of electrons exist at specific values of energy in a materials.

② Atomic Force Microscopy:-

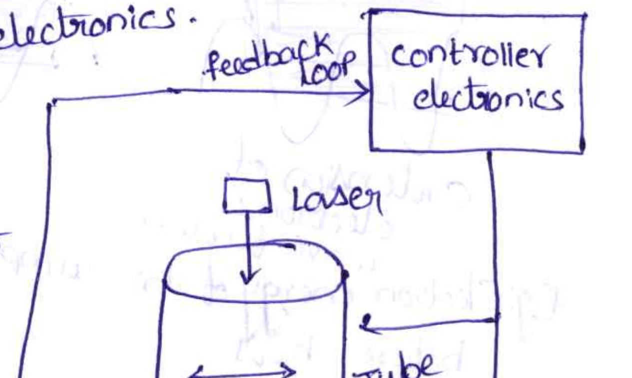
→ In this technique, the interactions b/w a sharp probe & a sample are used for imaging. the cantilever which probes the surface has an atomically sharp tip which is brought into contact with the surface.

→ the displacement of the cantilever is monitored by the reflection of a laser from the back of the cantilever, detected on a segmented photodetector. A four segment photodiode is used for this purpose.

→ In the very first AFM, the interaction was measured by the difference in tunneling current, with the tip being fixed on the back of the cantilever. this allows the detection of normal & lateral displacements of the cantilever.

→ the image is generated from the interaction force. In the scan, the interaction force is kept constant by a feedback control. the increase in the interaction force when the tip approaches an elevated part is related to the vertical displacement of the scanner needed to eliminate this increase in signal. this is converted to height.

→ thus, the basic components of the Microscope are the cantilever, the detector system, scanners & the electronics. this also suggest that depending on the kind of interactions b/w the cantilever & surface, various kinds of Microscopies are possible.



Schematic representation of (AFM)

→ the probe can be made magnetic to investigate the magnetic interactions with materials. this result in magnetic force Microscopy (MFM).

→ the tip can have specific temperature probes & the tip itself can be made of a thermocouple. this facilitates scanning thermal microscopy (SThM).

→ the tip may be attached with molecules which are designed to have specific molecular interactions with the surface. this result in chemical force Microscopy (CFM).

Optical Microscopies :-

→ It is refered as a light microscope, which uses the visible light & system of lens to magnify the devices on the small amount of samples. these are the oldest design of the microscope & it is invented in 17th century.

→ Improved resolution in optical microscopies can broadly be brought about in two different ways. the first belongs to far field Imaging & the second to near field Imaging.

→ In the former, the illumination occurs at a distance several microns away from the object to be Imaged & in the latter, it occurs within distance of a few nanometers from the surface.

(1) confocal Microscopy:-

→ Confocal Means 'having same focus'. In such a microscope, a point like light source, generally a laser, is used. this point source is derived by passing the light through a pinhole, which can be conveniently achieved by using a fiber optic connector.

→ this is directed to the specimen through a beam splitter & an objective, which illuminates a spot. the point of illumination can be moved across the sample by a scanner & there are several ways by which this can be done.

→ the emitted light from the sample, generally fluorescence, passes through the detecting pin hole & forms a point-like image on the detector.

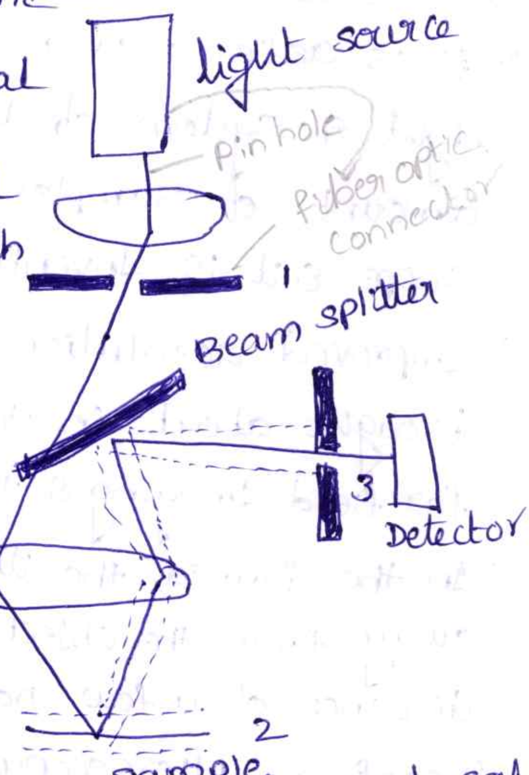
→ the light is scanned across the sample to obtain a two-dimensional Image & the depth from which the light is collected is varied by moving either the objective & the sample thus giving a three dimensional Image of the sample.

→ All these three points namely the illumination pinhole, sample spot & the detector pin hole, are optically conjugated together thus giving confocal microscope. the confocal microscope is therefore a confocal scanning optical microscope.

→ the optical sectioning aspect is the most important advantage of confocal microscope.

→ the principal advantage of confocal Microscopy is the image contrast, which is achieved by rejecting light that comes from other focal planes of the sample.

→ the most important application of confocal microscopy in nanoscience is in the investigation of the interactions of nanosystems with biological components.



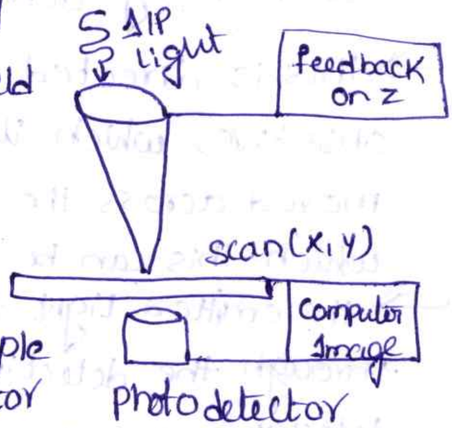
Schematic of a confocal Microscope.

② Scanning Near field optical Microscopy:-

→ the finite resolution of conventional optical microscopy shows that the limit of resolution is approximately λ/2, where λ is the wavelength of light used for illumination.

→ the fundamental aspect is that the near field light intensity decreases rapidly when the aperture dimension is small.

→ the probe is a tip which interacts with the sample at a close distance (d<<λ). the sample light interaction is detected by the photo detector placed at a distance away from the sample.



Schematic of a scanning near field optical Microscope.

→ the distance b/w the sample and the tip is kept very small, by the use of a feedback mechanism which is typically based on the modulation of the quartz tuning fork. the sample & the tip is scanned so as to construct an image of the sample.

→ there are numerous ways in which probes suitable for SNOM are made. one approach is to make probes from fibres, with one end tapered. the outer surface of the fibre is coated with a metal film & the very end of the fibre is exposed.

other Kinds of Microscopies :-

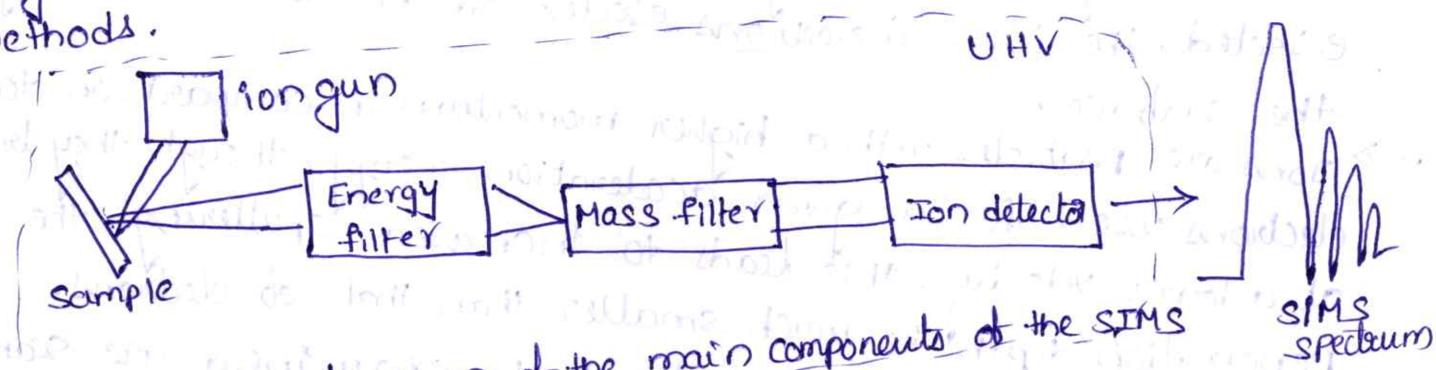
① secondary Ion Mass spectrometry (SIMS) :-

→ Ion based tools are Important in nanotechnology. two of the common tools are the focused ion beam-based lithography & secondary ion mass spectrometry (SIMS).

→ In SIMS, one is concerned with the mass spectrometry of ionized particles resulting from the Impact of primary particles on a surface. the surface can be liquid or solid & the primary particles may be electrons, ions, neutrals or photons.

→ the secondary particles emitted from a surface are electrons, neutral & ionic atoms or molecules, and neutral or ionic clusters. in SIMS, one is concerned only with the ions.

→ secondary particle emission is referred to as 'sputtering'. most of the particles emitted will be neutrals but a few ions are also emitted. mass analysis of these ions is carried out in one of several ways, such as time of flight, quadrupole & magnetic sector based methods.



Schematic diagram of the main components of the SIMS

→ In SIMS Imaging, the mass spectral Intensities collected from a surface are used to construct Images. the spatial resolution of the method depends on the dimension of the sampled area. thus it is necessary to have either a highly focused ion beam or a highly focused collection of ions.

→ SIMS Imaging is generally done in two ways. ① A focused ion beam is rastered across the sample & the spectrum at each point is collected. this method is called the 'microprobe mode'.

② the other mode is the microscope mode or the direct mode. here the ions are collected from specific points on the sample simultaneously by electron lens & are detected on a position sensitive detector.

→ the ion beams commonly used are Cs^+, O_2^+ or O^- or Ga^+, Although highly pointed beams of Ga^+ are possible, the secondary ion emission yield is small & therefore the first two are commonly used today.

→ SIMS is operated in two modes. ① static analyzers is usually related to time of flight (TOF) methods. ② Dynamic SIMS quadrupole & magnetic sector analyzers are used.

⑧ Focused Ion Beam (FIB):-

→ the focused ion beam technique utilizes a liquid metal ion source & the interaction of high energy ion with the sample is used to investigate or modify the sample. Elastic & inelastic collisions take place when the ion beam strikes the sample.

→ Elastic collisions lead to the sputtering of atoms & inelastic collisions yield secondary electrons & x-rays. ions are also ejected. the ions & electrons ejected can be used for imaging the surface.

→ Ions are particles with a higher momentum in comparison to the electrons used for a given acceleration energy, though they travel at a lower velocity. this leads to increased sputtering. the ion penetration depth is much smaller than that of electrons.

→ In SEM & FIB, the particles to be examined are scanned on the surface. the secondary particles (ions & electrons) are used for imaging in FIB.

→ In addition to imaging, FIB is used for ion milling. selective sputtering can be achieved by a method known as gas assisted etching (GAE). FIB can also be used for implantation.

→ In addition to single ion beam, an ion beam & an electron beam combination may be used, which will combine the capabilities of FIB & SEM.

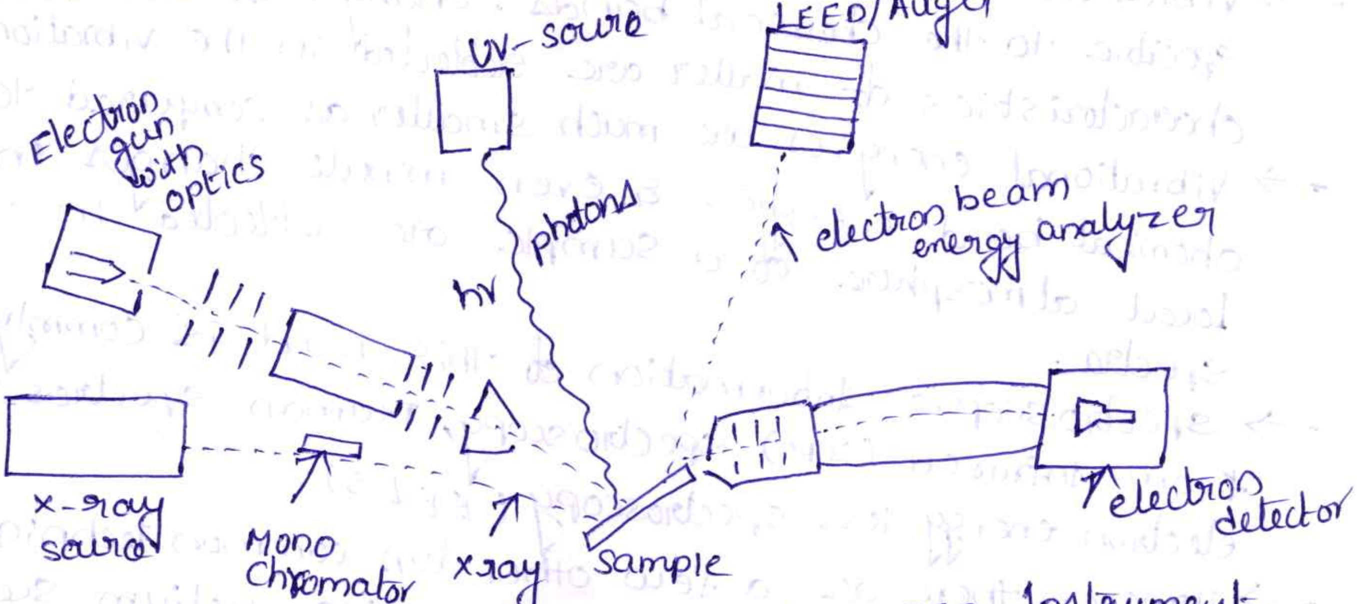
This can help achieve lithography, imaging & characterization together. such an instrument has several applications in nanotechnology.

③ photo Electron Microscopy:-

→ photoelectron spectroscopy (PE) is concerned with a broad range of analytical techniques, all of which are based on Einstein's photoelectric equation, $h\nu = KE + \phi$, where $h\nu$ refers to the photon energy, ϕ refers to the work function & KE refers to the kinetic energy of the ejected electron.

→ the principal PE techniques are x-ray photoelectron spectroscopy (XPS), which uses x-rays, and ultraviolet photoelectron spectroscopy (UPS) which uses soft x-rays & ultraviolet radiation for photoelectron emission.

→ XPS is generally used for the analysis of solids & surfaces where as UPS is also used for gaseous sample.



Schematic of a modern PES Instrument.

→ there are principally five analytical techniques in this branch, all of which deal with the kinetic energy of electrons ejected or reflected from materials. there are also electron spectroscopic techniques dealing with inelastically scattered electrons called electron energy loss spectroscopy (EELS).

→ Kinetic energy analysis of Auger electrons constitutes another electron spectroscopic technique, namely Auger electron spectroscopy (AES). the last technique is called Bresstrahlung isochromat spectroscopy (BIS).

→ while XPS, UPS & AES are used to investigate occupied energy states. BIS is used to study occupied states. EELS is used for the investigation of excitation b/w the occupied & unoccupied states & also for the study of molecular vibrations, especially when the molecule is adsorbed on a surface.

→ Each of these techniques can be applied for different kinds of samples. the instrumentation for these techniques can be different thus giving different types of information.

→ In photoelectron spectroscopy, the electron kinetic energy that one normally encounters is of the order of 10 - 1000 electron volts.

(4) Vibration Microscopy:-

→ vibrational spectra are characteristics of the material & are specific to the chemical bonds. changes in the chemical - characteristics of matter are reflected in the vibrational spectra.

→ vibrational energies are much smaller as compared to the chemical bond energies & even minute changes in the local atmosphere of a sample are reflected in the spectra.

→ spectroscopic information of this kind is commonly derived from infrared (IR) spectroscopy, Raman spectroscopy & electron energy loss spectroscopy (EELS).

→ However, there are a few other less common techniques such as inelastic electron & neutron tunneling, helium scattering & sum frequency spectroscopy which may be used to obtain information on vibrations.

→ All these are more involved techniques in terms of both money & effort. the first three techniques are more common & are used in various ways to analyse nanomaterials.

→ Vibrational spectroscopy is used to derive Information on the vibrational excitation of molecules.

→ Most of the time, the excitation is limited to the fundamental vibrational frequency.

(5) X-Ray diffraction:-

→ Although the method of x-ray diffraction is quantitative in general, it is used for qualitative analysis. this form of analysis extends to all crystalline solids including ceramics, metals, Insulators, organics, polymers, thin films, powders etc.,

→ x-ray diffractometers can be used either for single crystals or for powders with both significantly different Intra-structures. while single crystal diffractometers are used for the study of molecular structure, powder diffractometers are used for the analysis of phases.

→ x-rays corresponds to electromagnetic radiation in the wavelength range of 1A°. the wavelength range is below that of ultraviolet light & above that of gamma rays.

→ x-rays are generally produced when electrons of several thousands of electron volts are decelerated or stopped by metals. this will produce a white radiation upto a threshold freq corresponding to the kinetic energy of the particle.

→ this threshold corresponds to a wavelength $\lambda = 12399/V$ where V is the accelerating voltage of the electrons. the wavelength of a given x-ray line depends on the atomic number.

Carbon Nanotubes (CNT) :-

→ carbon is a unique element. it can exist in several different allotropic forms at room temperature, namely graphite, diamond, amorphous carbon, carbon clusters (like C_{60}, C_{70}, etc.) & carbon nanotubes.

→ from the soft graphite to the hard diamonds, the electrically conducting graphite to insulating diamonds & semiconducting CNTs, carbon can exhibit extreme variations in properties due to difference in their bonding & structure.

→ carbon atoms can be chemically bonded to each other either in the sp^2 (graphite, carbon clusters, CNT) or sp^3 (diamond) hybridized states.

Types of carbon nanotubes :-

→ A carbon nanotube is a planar sheet of graphite (called graphene) rolled up into a seamless cylinder with diameter in the order of a nanometer.

→ this results in a nanostructure where the length to diameter ratio exceeds nearly 10,000. each end of the long cylinder is capped with half a fullerene molecule.

→ CNT's can in general be classified as either single walled nanotubes (SWNT's) or multi-walled nanotubes (MWNT's). SWNT's have a cylindrical shell with one atom thickness. the concentric arrangement of several single walled nanotubes of slightly varying diameters is termed as a multi-walled nanotubes. carbon nanotubes are unique nano-structures with remarkable electronic & mechanical properties.

synthesis of carbon nanotubes :-

→ basically they are three methods for synthesis of CNT's.

① Electric arc discharge

② chemical vapour deposit (CVD).

ⓐ Hot wall CVD

ⓑ cold wall plasma CVD's.

③ Laser Ablation.

① Electric arc discharge method :-

→ In arc-discharge, carbon atoms are evaporated by the plasma of helium gas ignited by high current passed through the opposing carbon anode & cathode as shown in the fig.

→ Arc discharge synthesis uses a low-voltage (~12 to 25V), high current (50 to 120 A) power supply. An arc is produced across a 1-mm gap b/w two graphite electrodes 5 to 20mm in diameter.

→ An Inert gas such as He & Ar is used as the atmosphere for the reaction, at a pressure of 100 to 1000 torr. the arc discharge method Involves condensation of carbon atoms generated from the evaporation of solid carbon atoms.

→ the temperature involved with this method is close to the melting point of graphite, 3000 - 4000°c. Arc discharge has been developed into an excellent method for producing high quality multi & single walled nanotubes.

→ MWNT's can be grown by controlling growth conditions such as the pressure of Inert gas in the discharge chamber & the arcing current. MWNT's synthesized previously by this method have lengths in the order of ten microns & diameters in the range of 5-30 nm.

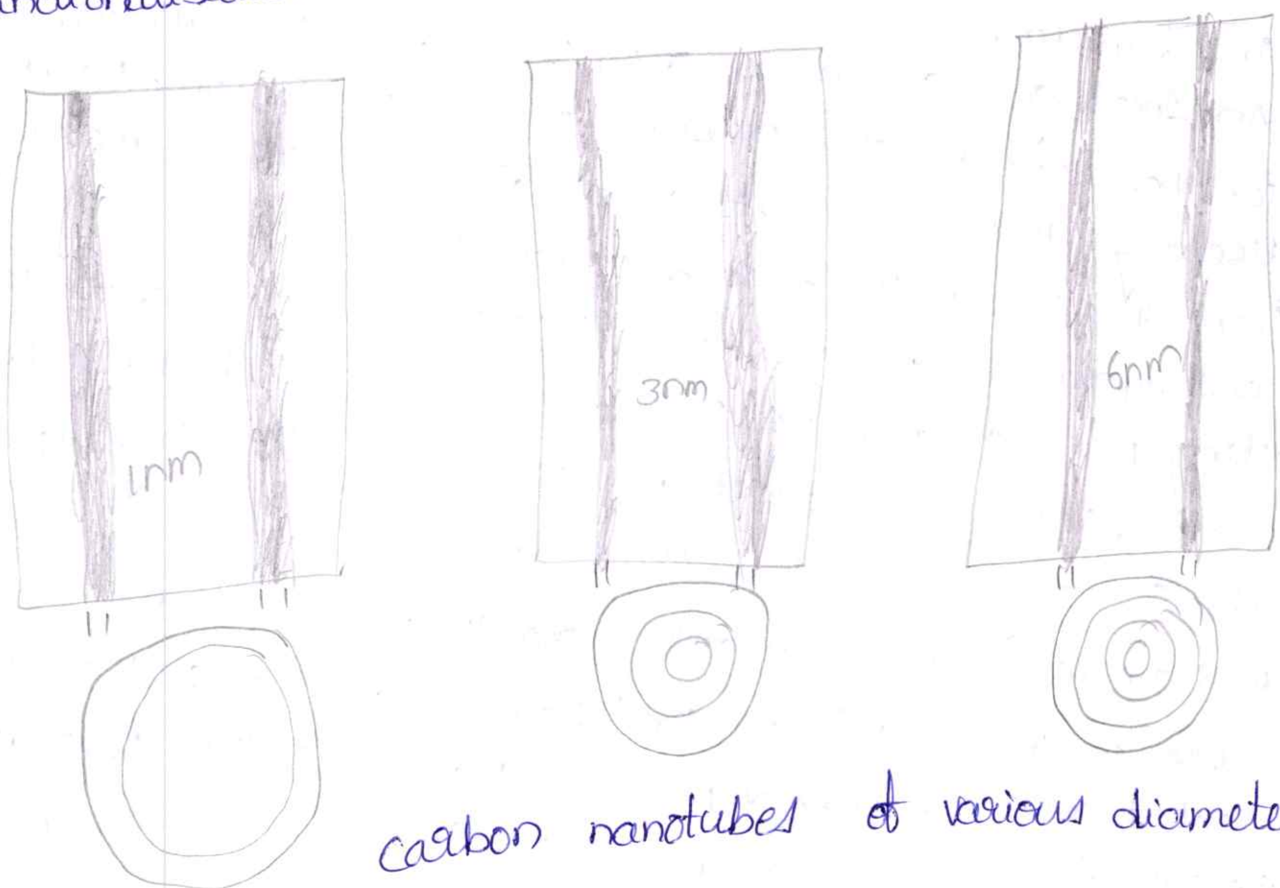
① Single walled Nanotubes :-

→ Most single walled nanotubes (SWNT) have diameter close to 1 nanometer, with a tube length that can be many thousands of times longer.

→ single walled nanotubes with length up to orders of centi-meteres have been produced. single walled nanotubes are a very Important variety of carbon nanotube bcoz they exhibit Important electric properities that are different from those of multi-walled carbon nanotubes (MWNT) variants.

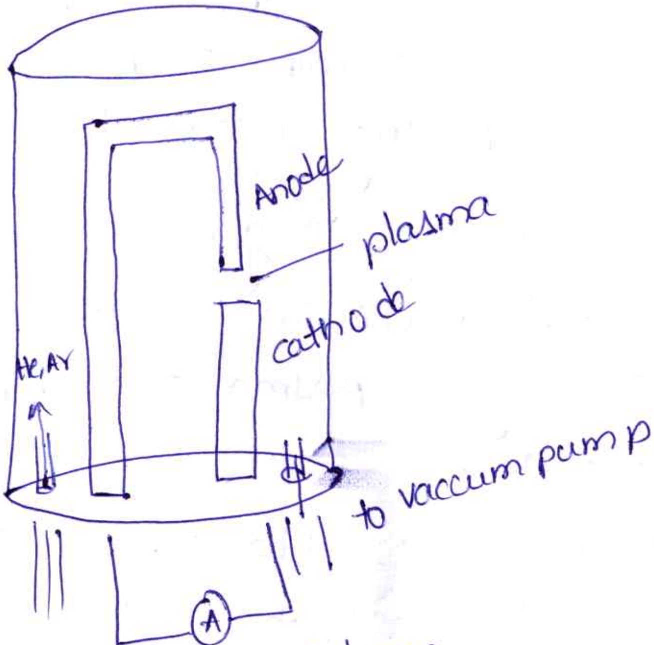
② Multi-walled Nanotubes :-

→ Multi walled nanotubes (MWNT) consist of multiple layers of graphite rolled in on themselves to form a tube shape. the distance b/w these layers is close to the graphene layer distance in graphite. this is especially Important when functionalisation is required to add new properties to CNT's.



carbon nanotubes of various diameter.

→ In general, the nanotubes produced by this method need extensive purification before use.



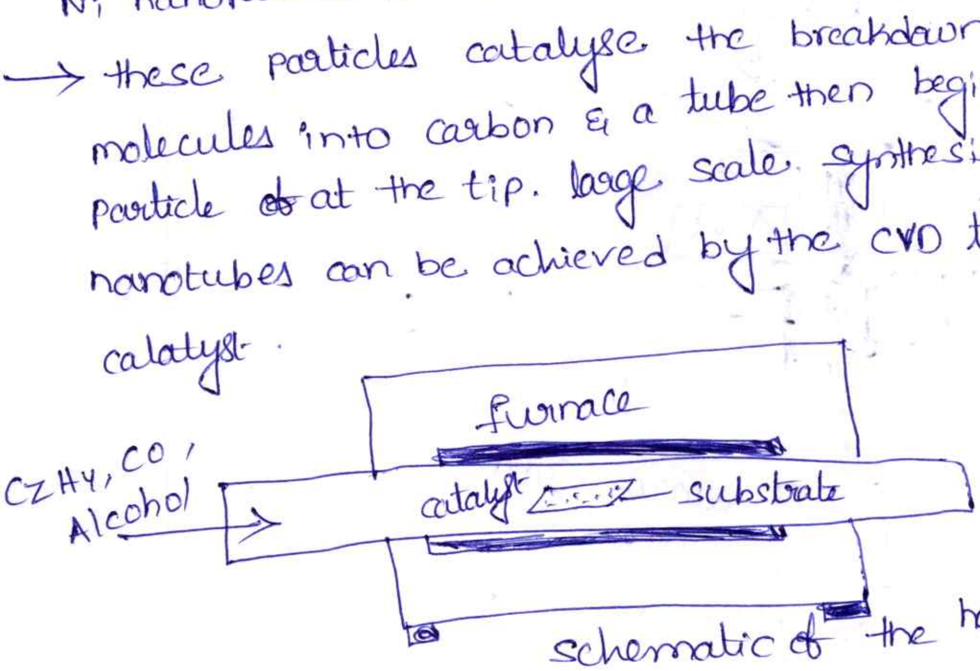
Arc discharge scheme.

② chemical vapour Deposition (CVD):—

→ Both hot-wall as well as cold-wall plasma enhanced CVD's have been developed for the synthesis of CNT's.

ⓐ Hot wall CVD method:— this process includes catalyst-assisted decomposition of hydrocarbons, usually ethylene or acetylene in a tube reactor at 550 - 750°c & the growth of carbon nanotubes over the catalyst when the system is cooled. Fe, Co & Ni nanoparticles can be used as catalysts.

→ these particles catalyse the breakdown of the gaseous molecules into carbon & a tube then begins to grow with a metal particle at the tip. large scale synthesis of aligned carbon nanotubes can be achieved by the CVD technique with Iron as catalyst.



schematic of the hot-wall CVD

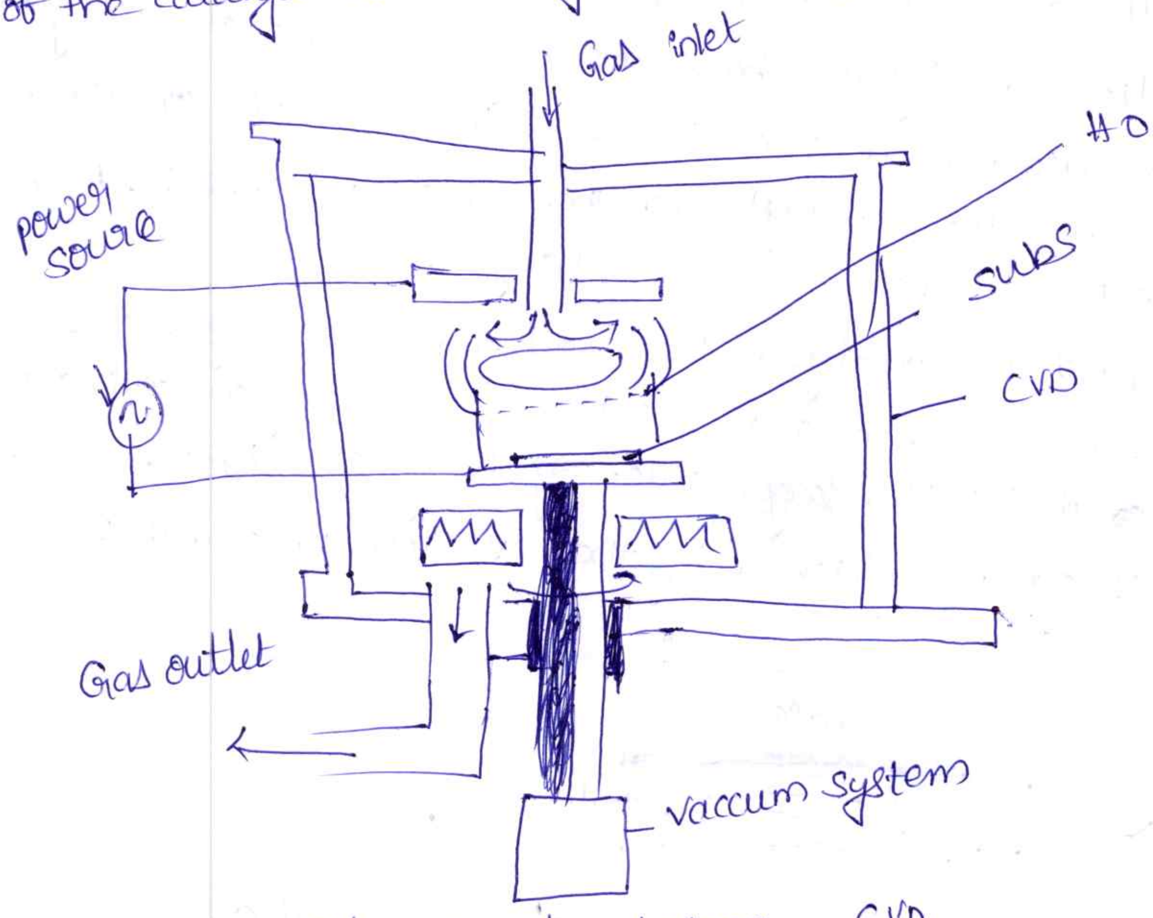
(b) cold-wall CVD synthesis :-

→ plasma-enhanced chemical vapour deposition (PECVD) sytems have been used to produce both SWCNT'S & MWCNT'S. PECVD is a general term, encompassing several differing synthesis methods.

→ In PECVD, a glow discharge is generated in a chamber when a high voltage is applied b/w two electrodes. fig shows a schematic diagram of a typical plasma CVD apparatus with a parallel plate electrode structure.

→ In PECVD, a uniform film is obtained by the supply of reaction gas from a plate held opposite to the substrate which is placed on the grounded electrode.

→ catalytic metals such as Fe, Ni & Co, are used on a Si, SiO_2 or glass substrate using thermal CVD or sputtering. CNT growth in CVD can be split into two basic types depending on the location of the catalyst. so called gas phase growth & substrate growth.



Schematic of plasma CVD

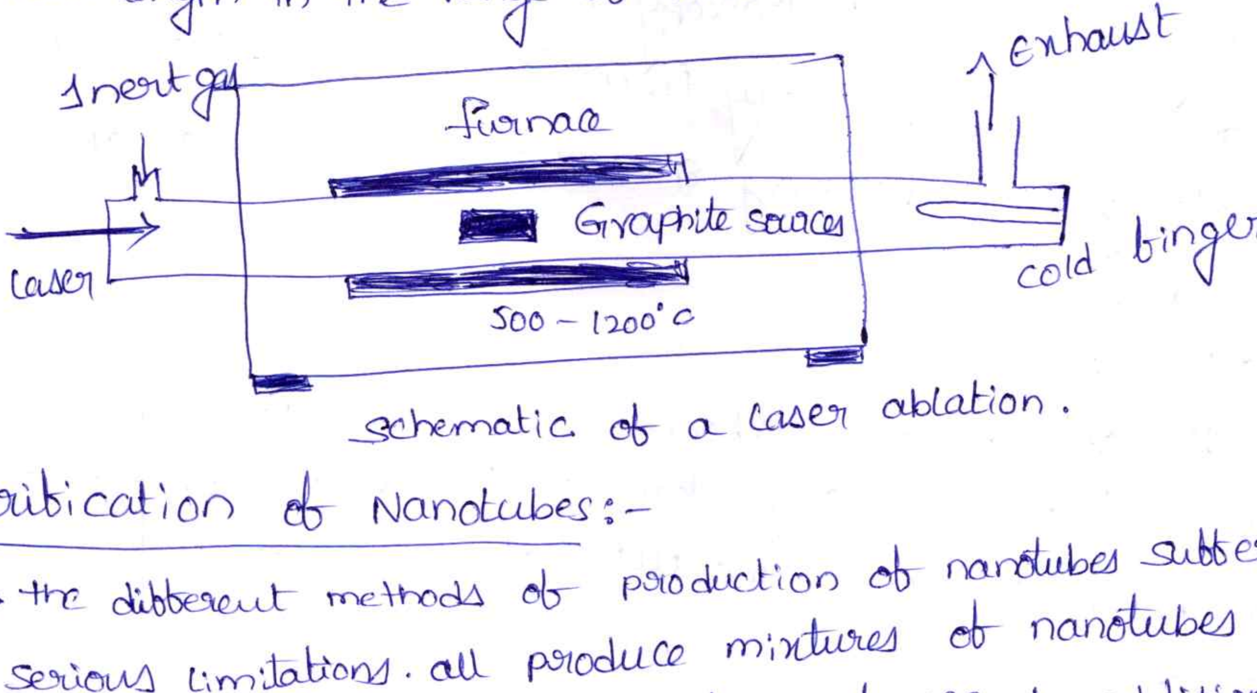
Laser Ablation :-

→ the laser ablation technique uses a 1.2 at.% of cobalt / nickel with 98.8% at.% of graphite composite target that is placed in a 1200°c quartz tube furnace with an inert atmosphere of ~500 torr of Ar or He & vaporized with a lazer pulse.

→ A pulsed or continuous wave laser can be used. Laser ablation gives high yields of SWNT's. the process involves laser ablation of graphite rods with small amounts of Ni & Co at 1200°C.

→ In this process, a mixture of graphite & (Co, Ni) catalyst is vaporized by a laser beam in a tube furnace at 1200°C. the nanotubes are deposited on a collector (water cooled) kept outside the furnace.

→ the laser ablation yields > 70% hightly endless, highly tangled ropes of SWNT's along with nanoscale impurities. the potential use of the nanotubes in nano electronic devices requires nanotubes with length in the range of 10-300nm.



schematic of a laser ablation.

Purification of Nanotubes:-

→ the different methods of production of nanotubes suffer some serious limitations. all produce mixtures of nanotubes & nano particles sticking together in larger lumps. In addition, the length of the tubes varies widely & the nanotubes have a number of defects in them.

→ purification is basically the separation of tubes from the soot & elimination of defects by different post-growth treatments.

→ ultrasonication is one of the techniques by which the tubes are freed from particles. while the larger contaminants can be removed by sedimentation in a solvent, it is not easy to remove the smaller particles.

→ one possibility for MWNT's is to perform an oxidative treatment, either by heating the powder in air at 650°c or by a liquid phase treatment in an acidic environment.

→ heating the carbon nanotubes up to 300°k can also eliminate Impurities & defects in the tubes.

Properties of carbon nanotubes :-

① Transport properties :-

→ scanning tunneling spectroscopy has shown that the band gaps of the nanotubes vary from 0.2 to 1.2eV. the gap varies along the tube body & reaches a min value at the tube ends.

② Mechanical properties :-

→ the strength of the carbon-carbon bond is among the highest & as a result, any structure based on alinged carbon carbon bonds will have the ultimate strength.

ⓐ strength :-

→ carbon nanotubes are the strongest & stiffest materials on earth, in terms of tensile strength & elastic modulus respectively. this Individual carbon atoms covalent sp^2 bonds fromed b/w them to result in high strength.

→ In 2000, a multiwalled carbon nanotubes was tested to have a tensile strength of 63 gigapascals (GPa). Since carbon nanotubes have a low density for a solid, its specific strength of up to the best of known materials, compared to high carbon steels.

② Kinetic :- Multi-walled nanotubes, multiple concentric nanotubes precisely nested within one another, exhibit a striking telescoping property whereby an inner nanotube core may slide, almost without friction, within its outer nanotube shell thus creating an atomically perfect linear or rotational bearing.

→ this is one of the first true examples of molecular nano-technology. already this property has been utilized to create the world's smallest rotational motor.

③ one dimensional transport :-

→ due to their nanoscale dimensions, electron transport in carbon nanotubes will take place through quantum effects & will only propagate along the axis of tube.

→ because of this special transport property, carbon nanotubes are frequently referred to as 'one dimensional' in scientific articles.

Applications of carbon nanotubes :-

① Electrical application :- the use of nanotubes as electrical conductors is an exciting possibility. A nanotube based single molecule field effect transistor has already built.

② Electromagnetic Applications:- It is possible to construct hetrojunction by having junction b/w nanotubes of different helicities.

→ this approach facilitates the creation of device with one molecule.

→ one area of Immediate commercial application of nanotubes is CNT based field emission displays.

③ Nanotips can be used as nanoprobes

④ Nanotubes are used as flow sensors

⑤ chemical applications

⑥ Mechanical applications

⑦ electroacoustic applications.

⑧ BioMedical applications.

UNIT-2

Models of semiconductor quantum wells, quantum wires & quantum dots

Introduction :-

→ the Idea of a quantum well, a quantum wire & a quantum dot was Introduced using a simple particle in a box model. the main differentiating characteristic among the three structures was the size of the structure in each coordinate with respect to a particle's wavelength at the fermi energy :

$$\lambda_F = \frac{h}{\sqrt{2m_e^* E_F}}$$

→ If the electron's environment is large compared to λ_F, then the electron will behave approximately as if it is free. If the electron's wavelength is on the order of, or is large compared with its environment, then it will behave in a combined fashion with the three structures as shown in fig. where

→ to summarize, the three structures

① If $\lambda_F << L_x, L_y, L_z$, then we have an effectively three dimensional system - the system in all directions is large compared to size scale of an electron.

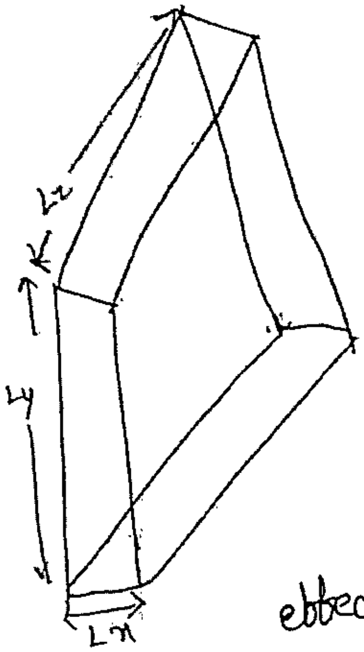
② If $L_x \le \lambda_F << L_y, L_z$, then we have an effectively two dimensional system - a two dimensional electron gas or quantum well.

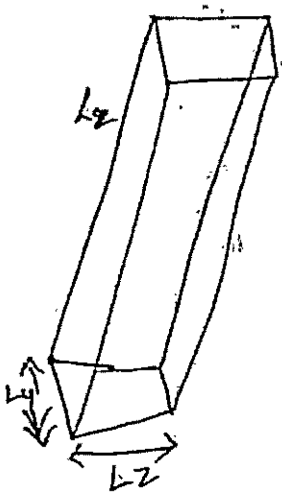
③ If $L_x, L_y \le \lambda_F << L_z$, then we have an effectively one dimensional system - a quantum wire.

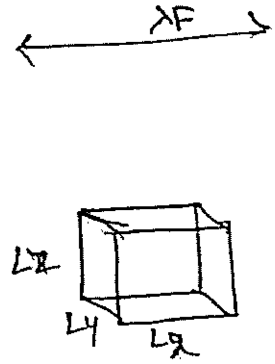
④ If $L_x, L_y, L_z \le \lambda_F$, then we have an effectively zero dimensional system - a quantum dot

In metals typically $\lambda_F \sim 0.5 - 1nm$ & in typical semiconductors, $\lambda_F \sim 10 - 100nm$.

23.	**Prasad K,** K.Lakshmi Prasanna, O.Bhavya Sree, S.Basha, K.Divya	Design of Miniacturized Dual Band Microstrip Antenna For Wireless LAN Applications	Journal of Interdisciplinary cycle research	Volume 3, Issue:16	1428-1432	0022-1945	Non-UGC	June 2021
24.	**C.Venkatesh,** Polaiah Bojja	IoT Based Lung Cancer Detection Using Machine Learning and Cuckoo Search Optimization	International Journal of Pervasive Computing and Communications, Emerald Publication	Volume: 17, Issue: 5	549-562	1742-7371	WoS & Scopus	June 2021







effectively two, one & zero dimensional regions of space.

Semiconductor Heterostructures & Quantum wells:-

→ crystal growth techniques can produce atomically abrupt Interfaces b/w two materials, especially if the lattice types & lattice constants of the two materials are similar. for example, we could sandwich a small bandgap material, such as GaAs b/w thick layers of a large bandgap material, such as AlGaAs as shown in the fig ①

→ this sandwich is called a semiconductor heterostructure. Quantum wells are formed in both the conduction & valence bands as shown in the real space energy band diagram fig ②.

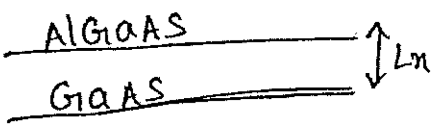
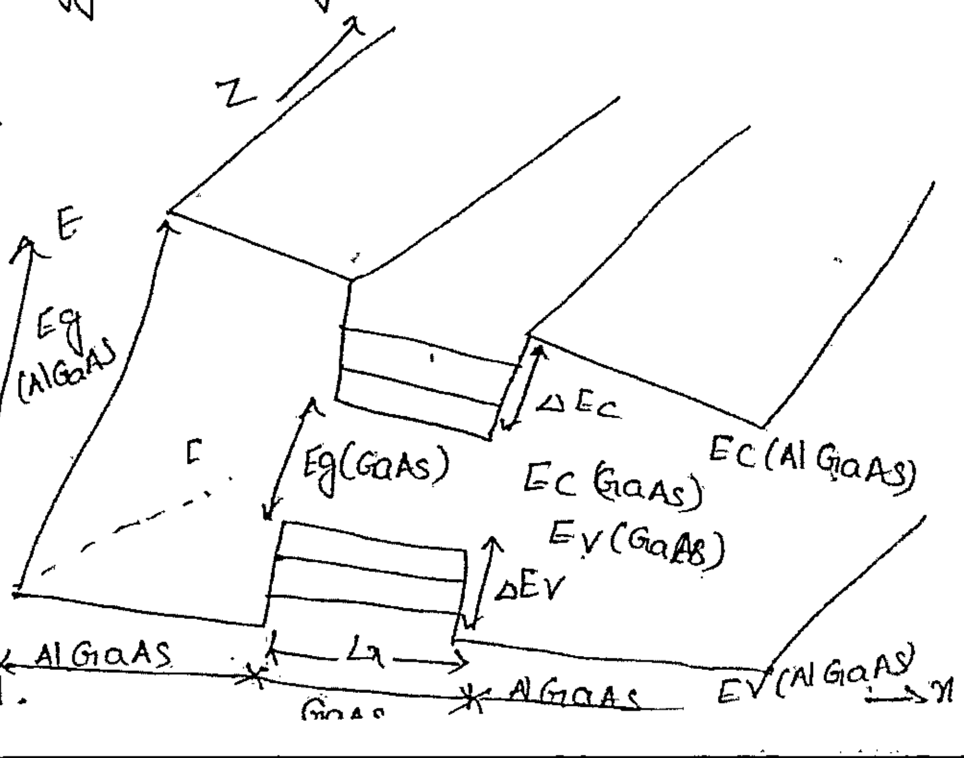


fig ①

fig ② semiconductor hetero structure made ~~of~~ from AlGaAs & GaAs. Quantum well is formed.



21.	**S.Nazeer Hussain,** K.Chandrakalavathi, A.Chandrakala, B.Dharani	Design of Low Power High Speed Sense Amplifier Based Flipflop Using Lector Technique in 45nm CMOS Technology	Journal Of Interdisciplinary Cycle Research	Volume: 13, Issue:7	403-408	0022-1945	Non - UGC	July 2021
22.	**K. Prasad,** M. Venugopal, T. Yogeswar Reddy, V. Surendrababu, B.Sreenivasulu	Real Time Water Quality Monitoring System	Journal Of Interdisciplinary Cycle Research	Volume 13, Issue6	1433-1438	0002-1945	Non-UGC	June 2021

→ to a good degree of accuracy, semiconductor hetrostructure composed of crystalline materials can be analyzed by replacing the actual crystal structure with a potential energy profile, & using the value of effective mass appropriate to the material.

we use the effective mass schrodinger's equation

$$\left(-\frac{h^2}{2m^*}\nabla^2 + V(x)\right)\psi(r) = E\psi(r)$$ where, m = effective mass of the particle at a given point in the hetrostructure.

→ the effective mass schrondinger's equation actually does not strictly hold for alloys such as AlGaAs, which do not have pure periodic (crystalline) structure. however, it often suffices to treat the alloy as having a periodic nature.

→ for instance, AlGaAs is modeled as having properties b/w AlAs & GaAs. this is called the virtual crystal approximation. for AlAs, $E_g \simeq 2.2eV$ & for GaAs, $E_g \simeq 1.5eV$ & so AlGaAs has a bandgap on the order of $E_g \simeq 1.85eV$. more specifically, AlGaAs is an Alloy, written as $Al_\alpha Ga_{1-\alpha}As$, where α is the mole fraction of Al. the band Gap can be empirically approximated as $E_g \simeq 1.426 + 1.247\alpha$. for $\alpha < 0.45$.

Using the separation of variables technique we solve by writing

$$\psi(x,y,z) = \psi_x(x)\psi_y(y)\psi_z(z) \quad \text{which results in} \rightarrow (1)$$

$$\left(\frac{1}{\psi_x}\frac{d^2}{dx^2}\psi_x + \frac{1}{\psi_y}\frac{d^2}{dy^2}\psi_y + \frac{1}{\psi_z}\frac{d^2}{dz^2}\psi_z + \frac{2m^*}{h^2}(E - V(z))\right) = 0 \rightarrow (2)$$

Using the separation argument, we obtain

$$\frac{1}{\psi_y}\frac{d^2}{dy^2}\psi_y = -k_y^2 \rightarrow \psi_y(y) = Ce^{ik_y y} + De^{-ik_y y}, \rightarrow (3)$$

$$\frac{1}{\psi_z}\frac{d^2}{dz^2}\psi_z = -k_z^2 \rightarrow \psi_z(z) = Ae^{ik_z z} + Be^{-ik_z z} \rightarrow (4)$$

leading to $$\left(-k_y^2 - k_z^2 + \frac{1}{\psi_x}\frac{d^2}{dx^2}\psi_x + \frac{2m^*}{h^2}(E - V(x))\right) = 0 \rightarrow (5)$$

→ therefore, in the unconstrained directions (y & z) the wavefunction is represented by plane waves. since k_x & k_z can be allowed to take on positive & negative values for our purposes it is sufficient to

take

19.	**B.Abdul Raheem,** G.Sreevalli, P.Preeethi, M.Prem Kumar Reddy, V.Anil	Indexing and Retrivel System for Speech Annotated Digital Images	International Journal Of Advanced Trends In Engineering, Science And Technology	Volume: 06, Issue: 4	16-20	2456-1126	Non - UGC	July 2021
20.	**K. Shankar,** T. Dhanusha, R. Dileep kumar Reddy, S. Lahari, S. R. Andro Martin vivek	Design Of Dual Band CPW Fed Line Microstrip Patch Antenna For Gps And Wlan Applications	Journal Of Interdisciplinary Cycle Research	, Volume XIII, Issue VII,	195-199	0022-1945	Non - UGC	July 2021

$$\psi_y(y)\,\psi_z(z) = A e^{ik_y y} e^{ik_z z} \rightarrow (6)$$

it remains to solve $\left(-\frac{\hbar^2}{2m^*}\frac{d^2}{dx^2} + \frac{\hbar^2}{2m^*}(k_y^2 + k_z^2) + V(x)\right)\psi_x(x) = E\psi_x(x)$ → (7)

by solving schrodinger's one dimensional equation

$$\left(-\frac{\hbar^2}{2m}\frac{d^2}{dx^2} + V(x)\right)\psi(x) = E\,\psi(x) \rightarrow (8)$$

→ this equation & (7) will have the same form & thus the solution of (8) can be used as the solutions of (7), if we define an effective potential such that

$$V_e(x,k) = \frac{\hbar^2}{2m^*(x)}(k_y^2 + k_z^2) + V(z)$$

eq (7) becomes $\left(-\frac{\hbar^2}{2m^*}\frac{d^2}{dx^2} + V_e(x,k)\right)\psi_x(x) = E\psi_x(x)$ → (9)

in summary we have $\psi(x,y,z) = A e^{ik_y y} e^{ik_z z}\psi_x(x)$ → (10)

→ where k_y & k_z are continuous variables & $\psi_x(k_x)$ will be determined by subject to boundary conditions in the x-coordinate.

Quantum wires & Nanowires :-

→ the preceding analysis assumed that electrons were confined along one coordinate, x, where the confinement was provided by the difference in bandgap b/w different materials.

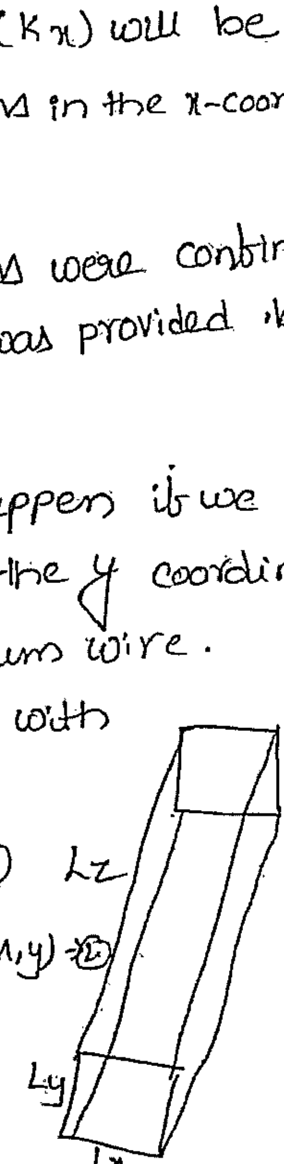
→ the next logical step is to consider what happen if we confine electrons in a second direction saying along the y coordinate. the resulting structure is called a quantum wire.

→ to analyze the quantum wire, we start with schrodinger's equation

$$\left(-\frac{\hbar^2}{2m^*}\nabla^2 + V(x,y)\right)\psi(r) = E\psi(r) \rightarrow (1)$$

& express the wavefunction as $\psi(r) = e^{ik_z z}\psi(x,y)$ → (2)

ie, the electron will be free to move along the z coordinate ie, along the wire, but will be



Quantum wire.

17.	**M. Venkata Dasu,** Veera Narayana Reddy P, Chandra Mohan Reddy S	RNN-based multispectral satellite image processing for remote sensing applications	International Journal Of Pervasive Computing And Communications,	Volume: 17, Issue No.5	583-595	1742-7371	WOS & SCOPUS	September 2021
18.	N. Mallikharjuna Rao, Sasidhar Choragudi and **J. Chinna Babu**	Outcome-based education: a paramount model for higher educational institutions in India	International Journal Of Continuing Engineering Education And Life Long Learning	Volume 31, Issue 4,	462-475	1741-5055	WOS & SCOPUS	August 2021

Confined in other directions, sub eq ① & ② we obtain

$$\left(-\frac{\hbar^2}{2m^*}\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)+\frac{\hbar^2 k_z^2}{2m^*}+V(x,y)\right)\psi(x,y) = E\psi(x,y) \rightarrow ③$$

Given a certain potential $V(x,y)$ we can slove eq ③ analytically if V has a particular simple form or numerically or using some approximate method.

Energy relation form is given by $E = E_{nx,ny} + \frac{\hbar^2}{2m^*}k_z^2 \rightarrow ④$

where k_z is now the longitudinal wave number. this will be a continuous parameter since electrons are free along the z coordinate

→ the discrete indices n_x & n_y correspond to subband indices. the subband energy $E_{nx,ny}$ will be given by

$$E_{nx,ny} = \frac{\hbar^2}{2m^*}\left(k^2_{x,nx}+k^2_{y,ny}\right) \rightarrow ⑤$$

→ where $k_{x,nx}$ & $k_{y,ny}$ will be discrete & will depend on the specific form of potential $V(x,y)$.

$$k_{x,nx} = \frac{n_x\pi}{L_x}, \quad k_{y,ny} = \frac{n_y\pi}{L_y}$$ where $n_x, n_y = 1, 2 \ldots$ such that

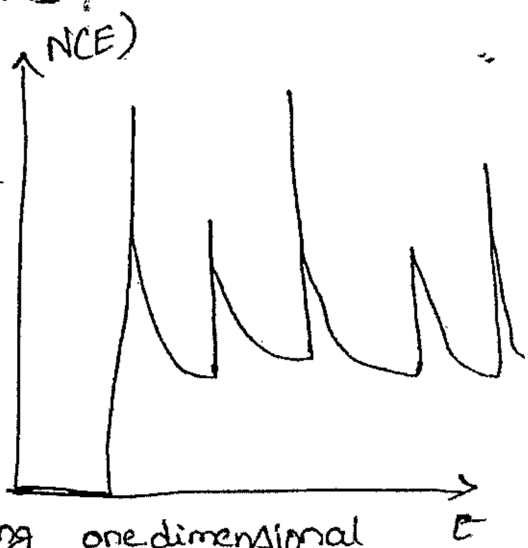
$$E_{nx,ny} = \frac{\hbar^2\pi^2}{2m^*}\left(\left(\frac{n_x}{L_x}\right)^2+\left(\frac{n_y}{L_y}\right)^2\right) \rightarrow ⑥$$

→ the density of states in one dimension is,

$$N(E) = \frac{1}{\pi\hbar}\left(\frac{2m^*}{E-V_0}\right)^{1/2} \rightarrow ⑦ \text{ for } E>V_0.$$

If the energy level E is low, such that only the first subband is filled, the preceding density of states hold & the system is one dimensional.

→ As energy increases & more subbands are filled, the system is one dimensional. in this case the density of states is found by summing one dimensional density of states over all subbands resulting in



$$N(E) = \frac{1}{\pi\hbar}\sum_{nx,ny}\left(\frac{2m^*}{E-E_{nx,ny}}\right)^{1/2} H\left(E-E_{nx,ny}\right) \rightarrow ⑧$$

15.	**Fahimuddin Shaik,** Gautam Bommagani	Histogram Equalized Thresholding method for analysis of Diabetc Myonecrosis related images	Helix The Scientific Explorer	Volume: 11, Isssue No: 5	32-46	2319-5592	Non-UGC	October 2021
16.	**J. Chinna Babu,** Nuka Mallikharjuna Rao, Kadiyala Ramana and Vidhyacharan Bhaskar	A Dynamic Hybrid Decoder Approach Using EG-LDPC Codes for Signal Processing Applications	Wireless Personal Communications	Volume 122	1435-1454	1572-834X	WOS & SCOPUS	September 2021

→ this quasi one dimensional density of states is shown in fig. the discontinuities in the density of states are known as Van Hove singularities.

Quantum Dots & Nano particles :—

→ If we confine electrons in all three coordinates, forming a quantum dot electrons do not have a plane wave dependence in any direction. the three dimensional schrodinger's equation

$$\left(-\frac{\hbar^2}{2m^*}\nabla^2 + V(x,y,z)\right)\psi(r) = E\,\psi(r) \rightarrow ①$$

must be solved & not unexpectedly, the resulting energy will be fully quantized.

$$E = E_{n_x,n_y,n_z} = \frac{\hbar^2\pi^2}{2m^*}\left(\left(\frac{n_x}{L_x}\right)^2 + \left(\frac{n_y}{L_y}\right)^2 + \left(\frac{n_z}{L_z}\right)^2\right) \rightarrow ②$$

→ In general, regardless of the specific potential $V(r)$, energy will take the form $E = E_{n_x,n_y,n_z} = \frac{\hbar^2}{2m^*}\left(k^2_{x,n_x} + k^2_{y,n_y} + k^2_{z,n_z}\right) \rightarrow ③$

→ where k_{x,n_y}, k_{y,n_y}, k_{z,n_z} will be discrete & must be found from the specific boundary conditions. the density of states for a Quantum dot is a series of delta functions.

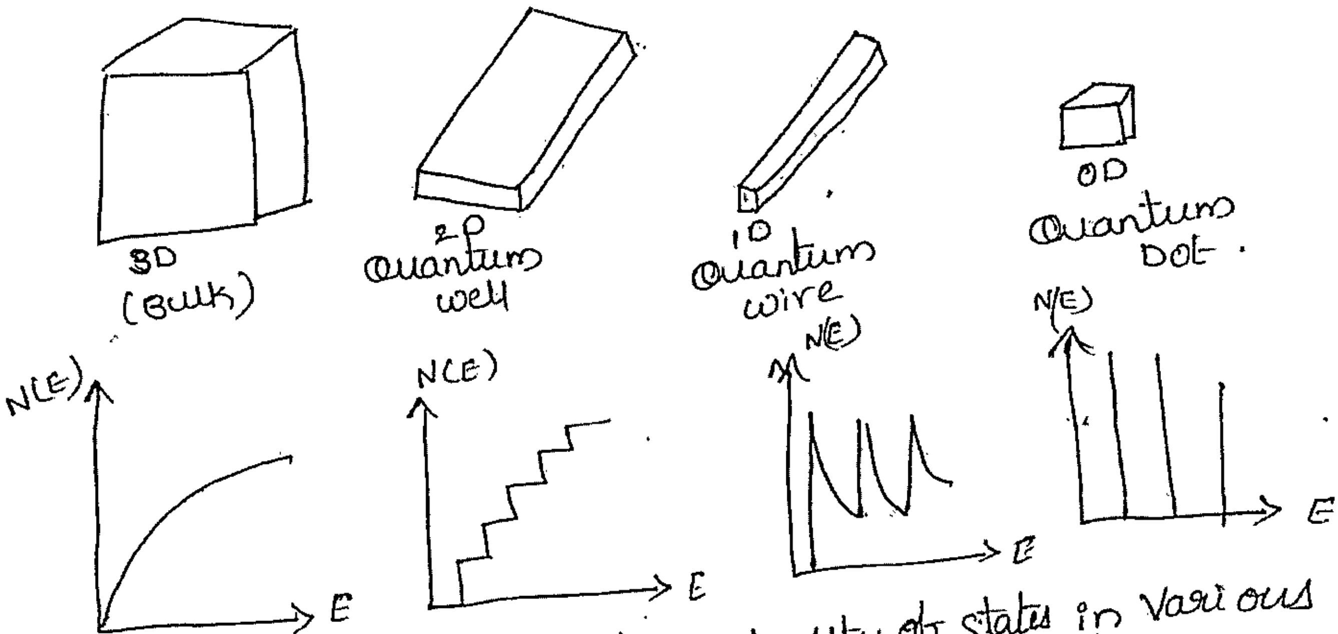
→ this discrete density of states leads to several fundamental differences compared with higher (than zero) dimensional systems, which have at least a piecewise continuous density of states.

→ for example, electron dynamics are obviously quite different in a quantum dot, since current cannot "flow". thermal effects will be different in quantum dots than in bulk materials (or even quantum wells), since thermal energy can only excite electrons to a limited number of widely separated states.

→ for this reason, the freq spectrum of emitted optical radiation from energy level transitions called the luminescence line width in quantum dots is very narrow even at relatively high temperatures.

13.	**G.Thirumalaiah,** S. Immanuel Alex Pandian	An optimized complex motion prediction approach based on a video synopsis	International Journal Of Intelligent Unmanned Systems	Volume1, Issue1	2049-2064	2049-6427	WOS & SCOPUS	December 2021
14.	**C. H. Nagaraju** Bharath Naga Raju	Recursive Least Squares Linear Equalizer for Spectral Efficiency Enhancement in Green Radio Communications	Lecture Notes in Electrical Engineering	Volume 783	1429 - 1435	1876-1119	Scopus	November 2021

→ this makes Quantumdots attractive in laser applications, as biological markers, in a host of other optical applications in particular, their use as charge islands in coulomb blockade circuits & in Medicine.



A comparison of the density of states in various dimensions.

Fabrication techniques for Nanostructures :-

→ the mainstay of commercial silicon technology fabrication is optical lithography. It seems that optical lithography can be pushed to resolutions on the order of several tens of nanometers.

→ other technologies, like extreme UV lithography, immersion lithography & electron beam lithography may become sufficiently mature for commercial applications in the near future.

→ there are 4 fabrication techniques ① Lithography ② Nanoimprint lithography ③ split Gate technology ④ self Assembly.

① Lithography:-

→ Here a brief recapitulation of electromagnetic lithography, which includes optical, EUV, & x-ray techniques is provided.

① Electromagnetic energy is directed at a photomask containing opaque & transparent regions that correspond to the desired pattern.

11.	**G.Thirumalaiah,** J.Geethanjali, P.C Anil kumar, S.Asif, S.Archana	Solar Based Smart Card Electrical Charging Points For Diversified Energy Loads Using Arduino	The International Journal Of Analytical And Experimental Modal Analysis	Volume XIV, Issue II	1118-1122	0886-9367	Non - UGC	February 2022
12.	**Shaik Karimullah,** Dr. D. Vishnuvardhan	Pin Density Technique for Congestion Estimation and Reduction of Optimized Design during Placement and Routing	Applied Nanoscience	Volume 1	110-114	2190-5517	WOS & SCOPUS	January 2022

② Energy that passes through the photomask reaches a substrate coated with a photoresist, & sections of the photoresist that are illuminated by the energy undergo a chemical reaction due to illumination.

③ upon washing the structure in a solvent, sections of the resist are dissolved, forming a pattern on the resist.

④ further processing steps are used to transfer the pattern from the resist to the substrate or otherwise to change the substrate in the desired manner. these include.

ⓐ wet etching :- wet etching is the removal of materials using acid or any liquid solution that will dissolve the material. the depth of the etch can be controlled by the choice of etchant, & by limiting etching time.

ⓑ Dry etching :- Although there are several forms of dry etching, the easiest to understand is a method of bombarding the material by energetic ions inside a vaccum chamber.

ⓒ Doping :- for semiconducting substrates, it is often necessary to dope the material. this can be accomplished, for instance, by accelerating a beam of dopant ions towards the substrate. this is known as ion implantation.

ⓓ Material deposition :- Material may be deposited (eg: metal) onto the wafer. there are several methods of deposition:

① sputtering :- sputtering is basically the bombardment of material (target) by energetic ions inside the vaccum chamber. the ions collide with atoms in the target, resulting in momentum transfer, causing these atoms to be ejected from the surface of the target. these atoms then become deposited on the adjacent substrate, forming a thin film. since sputtering is essentially a mechanical process, a wide range of materials can be deposited on the substrate.

9.	**V. Sai Anusha,** K Shilpa, K. Deepanjali, U, Moulali, C.V. Gouri Priya,	Social Distancing Indicator	International Journal Of Science, Engineering And Technology	Volume 10, Issue1	1-4	2348-4098	Non - UGC	March 2022
10.	**R.Mahesh Kumar,** D. Kavitha, G. Lakshmi Prassana, C. Akila, D. Kallel	MQTT Protocol Based Smart Home Automation Using Esp8266	The International Journal Of Analytical And Experimental Modal Analysis	Volume XIV, Issue II	1114-1117	0886-9367	Non - UGC	February 2022

(ii) chemical vapor deposition (CVD) :- In CVD, a substrate is placed inside a chamber with a number of gases forming a thin film.

(iii) evaporation :- In evaporation, a metal to be deposited & a substrate are placed inside a vaccum chamber. the metal is heated till it melts, & begins to evaporate.

(iv) Laser ablation :- In laser ablation, a pulsed laser beam vaporizes part of a target, & the evaporate forms a thin layer on a nearby substrate.

(v) molecular beam epitaxy (MBE) :- Molecular beam epitaxy is an important technique that is some what similar to CVD. however, it can result in epitaxial layers of materials, including compound semiconductors.

(e) After processing, the photo resist is removed (along with any material deposited on top of the photo resist, which is known as lift-off), leaving the desired structure.

(2) Nanoimprint Lithography :-

→ Nanoimprint lithography (NIL) consists of pressing a stamp or mold conforming to the desired pattern onto a thin film on top of a wafer.

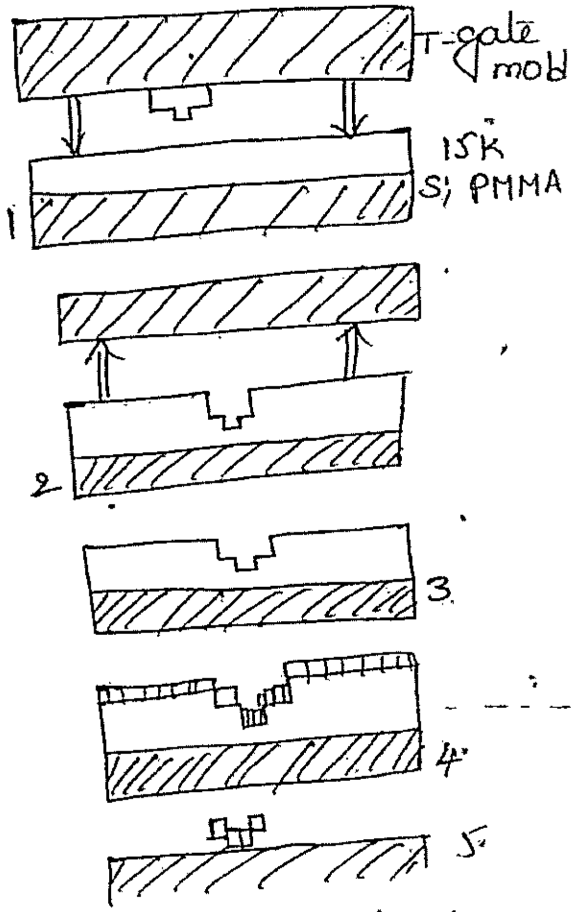
→ the resist is heated to a temperature at which it is thermo-plastic, becoming a viscous liquid. thus, the film can flow & be deformed into the shape of the mold. as shown in the fig.

→ Various processing steps including etching & material deposition, are then performed, as is done. the mold itself is often produced by electron beam lithography.

7.	Uma Maheshwar Janniekode, Rajendra Prasad Somineni, Osamah Ibrahim Khalaf, Malakeh Muhyiddeen Itani, **J. Chinna Babu,** Ghaida Muttashar Abdulsahib	A Symmetric Novel 8T3R Non-Volatile SRAM Cell for Embedded Applications	Symmetry-Mdpi Journal	Volume 14,Issue 4	1-15	2073-8994	WOS & SCOPUS	April 2022
8.	**V. Sai Anusha,** M. Kusuma, M. Mounika, G. Lokeshwara Reddy, K Rama Krishna Reddy	Medication Alerts And Supervisory Of Health Using IoT	Journal Of Information And Computational Science	Volume 12, Issue 3	137-142	1548-7741	Non - UGC	March 2022

→ It is a lithography technique that combines the speed of Lithography with the resolution of electron beam. we use nano imprint lithography for the nano structure.

→ it is a combination of optical lithography & electron beam lithography for many applications.



NIL lithography to make a T structure.

③ split Gate technology :-

→ Another method to form laterally confined nanostructures is the use of what are called split gates.

→ this forms an electrically controllable structure that can be adjusted by an applied voltage.

→ the idea is schematically depicted in the fig ⓐ & ⓑ.

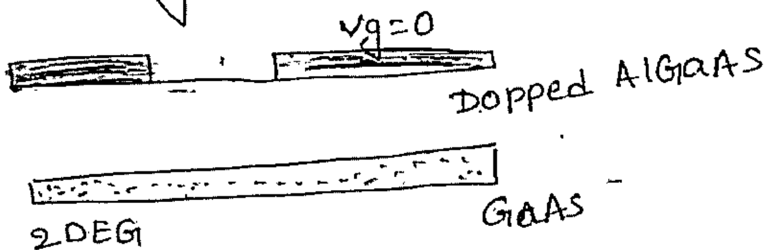


fig ⓐ split gate electrodes over a two dimensional electron gas.

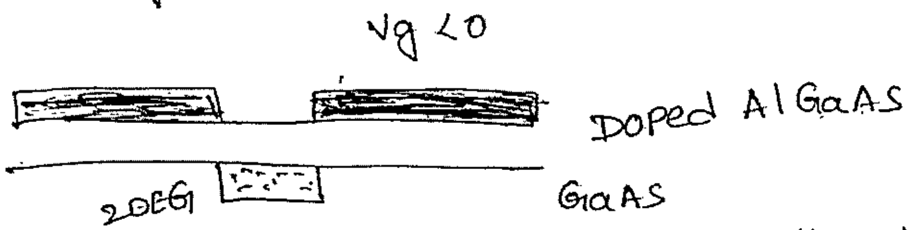


fig ⓑ split gate electrodes over a two dimensional electron gas.

→ one starts with a two dimensional electron gas, formed, for instance, by a semiconductor heterostructure. As shown in fig ⓐ schottky gate electrodes are deposited on top of the heterostructure.

Design, Simulation and Analysis of Wide-Band Directional Antenna Using Artificial Magnetic Conductor for Ultra Wide-Band Applications

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[1st]Associate Professor ,UG Scholar, Department of Electronics and Communication Engineering , Annamacharya Institute of Technology and Sciences(Autonomous), Rajampet, Andhra Pradesh ,India-516126

Abstract: Antennas is considered as one of the most important functioning element in wireless communication system. In this paper a wide-band directional antenna by using Inverted E-shaped slot Artificial Magnetic Conductor (AMC) for ultra wide-band applications is designed and simulated. In the recent antenna designs it is noticed that the AMC's are widely applicable as reflectors, in order to improve the radiation properties of antenna. As per the literature available the study says AMC's can achieve ±90° of reflection phase and bandwidth of 4.07 GHz (44.69%) and therefore they are very much suitable as reflectors. For wide band directional applications specific type of antenna is required. In this research work a proposed wide-band directional antenna which is made up of 5×4 AMC unit cell array having size of 56mm × 56mm is introduced. This proposed antenna is designed to operate over bandwidth of 91.5% (3.13-8.41GHz) and also improves the radiation properties. The proposed antenna's measured performance agrees well with simulated results. The proposed antenna structure is suitable for ultra-wide-band applications such as personal area network wireless connectivity, wide-range, low data rate communication, and radar and imaging systems.

Keywords: Antenna, Artificial magnetic conductor, wide-band directional antenna, HFSS.

I.Introduction

Nowadays, wireless communication is a common occurrence in daily life. The Majority of the electrical and technological devices in our environment use wireless technology. With the help of Wireless Communication, the transmitter and receiver can be placed anywhere between few meters (like a T.V. Remote Control) to few thousand kilometers. Antennas are a crucial components of this wireless network. The antenna design is very flexible, and rather than having an impact on the propagation characteristics, the choice of antenna is mostly driven by cost and profile considerations. Antenna is defined as electrical devices that transform the electrical signals to radio signals in the form of Electromagnetic Waves and vice-verse. An Electromagnetic Wave consists of both electric and magnetic fields in the form of time varying sinusoidal waves. Electromagnetic Waves carry the electromagnetic energy of electromagnetic field through space. An Antenna can be used either as a transmitting antenna or a receiving antenna. An antenna enables electromagnetic waves to travel from one end to the other without the use of a wiring system[3]. Generally it is witnessed the frequent use of wireless communication applications in our daily lives that made the living styles of individuals with more ease and comfort. Everything is related to wireless communication, from signals reaching the television to watch a variety of shows to talking with anyone on a mobile network. Thus, an antenna is required. Over recent years, considerable research efforts have been directed towards the development of antennas. Ultra Wide-Band technology has become a hot topic in recent research. Ultra wide-band is a technology for transmitting information across a wide bandwidth more than 500MHz. As a result, a significant amount of signal energy can be transmitted in the same frequency band without interference. UWB

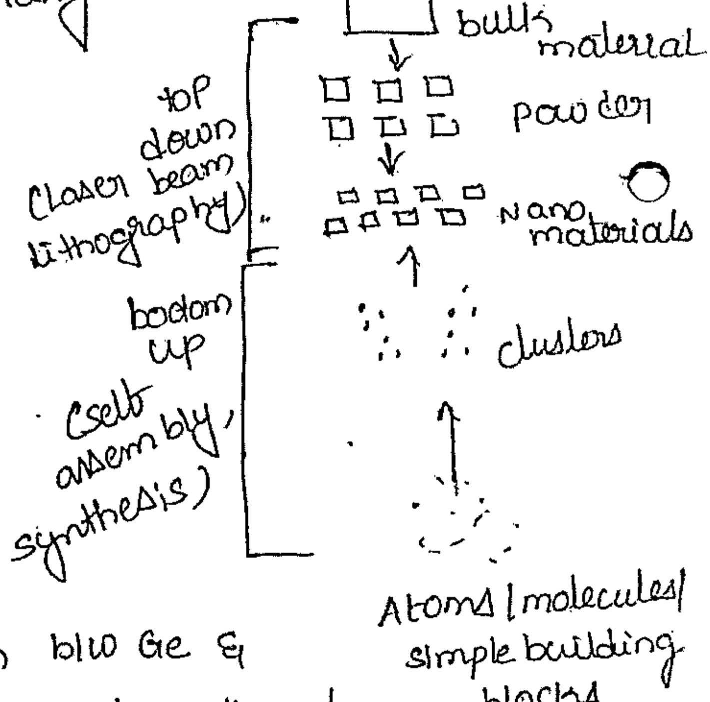
→ left unbiased, the electron gas remains unperturbed. however, application of a -ve potential to the electrodes depletes the electron gas below the gate & so the gate electrodes from a narrow electron gas channel under the split, resulting in a quantum wire.

→ As shown in fig (b) often the lateral etching, the confinement forming the wire is somewhat weak resulting in a soft barrier. Negative gate bias depletes electron below the gates, constraining the electron gas to a narrow region, forming a quantum wire.

→ Quantum dots can also be fabricated in a similar manner. In this case of a split Gate quantum dots the electrode pattern constrains the 2DEG formed by heterojunction in the shape of hole in the electrode.

④ Self - Assembly :-

→ self assembly techniques can be used to form a variety of nanostructures, & self assembly is one of the ultimate goals in nanostructure fabrication. Many new techniques will undoubtedly be developed.



① Lattice mismatch :-

→ the different crystallographic features of different materials can be used to advantage in self assembly, especially in the formation of quantum dots & related nanostructures.

→ for example, the lattice mismatch b/w Ge & Si results in the formation of three dimensional islands when Ge is deposited epitaxially on Si. the shape of the islands depends on the no of monolayers of Ge deposited on the Si surface - for six monolayers characteristic square pyramids tend to form.

17.	**P.Siva Kalyani**, M.Gangadhar, M.Harshitha Reddy, N.Lasya, M.Jaya Bharath Reddy	Analysis of Nephropathy Image Using LPMPR Filter And Morphological Watershed Segementation Alogorithm	Journal of Interdisciplinary Cycle Researcher	Volume: 13, Issue: 6	1422-1427	0022-1945	Non-UGC	June 2021
18.	**Dr.CH. Nagaraju**, U. Hima Bindu, B. Khadeej Ul Umerah, N. Chandrasekhar, P.Chakradhar Raju	Fixing DRC and LVS of the Layout for Sense Amplifier	Journal of Interdisciplinary Cycle Researcher	Volume: 13, Issue: 6	1607-1615	0022-1945	Non-UGC	June 2021
19.	**L. Siva Yamini**, B. Rani, V. Muni Lalith Kumar, G. Sree Vastav Reddy	A Hybrid Method for Vascular Enhancement and Artery Segmentation on 2D Retinal Images	Journal of Interdisciplinary Cycle Research	Volume: 13, Issue: 6	1622-1626	0022-1945	Non-UGC	June 2021
20.	**K. Sreenivasa Rao**, D. Bhargav Reddy, M. Lakshmi Kanthamma, S. Haseena Begam, P. Charan Teja	Saliency Based Image Segmentation to Analyse Covid-19 Infected CT scan Images	Journal of Interdisciplinary Cycle Research	Volume: 13, Issue: 6	1627-1632	0022-1945	Non-UGC	June 2021

② **Wet chemistry Methods:** – Quantum dots can also be synthesized by forming nano sized precipitates from chemical solutions. Quantum dots so formed are called colloidal quantum dots. this method has the advantage of producing large quantities of quantum dots in solution, which is often useful for biological & medical applications.

③ **Molecular self assembly:** – Molecular self-assembly is, as the name implies, the process of molecules organizing themselves into a desired structure. often this takes place in liquids, but it can occur in a gas & other host mediums. molecular self-assembly is obviously the goal in molecular electronics.

13.	**B. Prasanthi**, K.Himaja, A.Divya, L.Charan Kumar Reddy, C.Amarnath	Detection of Triple Riding Without Helmet Riders Using Yolov2 Detector Algorithm	Journal of Interdisciplinary Cycle Reasearch	Volume: 13, Issue:6	1359-1365	0022-1945	Non-UGC	June 2021
14.	**Dr.K.Riyazuddin**, G.Obulreddy, G.Pranavi, D. Sai Krishna ,P. Mohammad Imran	A Fencing System for contact Traceability of Covid-19	Journal of Interdisciplinary Cycle Reasearch	Volume13, Issue:6	1397-1403	0022-1945	Non-UGC	June 2021
15.	**R.Mahesh Kumar**, **N.Bala Dasthagiri**, D.Swathi, S.Swaroop Kumar	Design of Low Power Low Noise Current Mirror OTA using 45nm Technology	Journal of Interdisciplinary Cycle Reasearch	Volume:13, Issue:6	1404-1407	0022-1945	Non-UGC	June 2021
16.	**K. Naganarasaiah Goud,** S. Shermila, P. Siva Prasad , B. Siva Jyoshna, D. Shantha Babu	IOT based device for controling home appaliances using hand gestures	Journal of Interdisciplinary Cycle Researcher	Volume: 13, Issue: 6	1412-1416	0022-1945	Non-UGC	June 2021

UNIT-3

Quantum Electronics

→ Traditionally, Microelectronics is based on scaling towards smaller structures. when the dimensions of these structures reach the nanometric scale, microelectronics has already transformed to nanoelectronics.

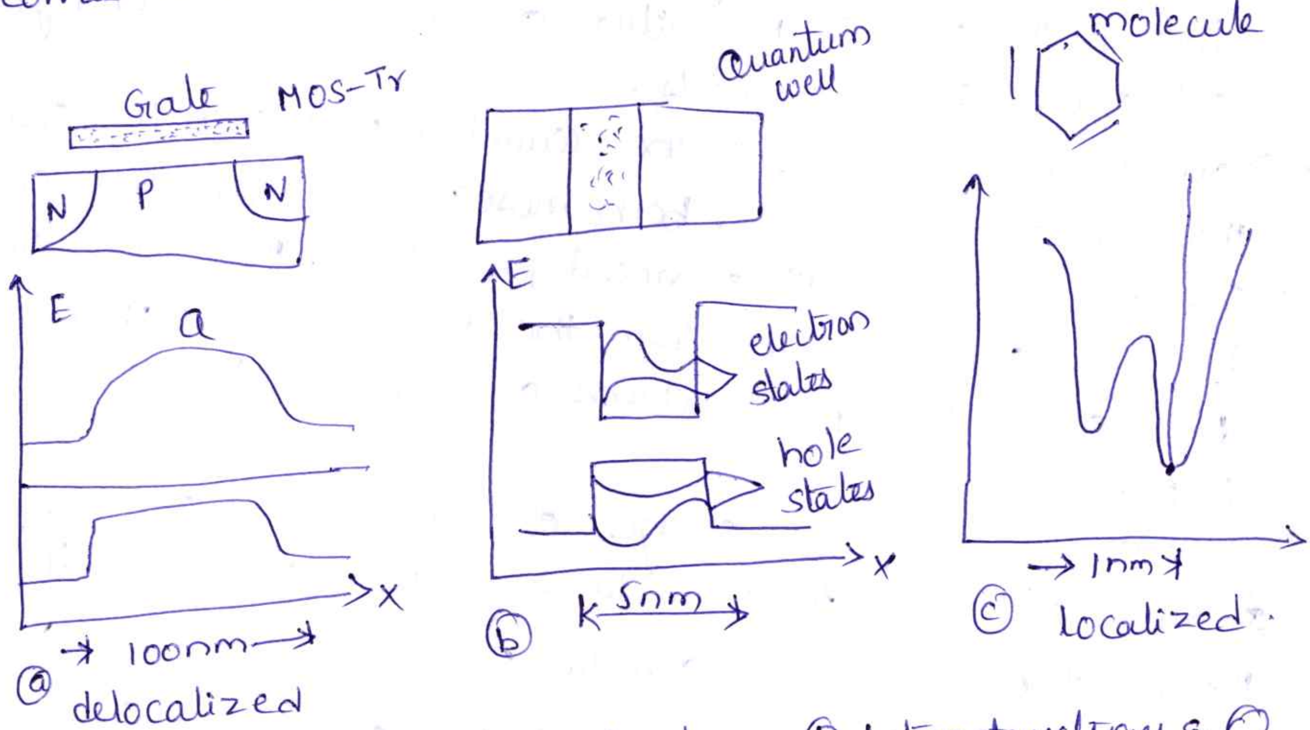
→ future systems that are composed of these nanometric structures require both novel architectures & Modern switching devices.

Quantum Electronic Devices :- (QED)

upcoming Electronic Devices :-

→ In the classical sense, a semiconductor switch depends on electrons that can be characterized by their elementary charge q. this simplified model is becoming technically obsolete when it comes to nanoelectronics.

→



(a) delocalized (b) (c) localized.

fig: charge storage : (a) homostructure (b) heterostructures & (c) molecule. the switching event of the MOS transistor is characterized by many electrons, whereas other devices only change the state of a single electron.

→ Nano electronics has a much higher packing density than conventional FET electrons, thus it is most Important to work towards new architecture concepts.

→ At present, the min feature size of Integrated ckts is ruled by the delocalized charge storage & is in the range of almost 100nm. however, within the boundaries of classical physics local charge storage is known, e.g molecules, only requires few nanometers.

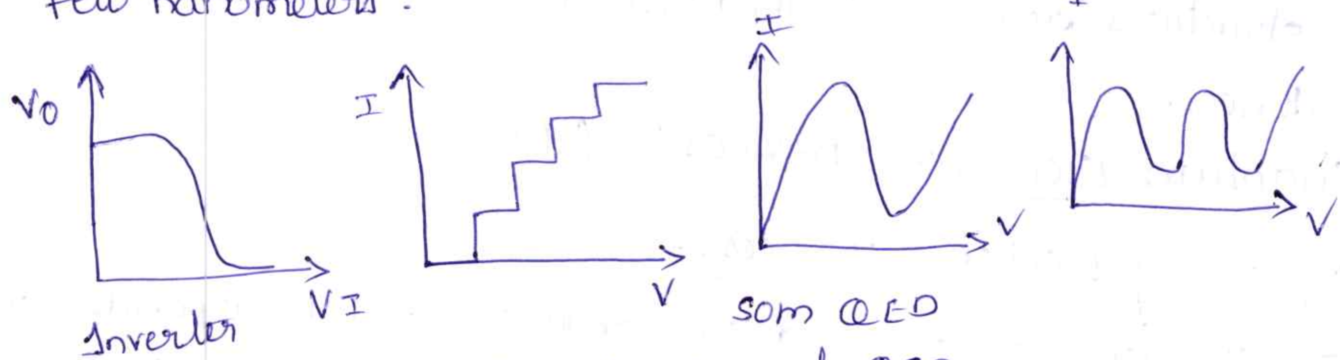
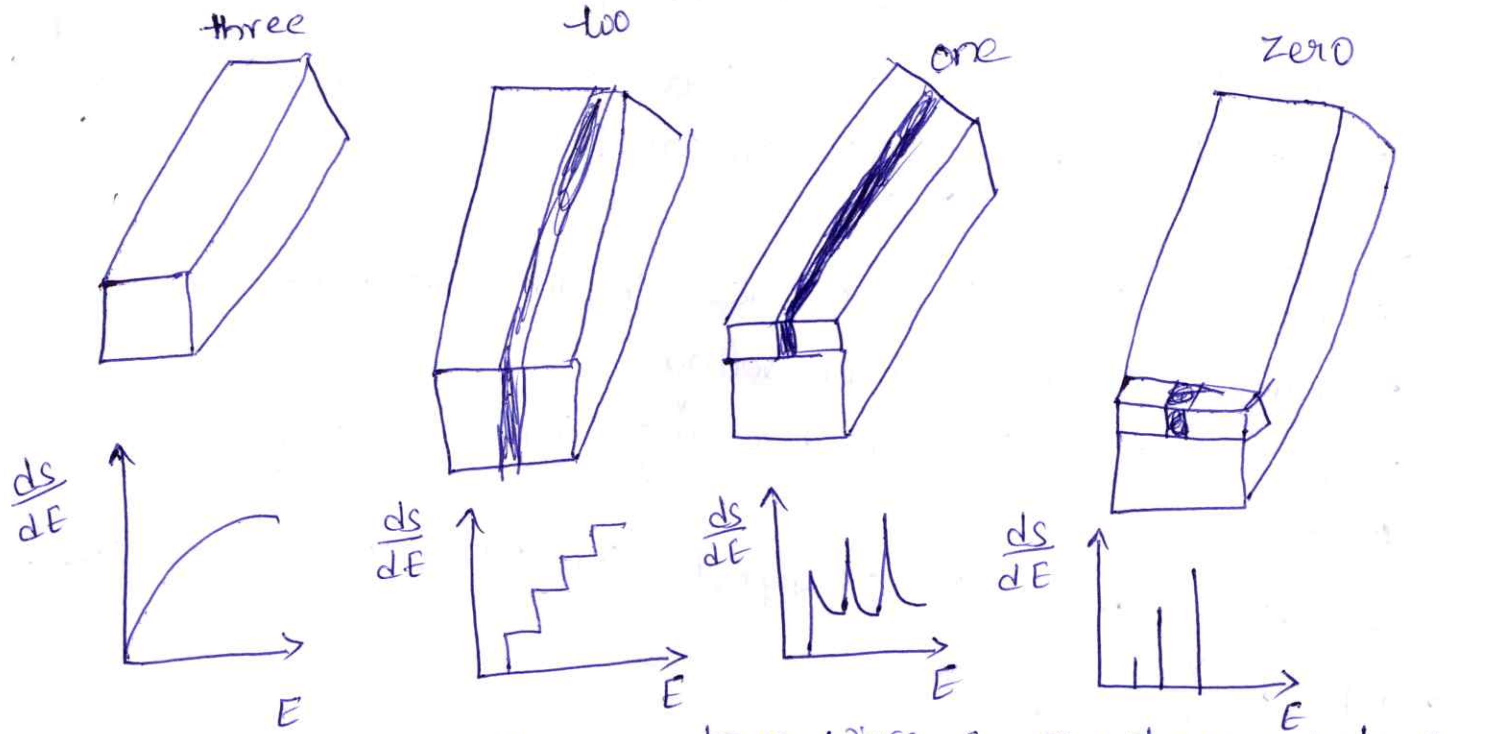


fig some I-V characteristics of QED.

→ these dimensions can be reached in terms of very thin semi-conductor & Insulator layers. Devices that have at least one dimens-ion in the order of magnitude of the electron wavelength are called mesoscopic elements.

→ one of these elements is the Quantum well with its characteristics thin semiconductor layer. both mesoscopic & Quantum effect devi-ces are featured with enhanced properties. the single electron transistor (SET) emerges from the MOS transistor if it is scaled down & the two pn-Junctions are replaced by tunneling element (TE).

→ within the SET the charge of one electron controls the current of single electrons. In a similar way flux quantum devices control the no of magnetic flux Quanta in a ring structure via two tunneling elements, the dimensions of such a configuration need not be in the nanometric range.



Quantum well, quantum wire & quantum dot structures

Short channel MOS Transistor :-

→ since the conducting channel of a MOS transistor is very thin, its inversion layer can be considered as a two dimensional electron gas in a quantum layer. therefore different stationary electron waves can be traced in its cross section.

→ the discrete energy levels of such a quantum layer appear at low temperatures. experimental results reveal oscillations in the I-V characteristics of short channel MOS transistors as shown in the fig.

→ these oscillations are due to quantum effects.

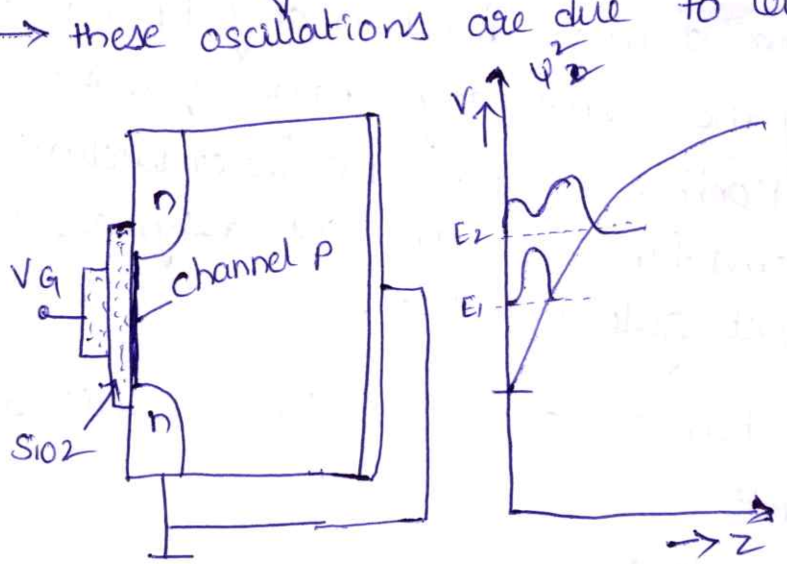
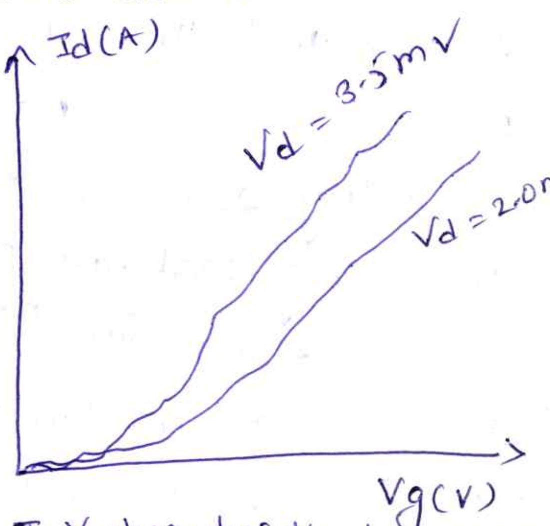


fig: Appropriate doping & adequate dimensions



I-V characteristic of a MOS transistor.

→ At lower electric fields the electron drift velocity is proportional to the electric field but at higher electric fields the electron drift velocity gets saturate.

<u>effects</u> :-

① electron drift characteristics in the channel.

② change in the threshold voltage.

③ Drain Induced barrier Lowering & punch through

④ surface scattering

⑤ velocity saturation ⑥ Impact ionisation ⑦ Hot electrons.

Split Gate transistor :-

→ the split gate transistor is an Interesting example of mesoscopic systems. the small dimensions of the gate split result in different wave configurations that have a direct impact on the conductance b/w the source & drain contacts.

→ the gate voltage alters the shape of the potential well. mainly, the depth of the potential well is modified so that more eigen-states can be occupied. consequently, the conductivity b/w S & D Increases.

→ this Increase does not take place in a continuous way, but is a staircase function of the gate voltage. It is of fundamental Interest that the step of the staircase function only depends on physical Quantities, namely the elementary charge q & the elementary quantum of action h. therefore, parameter fluctuations that, in general, are problems for sub-um ckt designers are not an issue for the split gate transistor.

→ the grid of the stair case function can be derived heuristically from the uncertainty principle

$$\Delta E \Delta t \geq h \rightarrow ①$$

→ the energy is proportional both to the voltage V & to the charge 2q, bcoz each state below the fermi level can be occupied by two electrons. the time t depends on the transport time of an electron & can be expressed as q/I.

→ with respect to the uncertainty principle, the conductance can be expressed as

$$\Delta G = \frac{I}{U} = \frac{2q^2}{h} \rightarrow ②$$ which is equivalent to the step of the staircase function.

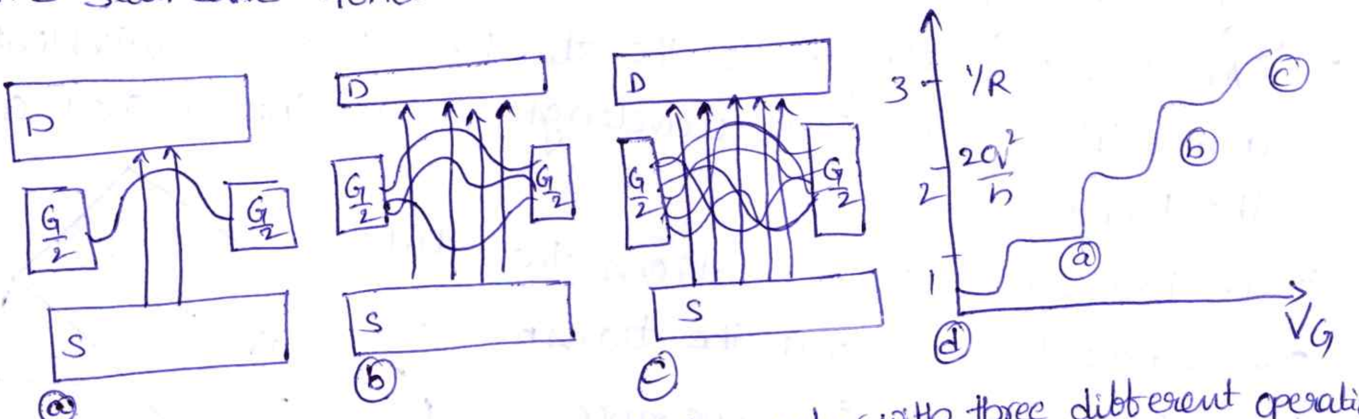


fig: Mesoscopic element: split gate transistor with three differrent operation conditions (a-c) & its GVg characteristics ⓓ that can be described by schrodinger's equation.

→ A similar behavior shows in the fig that comprises a MOS transistor with four connections. at the channel area. the 2D electron Gas (2DEG)

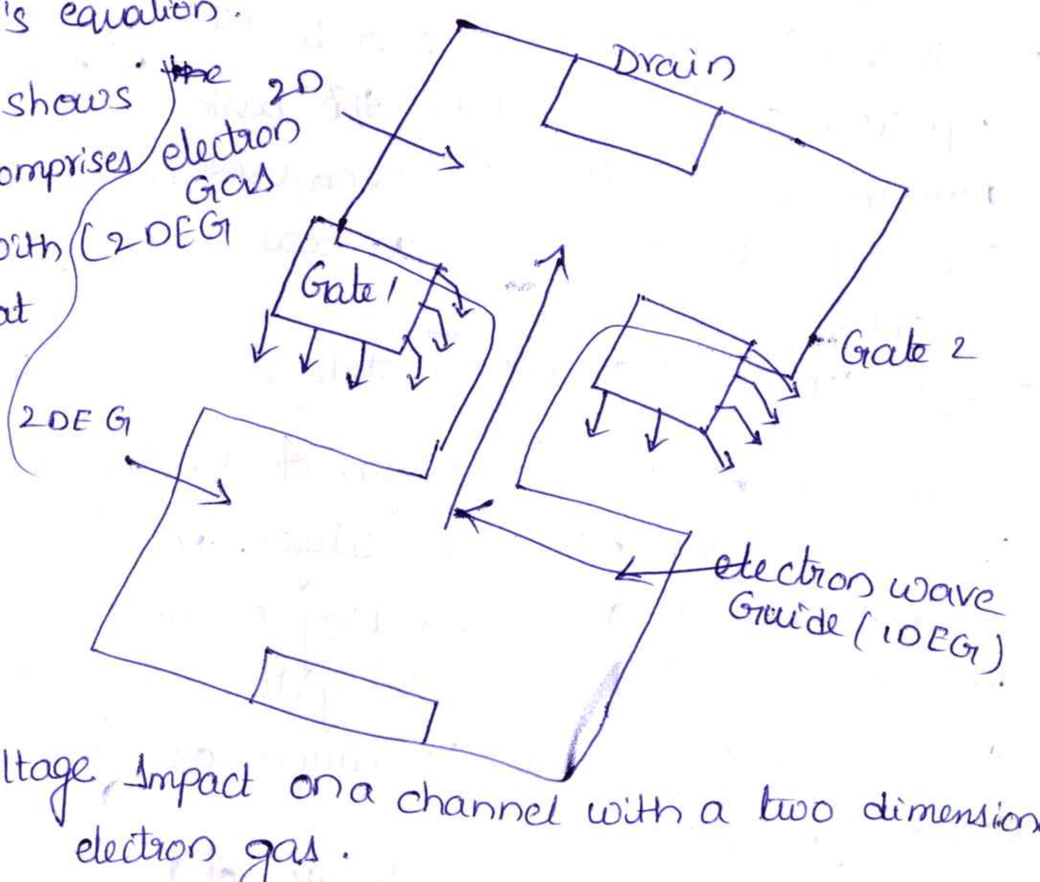


fig: voltage Impact on a channel with a two dimensional electron gas.

Electron Wave Transistor:-

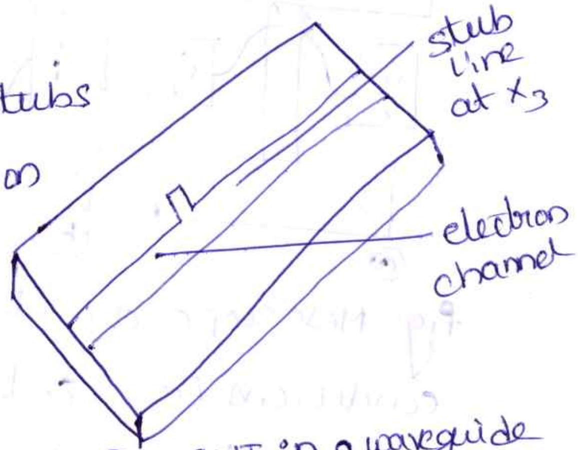
→ A further progress of the previously described devices leads to structures in which the electron waves have an even more important impact.

→ fig depicts a transistor in which single electrons form a current flow along the x-axis. the principle of the device is quite simple the effective length of the stub line can be varied via the gate voltage.

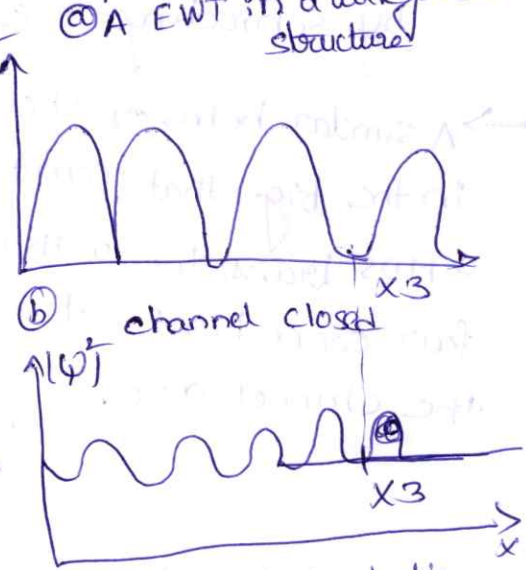
→ An effective length of the stub line that is equivalent to a multiple of the half wavelength results into a short cut at the tapping.

→ In this radio communications the stubs are commonly used with the transmission lines & wave guides for impedance matching purpose as well as for the frequency selective purpose.

→ these cases the stubs can be either capacitive or inductive type. the basic principle of stub line has been used in the electron wave transistor to switch ON & OFF.



ⓐ A EWT in a waveguide structure



ⓑ channel closed

channel conducting

case 1:-(ON state) conducting state:-

→ when the effective wavelength of the stub line ie, $n = \lambda/4$, n is a +ve integer. the electrons entering into conducting channel will have no effect due to gate voltage will move freely & this conducting state is called as ON state.

case 2:- OFF state

→ when the effective wavelength of stub line ie, $n = \lambda/2$, n is a +ve integer. the electrons entering into the conducting channel by the gate voltage & hence the electrons will get short circuit so there is no current at the O/P. this non conducting state is called as off state.

Electron Spin Transistor :-

→ Quantum electronics can also exploit the spin of a single electron. In the literature such a magneto-electronic approach is referred to as spintronics.

→ In a kind of bipolar structure the emitter & collector consist of ferromagnetic layers, whereas the base is made of a semiconductor material as shown in the fig.

→ As indicated by the arrows the magnetic layers have been magnetized by external magnetic fields. the spins of the electrons that enter through the emitter align to the magnetization of the emitter layer & travel towards the base.

→ Electrons can only pass from the base to the collector if their spin aligns with magnetization of the collector. for a correct operation, the layer thicknesses have to be in the nanometric domain. All lateral dimensions can also be scaled down, which leads to a real nanoelectronic device.

→ this technology of spintronics may be very promising for memories with large capacities. they may replace the magnetic hard discs.

fig: principle of the electron spin transistor.

→ A high collector current can only pass if the spins align with the magnetization of the collector.

→ whenever the transistor is on condition the allignment of ~~spin~~ spin of electrons entering collector from base is equal to the magnetization of collector.

→ whenever the transistor is off there is no allignment of spin of electrons entering collector from base is equal to the magnetization of collector.

Quantum cellular automata :-

→ the Idea of QCA's is quite young. Its concept describes a smart way to realize cellular automatas in a nanotechnology. presently, cellular arrangements of quantum dots count among highly Innovative concepts of solid-state electronics.

→ they are very promising, since they depends on neither metallic wiring nor electric currents. the basic QCA cell consists of four quantum dots that are arranged in a square as shown in fig.

→ Each QCA cell comprises two electrons. they autoarrange in a diagonal because of their coulomb Interaction. this results in two different configuration that are suitable for a binary representation.

→ Via an External Influence it is possible to change from one configuration to the other. typically, the External Influence consists of an electric field, meanwhile the potential barriers have to be lowered.

→ on the basis of this principle Information processing will be feasible. before changing the polarization of a QCA cell, the potential barriers have to be lowered in order to reduce the localization of the electrons & to Increase the tunneling probability.

→ Typically an adiabatic switching scheme is applied that is similar to the adiabatic charging & discharging of capacitance as shown in the fig.

→ this relatively slow switching scheme is equivalent to the clocking scheme of logic gates & supplies energy to the QCA.

→ During the switching event the localization probability of the two electrons is uniformly distributed on the four quantum dots. after raising again the potential barriers the desired configuration is set up with respect to the external field.

→ one has to keep in mind that the two stable configurations depends on two electrons. these electrons have to be fed in a lateral manner into a chain or even grid QCA structure.

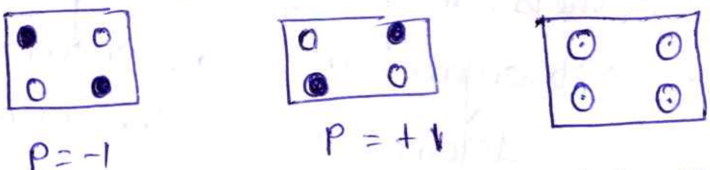


fig. QCA cell polarization used to encode binary Information.

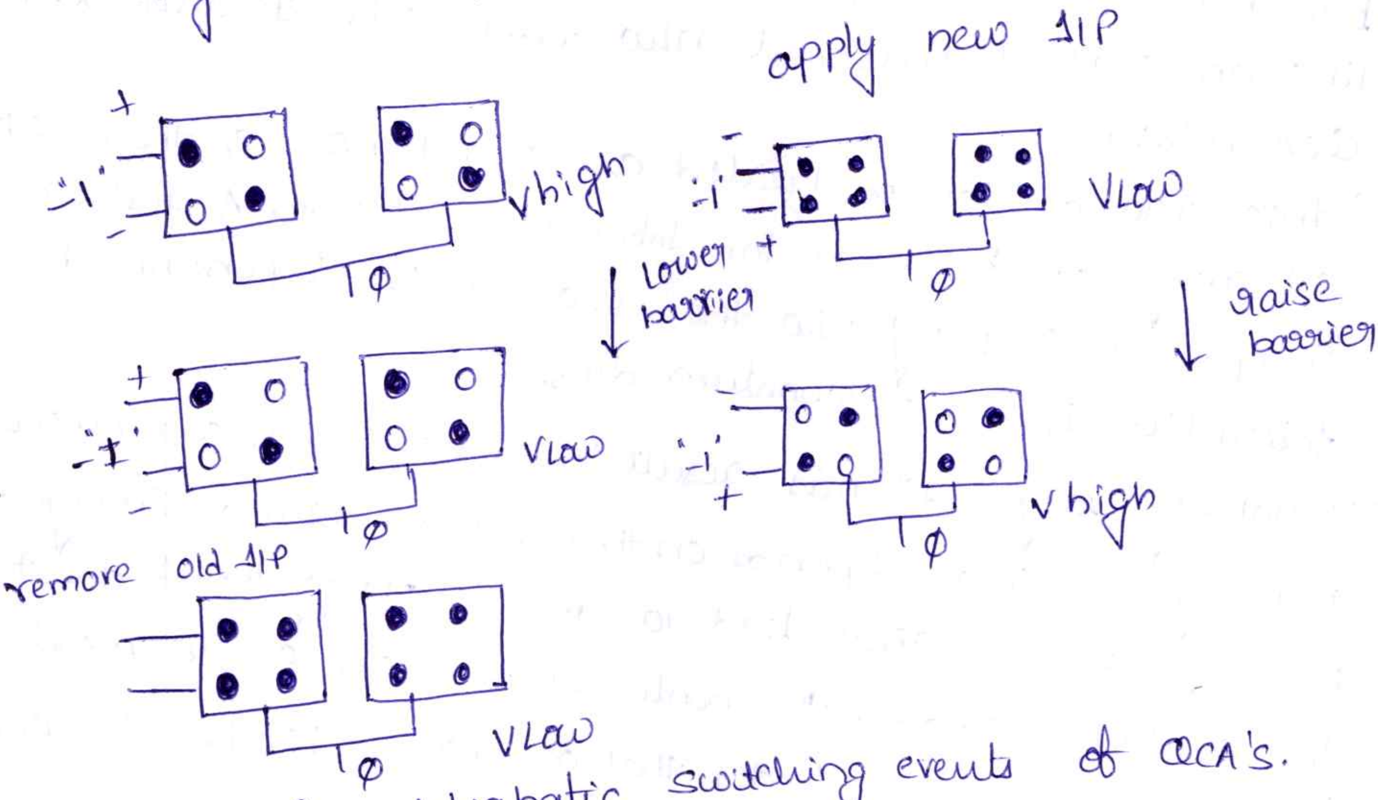
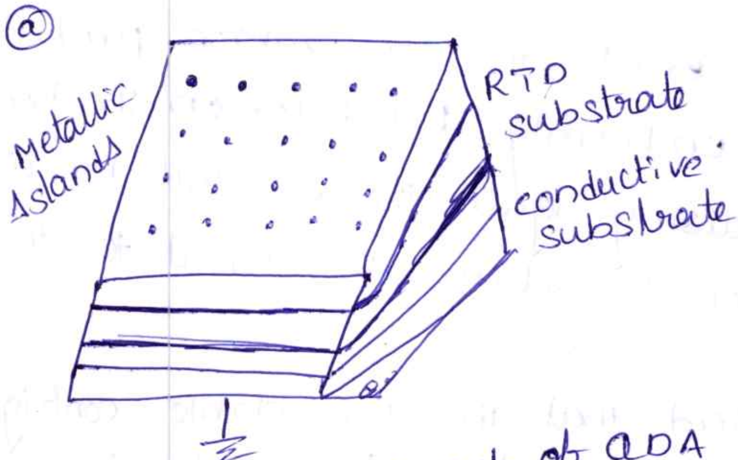


fig: Adiabatic switching events of QCA's.

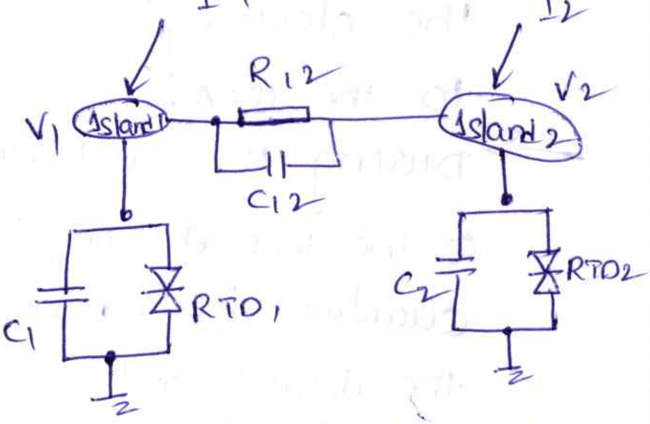
Quantum Dot Array :- (QDA)

→ A more advanced concept implements arrays of quantum dots that interact with their neighbors. due to the coupling the quantum dots shows an interesting dynamic behavior as shown in the fig.

@



fig@ technology arrangement of QDA



fig(b) equivalent networking with respect to their substrate interaction.

→ such quantum dot arrays can be realized e.g with metallic islands such as gold clusters. they might arrange themselves in a uniform process via self organization as shown in the fig.

→ the dimensions of a single island are in the domain of a few nanometers. this network has multiple stable states like an artificial neuronal n/w which sets it apart from QCA networks.

→ this islands can be treated as capacitances & their electrical charge can be used for information storage. A resistance & capacitive coupling b/w the islands is responsible for the interaction b/w the quantum dots.

→ Relatively large islands result in a nonlinear, continuous n/w system that depends on the stored island charge. however, small islands lead to discrete energy levels due to the coulomb blockade. the nonlinear behaviour can be modeled by resonant tunneling diodes that are located b/w the substrate and the Islands. typical for such Quantum dot networks are Image processing at low level & associative Information storage systems.

→ Boolean operations have been already realized with small Quantum dot networks. In principle, all problems that can be described with non-linear differential equation can be solved with these networks, assuming that the correct Initial & boundary conditions have been fed into the n/w.

A

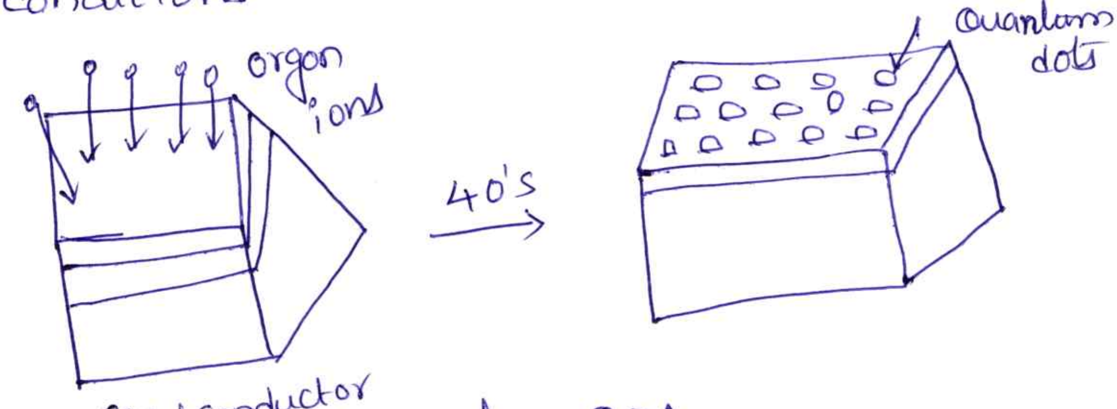


fig: Self assembling of a QDA.

Applications :-

1. Quantum computers.
2. Image processing.
3. Associative of memory for storage system.
4. solving non-linear differential equations.
5. Qubit - each dot represents. If the dots are located close to each other (≤ 4nm) the electrons states couple among themselves, which leads to coupled Qubits.

UNIT-4

Tunneling Devices

→ from today's point of view tunneling elements (TE) such as the resonant tunneling diode (RTD) are of fundamental relevance for Nanoelectronics. At present they are the most mature type of all quantum effect devices.

→ compared to single electron transistors (SET) & more advanced quantum dot architectures, resonant tunneling devices are already operating at room temperatures. technological advances, such as the development of a III-V, large scale integration process, & the demonstration of a Si/Si0.5 Ge0.5/Si resonant interband tunneling diode are a challenge for ckt designers to develop digital logic families & memory arrays.

Tunneling Element :-

→ Among all mesoscopic switching elements the tunneling elements (TE) are at present of fundamental relevance for nanoelectronics. A tunneling element consists of two conducting materials separated by a very thin insulator.

→ By means of bandgap engineering we can tune the I-V characteristics of the tunelling elements in such a way that it has a region with negative differential resistance (NDR). the tunneling diode (TD) & the resonant tunneling Diode (RTD) are the most common tunneling elements.

→ the basic idea behind Resonant tunneling device ckt design is to exploit the non-linear characteristics with the typical negative differential resistance (NDR) region.

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Ain Shams Engineering Journal
Volume 15, Issue 3, March 2024, 102482

Application of multi agent systems for advanced energy management in cyber physical hybrid microgrid systems

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Abstract

This paper develops a multi agent system in real time for hybrid microgrids as advanced energy management (ADEM) protocol using a Java agent development environment (JADE) frame work. The proposed system is configured with two micro-grids, each having 1kw solar photo voltaic power, 1.5Kw wind power, 24V, 150AH battery along with a local load, thus making it a hybrid Microgrid, modelled in MATLAB/Simulink. Due stability constraints while using MATLAB/Simulink, in a multi-threading environment, a middle ware called Multi agent Control Using Simulink with Jade Extension (MACSimJX) is adopted. The microgrid environment variables are captured through sensors, delivered to the agents operations in JADE, for the implementation of dynamic operation in hybrid microgrids. This results in maximizing operational efficiency of hybrid microgrids system. The simulation suggests that MAS can successfully manage dynamic loads, generated power in real time microgrids.

Previous

Next

Keywords

Micro-grids; *Multi Agent systems (MAS)*; *Real time simulation*; *Energy Management system (EMS)*; *JADE*; MACSimJX

1. Introduction

Tunneling Effect & Tunneling diode :-

Tunneling Effect :-

→ fig ① shows the schematics of two basic tunneling elements configurations. A convenient solution is the TE with a vertical layer structure as shown in fig ⓐ but technology most commonly uses horizontal layer structures. these layers can be precisely deposited & are in the range of 1 to 5nm, which roughly is equivalent to the no of SiO_2 layers.

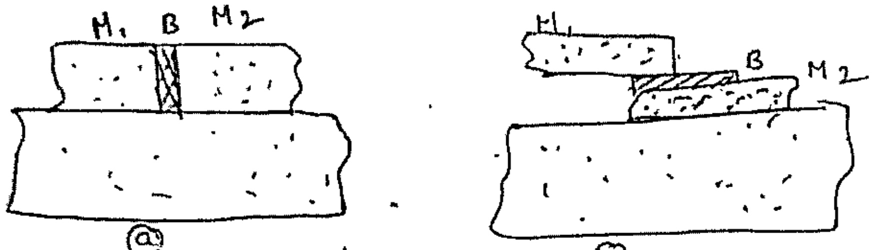

fig ① schematic views of tunneling elements with vertical & horizontal oriented barriers.

→ the tunneling effect refers to particle transport through a potential barrier where the total energy of a classical particle is less than the potential energy. In the classical sense this particle transport is not possible. this effect can be explained if the particle is treated as a material wave.

→ the course of the ψ function in the x-direction can be described by schrodinger's wave function. fig ⓑ shows the solution for a specific case. the solution of the wavefunction must satisfy certain boundary conditions at the abrupt interfaces of the barrier. this leads to a certain portion of an incident wave being transmitted & a certain portion reflected.

→ on the ~~other hand~~ left side of the barrier one can observe the entering & the reflected wave. within the barrier the wave is attenuated, whereas on the right side of the barrier the

Making Cell-Free Massive MIMO Using MRC Technique

| Conference paper | First Online: 27 September 2023

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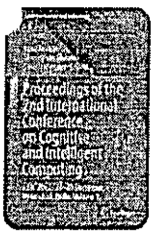

Proceedings of the 2nd International Conference on Cognitive and Intelligent...

(ICCIC 2022)

Sk. Khudsia Tabassum, D. Vishnuvardhan, G. Mamatha & Fahimuddin Shaik

Part of the book series: Cognitive Science and Technology ((CSAT))

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International Conference on Information and Management Engineering

Abstract

While demonstrating that partially or completely centralising signal processing at the central processing unit (CPU) improves spectral efficiency, this study advocates for the utilisation of maximum ratio trying to combine at each access point (AP) (SE). Cell-free massive MIMO is

wave of the tunneled electron can be found.

→ fig ③ depicts the solution & tunneling probability of the electrons. the tunneling probability increases for higher particle energies.

→ Due to reflections of the particle wave not all electrons can cross the barrier, even if their energy is higher than the potential energy of the barrier. the electron wave can only cross the barrier without dissipation if the energy of the electron is six times higher than the potential energy of the barrier.

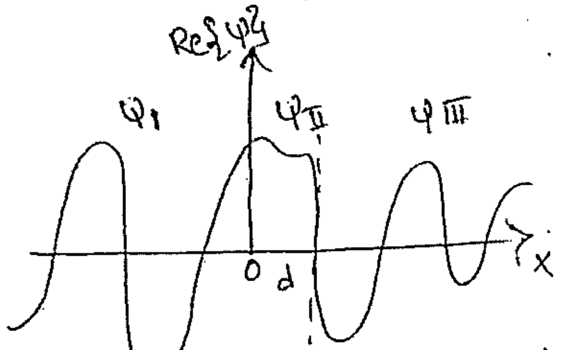

fig ② tunneling effect the material wave is attenuated within the barrier.

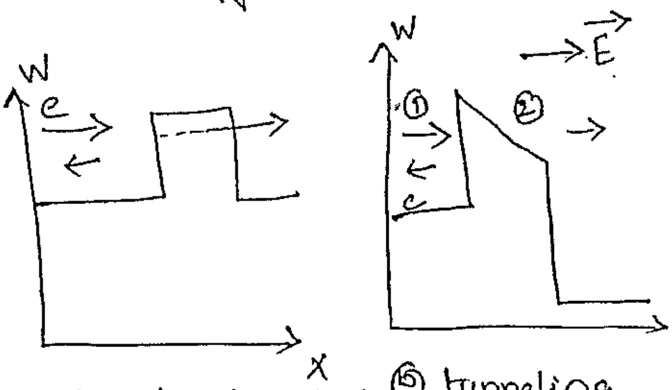

fig ③ ⓐ tunneling barrier in its ground state ⓑ tunneling element with applied voltage.

Tunneling probability $D \simeq C\left[-\frac{d}{h}\sqrt{2m(W_0 - E)}\right]$ $E = -\frac{h^2}{2m}$

C - constant proportional factor, h - planck's constant.

E - energy can tunnel with probability D through a potential barrier that has height W_0 & width d, m represents the electron Mass.

→ once the electric field Removed the barrier shape returns to its initial state & the tunneling probability decreases. this effect is used in EEPROM.

→ Tunneling elements are very Interesting switching elements for nanoelectronic applications bcoz the electron transport takes place without any loss of energy. Additionally, the switching speed of the elements is very high, bcoz the potential barriers are very thin.

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Multimedia Tools and Applications

Aims and scope

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C. Venkatesh, J. Chinna Babu, Ajmeera Kiran, C. H. Nagaraju & Manoj Kumar

A Correction to this article was published on 15 April 2024

This article has been updated

Abstract

Cancer is a common disease with an increasing mortality rate in recent years. Lung cancer is the most common cancer in men and women alike. It is caused by uncontrolled cell development in the lungs. These cells are divided into two types: benign and malignant. Benign tumours are usually harmless, do not spread to other cells, and have a smooth and regular shape, whereas malignant tumours can be dangerous and spread to other body cells to form a new cancerous nodule with an uneven shape. If lung cancer is detected early, it can be treated. Lung cancer symptoms typically appear in the human body when it is in its final stage, but advanced technology and computer-aided systems can detect it at an early stage. Currently, numerous conventional and machine learning techniques are used for such automated detection systems to detect lung cancer in its early stages, but such automated detection systems do not provide accurate detection and the processing of lung cancer detection takes a long time. As a result, a

Tunneling Diode (or) Esaki Diode :-

→ the interesting feature of a tunneling diode is its -ve differential resistance. It consists of two semiconductors that are separated from each other by a thin insulator. fig ①ⓐ shows the potential barrier caused by an insulator. Electrons can tunnel through this barrier only if it is thin.

→ A further requirement for the tunneling process is the existence of an unoccupied band on the other side of the barrier. the unoccupied band can pick up the tunneling electrons as shown in fig ①ⓑ. the barrier thickness can be altered by an electric field.

→ the tunneling process can still be impossible, even if the barrier thickness is very thin bcoz of the absense of a free band at the other side of the barrier. for higher electric fields the influence of the barrier can be neglected & the common diode effect can be observed. the complete I-V characteristics of the tunneling diode with its negative differential resistance region is depicted in fig ②

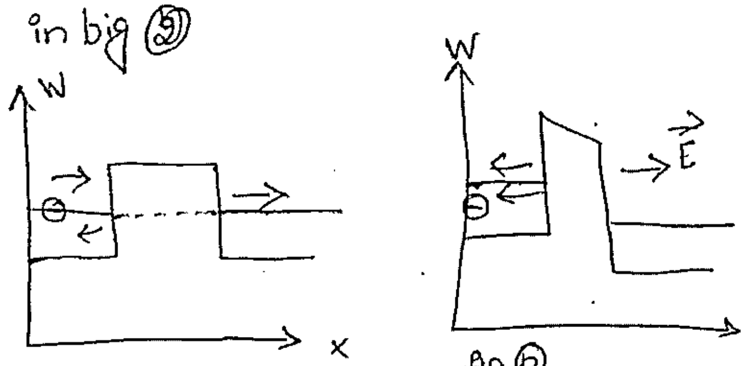

fig ① ⓐ tunneling effect in semiconductors fig ⓑ

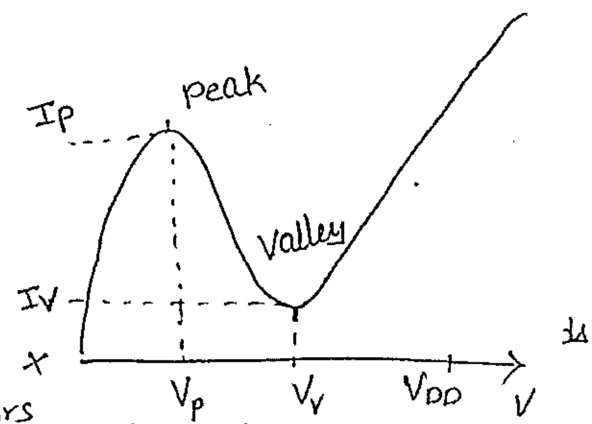

fig ② typical I-V characteristics of a tunneling diode

→ one can observe a falling slope in the characteristics, which in general is referred to as the negative differential resistance (NDR).

Deep concatenated features with improved heuristic-based recurrent neural network for hyperspectral image classification

Published: 06 November 2023

Volume 83, pages 49875–49904, (2024) Cite this article

Multimedia Tools and Applications

Aims and scope

Submit manuscript

Marri Venkata Dasu, P. Veera Narayana Reddy & S. Chandra Mohan Reddy

Abstract

Hyperspectral remote sensing is one of the important approaches in the area of remote sensing owing to the latest enhancements in the Hyper Spectral Imaging (HSI) technology. The classification represents a direct approach in the HSI field that provides every pixel a particular semantic label based on its behavior automatically. Nowadays, deep learning-oriented techniques have gained wide attention in the area of HSI classification. Although Convolutional Neural Network (CNN)-oriented techniques are subjected to the HSI classification, their performances are not up to the expectation. This is because; the majority of the traditional techniques cannot utilize the intrinsic behavior of distinct pixels in HSI

→ the essential parameters of the TD are the peak current I_P, the valley current I_V, the peak voltage V_P & the valley voltage V_V. these parameters can be derived from the band diagram. the ratio of I_P to I_V is important for circuit designers bcoz its direct influence on the signal Amplitude.

→ In this minimization of the valley current is a challenging issue. in the quiescent state of the gate this current has still to be delivered. therefore it seems that this technique is only suitable for low power applications if the valley current can be reduced to approximately zero.

→ for very fast circuits the valley current can almost be ignored, since capacitances is the main cause for the (dis) charging of parasitic power dissipation.

→ the Esaki diode consists of a pn junction with extremely high doped semiconductor regions. the upper part of the valence band that is located in the p-type region overlaps with the lower part of the conduction band that is situated in the n-type region. both regions are separated by a very thin space charge region that should prevent any current for small voltages.

→ Quantum mechanics explains the tunneling of electrons through such a thin space charge region. therefore one can observe a high current through this region even for a small voltages. this current reaches a max value for a specific voltage. for higher voltages the current start to drop bcoz the overlap of both bands shrinks.

→ for even higher voltages the regular diode current starts to contribute to the overall current, which therefore increases for a second time.

Multi-region minutiae depth value-based efficient forged finger print analysis

M. Baskar, Renuka Devi Rajagopal, PRASAD B. V. V. S., J. Chinna Babu , Gabriela Pajtinková Bartáková, T. S. Arulananth

Published: November 16,,2023 • https://doi.org/10.1371/journal.pone.0293249

Abstract

The application of biometrics has expanded the wings to many domains of application. However, various biometric features are being used in different security systems; the fingerprints have their own merits as it is more distinct. A different algorithm has been discussed earlier to improve the security and analysis of fingerprints to find forged ones, but it has a deficiency in expected performance. A multi-region minutiae depth value (MRMDV) based finger analysis algorithm has been presented to solve this issue. The image that is considered as input has been can be converted into noisy free with the help of median and Gabor filters. Further, the quality of the image is improved by sharpening the image. Second, the preprocessed image has been divided into many tiny images representing various regions. From the regional images, the features of ridge ends, ridge bifurcation, ridge enclosure, ridge dot, and ridge island. The multi-region minutiae depth value (MRMDV) has been computed based on the features which are extracted. The test image which has a similarity to the test image is estimated around MRMDV value towards forgery detection. The MRMDV approach produced noticeable results on forged fingerprint detection accuracy up to 98% with the least time complexity of 12 seconds.

Citation: Baskar M, Rajagopal RD, B. V. V. S. P, Babu JC, Bartáková GP, Arulananth TS (2023) Multi-region minutiae depth value-based efficient forged finger print analysis. PLoS ONE 18(11): e0293249. https://doi.org/10.1371/journal.pone.0293249

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Data Availability: All relevant data are within the paper and Supporting Information.

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Competing interests: The authors have declared that no competing interests exist.

1. Introduction

Various organizations have used the development of information technology to meet their goals. As the organizations have a variety of information on their system, which belongs to different users and business partners, they are responsible for securing the data most effectively. Any organization faces various challenges against the data maintained through threats. The security measures which can be different are enforced to secure the data and handle the problem of illegal access. Access restriction is the most dominant one, which restricts the illegal user from accessing the available data. In this way, different approaches are used, like profile-based access and key-based access restriction methods. However, the performance of such methods is not efficient in meeting the system's security requirements as they can be tampered with easily by various adversaries. Using biological features is more effective in enforcing such security systems. The facial features and thumb features are more challenging for the adversary that can support such security systems. Fingerprints and palm prints can be used towards the problem effectively.

Human fingerprint has great independence among other features of biometrics. It has unique characteristics which vary between any number of users. It has components of Minutiae ending, bifurcation, islands, dots, and so on. These components can be common in all human fingerprints but vary in numbers and sizes. The components and their numbers can be obtained by processing the fingerprint image. These numbers will not correlate with any other numbers. So, by adopting such finger analysis in security systems, the performance of authentication and illegal access restriction can be enforced most strictly.

The picture of the sample fingerprint is presented in Fig 1, which has both original and altered fingerprints. The adversary or malformed user would try to breach the security walls by producing an altered print to the system. However the system should be capable of differentiating the original and altered one. So, the security system should consider various features from the ridge like dots, islands, ends, enclosure, and bifurcation. By considering such features in the authentication and verification process, the problem of forgery detection can be handled effectively.

Resonant Tunneling Diode (RTD):-

→ the typical negative differential resistance of the tunneling diode is very noticeable for the resonant tunneling diode as shown in fig. within the RTD the source & drain contacts are seperated from the channel region W by tunneling elements. the channel region W can be described as the potential well.

→ Its behaviour can be derived from the Esaki tunneling diode. the band structure of the channel has to be approximately on the same level as the band structure of the source contact. otherwise only a small current flows through the device.

→ the term 'resonant' refers to the behavior of the de broglie wave in the quantum well. It is located b/w the two barriers & emerges if the energy of the tunneling electrons is equivalent to the level in the quantum well.

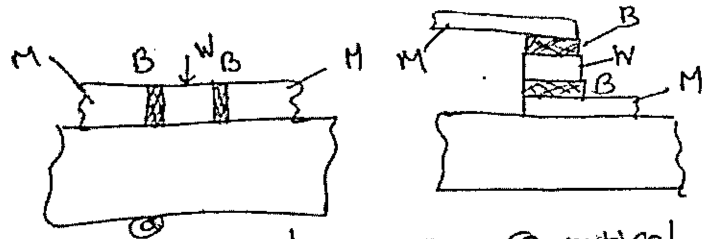

fig: cross section of the RTD (a) vertical barriers. (b) horizontal barriers.

Three terminal RTD's:-

→ the Monolithic Integration of an RTD structure into the emitter branch of a bipolar transistor is called a 'resonant tunneling bipolar transistor' (RTBT). In this case, the regular p-n junction b/w the two terminals base & emitter is replaced by an RTD structure as shown in the fig.

→ the I-V characteristics reveal the amplified collector current with the typical NDR behaviour. Another solution for the field effect transistor Isolation problem is the combination of the field effect transistor with an RTD (SET).

An IoT Framework to Support Rural Population with Diabetic Related Issues via Optimization Algorithms

| Chapter | First Online: 08 December 2023

| pp 387–394 | Cite this chapter

Modern Approaches in IoT and Machine Learning for Cyber Security

Vinit Kumar Gunjan, Fahimuddin Shaik & Rashmi Pathak

Part of the book series: Internet of Things ((ITTCC))

Abstract

Currently, image processing and IoT technologies are notable in unravelling various challenges

→ the essential parameters of the TD are the peak current Ip, the valley current Iv, the peak voltage Vp & the valley voltage Vv. these parameters can be derived from the band diagram. the ratio of Ip to Iv is important for circuit designers bcoz its direct influence on the signal Amplitude.

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→ Quantum mechanics explains the tunneling of electrons through such a thin space charge region. therefore one can observe a high current through this region even for a small voltages. this current reaches a max value for a specific voltage. for higher voltages the current start to drop bcoz the overlap of both bands shrinks.

→ for even higher voltages the regular diode current starts to contribute to the overall current, which therefore increases for a second time.

Design and implementation of a wireless communication-based sprinkler irrigation system with seed sowing functionality

Research Open access Published: 02 December 2023
Volume 5, article number 379, (2023) Cite this article

SN Applied Sciences

Aims and scope

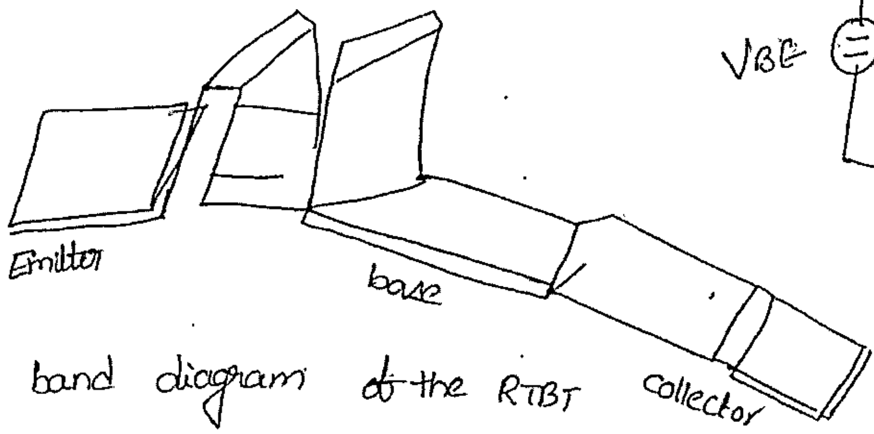
Submit manuscript

Bhupalam Venkatesh, Y. Suresh, J. Chinna Babu, N. Guru Mohan, C. Madana Kumar Reddy & Manoj Kumar

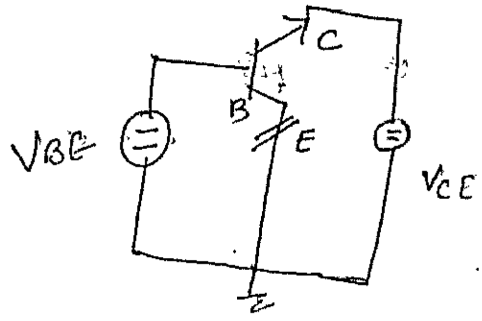
Abstract

This study addresses the critical health risks faced by farmers owing to the use of harmful chemical pesticides in agriculture. The primary objective is to create an effective solution to minimize these risks and reduce the use of pesticides. To achieve this, a smart irrigation system has been implemented by connecting various sensors, such as moisture sensors and thermal imagers through the Internet of Things. These sensors collect vital data on crop moisture levels and thermal images that are securely stored in a cloud-based

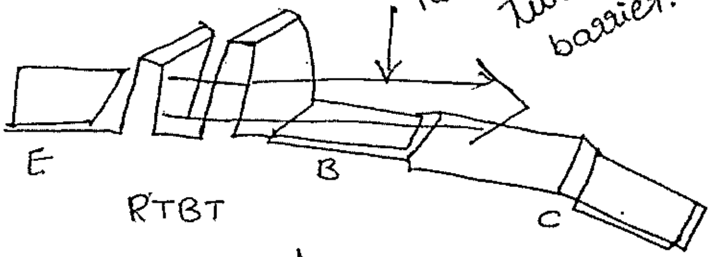
→ serial & parallel combinations of these two devices shows the negative differential resistance. In both cases the I-V characteristics can be altered by the gate voltage of the FET.



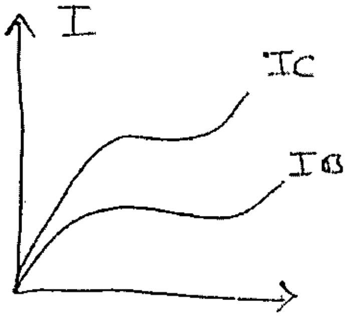
band diagram of the RTBT



RTO



RTBT



V-I characteristics

Technology of RTO:-

→ According to the schematic views of an RTO one would expect two layers of semiconductor material that form the quantum wells & one additional layer for the quantum well. RTO's could be easily co-integrated with conventional CMOS technology. this step would accelerate the introduction of the RTO technology & further nano electronic components.

→ fig shows the e the tunneling diode consists of an Esaki diode. the diode is composed of an n^+ doped contact & a p^+ doped diffusion region. the micrograph & the cross section of an RTO-FET combination that has been realized in an Indium phosphide technology.

(37)

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Detection and classification of COVID-19 using supervised deep learning on MRI images

by J. Chinna Babu; Mudassir Khan; Mallikharjuna Rao Nuka; C.H. Nagaraju

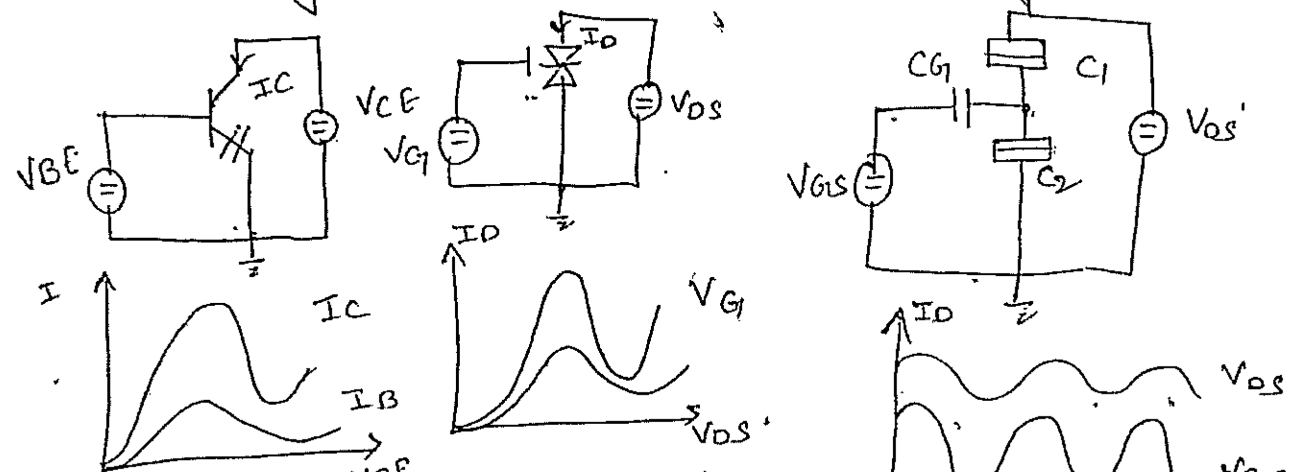
International Journal of Bioinformatics Research and Applications (IJBRA), Vol. 19, No. 4, 2023

Abstract: Healthcare services in many parts of the world, but especially in emerging countries, have been made aware of the risks presented by the COVID-19 pandemic. In areas where bulk traditional testing is not practical, new computer-assisted diagnosis methods are clearly needed to provide speedy and cost-effective screening. Pulmonary ultrasonography can be used to diagnose lung disease since it is portable, easy to clean, inexpensive, and non-invasive. In recent years, computer-assisted analysis of lung ultrasound images has showed considerable promise for identifying respiratory disorders, including COVID-19 screening and diagnosis. Detecting COVID-19 infections from lung ultrasound images using deep-learning algorithms and comparing their results. It was possible to use a variety of pre-trained deep learning architectures to this problem. There are 3,326 lung ultrasound images in the POCUS dataset, which we used to train and fine-tune our algorithm. Computed tomography (CT) proved useful in the diagnosis of corona virus infection particularly in the pandemic of new corona virus (COVID-19). Radiation from patients who underwent CT scans experienced alterations that were comparable to those seen in MRI scans. A chest MRI should be performed if a CT scan is unavailable, according to the study's findings.

Online publication date: Wed, 06-Dec-2023

→ the Micrograph reveals the present drawbacks of this approach. the RTO can be perfectly implemented as a mesoscopic device, whereas the remaining components such as wiring & contacts are still too large for any nanoelectronic applications.

→ thus, negative aspects are the low packing density as well as the large parasitic capacitances that increase gate delay times. this problem might be solved if it is possible to introduce RTO into the polymer technology. an RTO is composed of insulating & conducting molecules that form the tunneling elements.



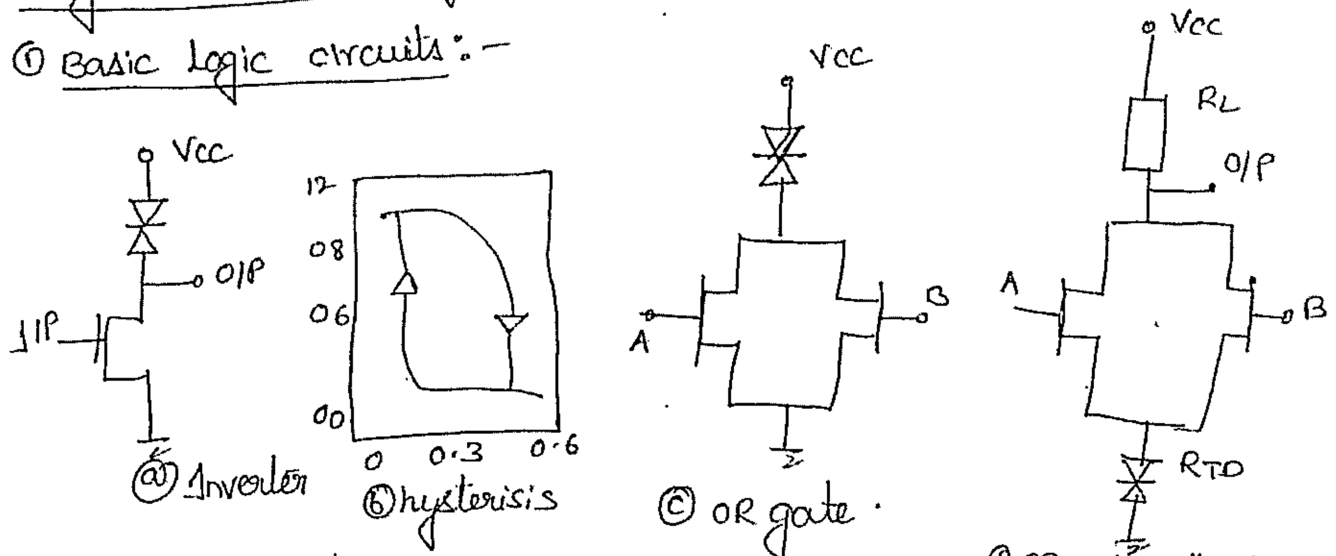
ⓐ Bipolar Quantum Resonant tunneling transistor

ⓑ Gated Resonant tunneling diodes

ⓒ single electron transistor.

Digital circuit design based on RTO's, basic logic gates :-

① Basic logic circuits :-



ⓐ Inverter

ⓑ hysterisis

ⓒ OR gate.

ⓓ OR Gate with RTD.

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RESEARCH ARTICLE VOLUME 9, ISSUE 12, E22844, DECEMBER 2023

Health Recommendation System using Deep Learning-based Collaborative Filtering

P. Chinnasamy • Wing-Keung Wong • A. Ambeth Raja • Osamah Ibrahim Khalaf • Ajmeera Kiran • J. Chinna Babu

Open Access • Published: November 24, 2023 • DOI: https://doi.org/10.1016/j.heliyon.2023.e22844 •

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PlumX Metrics

Abstract

The crucial aspect of the medical sector is healthcare in today's modern society. To analyze a massive quantity of medical information, a medical system is necessary to gain additional perspectives and facilitate prediction and diagnosis. This device should be intelligent enough to analyze a patient's state of health through social activities, individual health information, and behavior analysis. The Health Recommendation System (HRS) has become an essential mechanism for medical care. In this sense, efficient healthcare networks are critical for medical decision-making processes. The fundamental purpose is to maintain that sensitive information can be shared only at the right moment while guaranteeing the effectiveness of data, authenticity, security, and legal concerns. As some people use social media to recognize their medical problems, healthcare recommendation systems need to generate findings like diagnosis recommendations, medical insurance, medical passageway-based care strategies, and homeopathic remedies associated with a patient's health status. New studies aimed at the use of vast numbers of health information by integrating multidisciplinary data from various sources are addressed, which also decreases the burden and health care costs. This article presents a ...mended intelligent HRS using the deep learning system of the Restricted Bol... ...n ...e (RBM)-Coevolutionary Neural Network (CNN) that provides insights on ho... ...a n

→ In the fig, the classical CMOS circuitary RTD Based logic gates can be composed an Inverter, the tunneling diode acts as a switching operation but this is not a parasitic element on the effect of potential wells when increases the noise upto a certain level.

→ In fig ⓑ & ⓒ display an OR gate when applying the boolean operation with different FET's. In this combination different RTD's of I-V characteristics of the OR gate is similar to the inverter gate.

→ For the better performance & high gain & easy switching operation bcoz of RTD's have a negative differential resistance region (NDR). therefore, the switching operation is very fast.

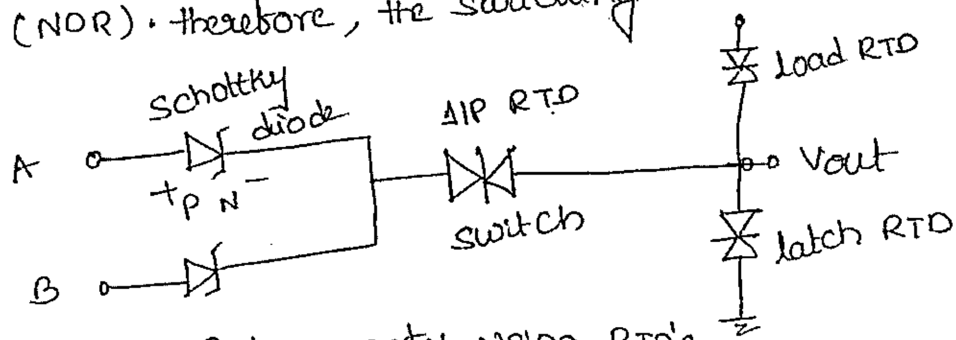

fig ② logic gates using RTD's.

→ As shown in the fig the basic logic gates is used to generate with single I/P of different kinds of O/P such as AND, OR, XOR, NOT.

→ the basic gates are composed of a logic element consisting of two schottky diodes & one RTD & latching consisting of two series connected of RTD's.

② Dynamic Logic Gates :-

→ Taking even more advantage of the NDR region leads to promising concepts. A good example in this regard is the monostable bistable logic transition element (MOBILE). It's plain configuration can be found in fig ⓐ.

→ In recent years high speed logic families based on the MOBILE have been proposed for tunneling devices.

Health and Technology
https://doi.org/10.1007/s12553-023-00807-6

ORIGINAL PAPER

Detection of Cardio Vascular abnormalities using gradient descent optimization and CNN

Ninni Singh[1] · Vinit Kumar Gunjan[1] · Fahimuddin Shaik[2] · Sudipta Roy[3]

Received: 28 September 2022 / Accepted: 5 December 2023

Abstract

Purpose The purpose of this study is to propose an advanced methodology for automated diagnosis and classification of heart conditions using electrocardiography (ECG) in order to address the rising death rate from cardiovascular disease (CVD).
Methods Buffered ECG pulses from the MIT-BIH Arrhythmia dataset are integrated using a multi-modal fusion framework, refined using Gradient Descent optimization, and classified using the K-Means technique based on pulse magnitudes. Convolutional Neural Networks (CNNs) are used to detect anomalies.
Results The study achieves an average accuracy of 98%, outperforming current state-of-the-art methods. Sensitivity, specificity, and other metrics show significant improvements. The results also show the type of Cardiovascular disease detected using Confusion matrix plots.
Conclusion The proposed methodology demonstrates the utility of advanced machine learning, particularly deep learning, in the assessment of cardiovascular health. Based on the MIT-BIH Arrhythmia dataset, this study contributes to the development of accurate and efficient diagnostic tools for addressing urgent cardiac health challenges.

Keywords Cardio vascular · ECG · Fusion · CNN · Gradient descent

1 Introduction

Out of the various ailments the Cardiovascular disease is considered to be the major reason for the death without any alarming also, conferring to the Centers for Disease Control & Prevention (CDC) as well as American Health Monitoring Organization [1]. Sometimes called as silent killer the Cardiovascular disease (CVD) is widely regarded as the significant factor of mortality worldwide [2]. The heart is considered to be the most important component of the circulatory system. The human heart is a muscular organ that pumps blood throughout the body to ensure that a person continues to have a beating heart. It achieves this goal by transporting oxygen and various other nutrients to the tissues, as well as by ridding the body of waste materials and carbon dioxide through the various pathways that make up the circulatory system [3]. The blood arteries that supply the heart muscle are being impeded by a blockage at this time. A heart attack is a catastrophic medical condition that has the potential to end a person's life.The absence of blood causes tissue to perish due to an inadequate supply of oxygen. Myocardial infarction is what medical professionals refer to as a "heart attack." A problem known as cardiovascular disease (CVD) is one that has an impact on both the heart and the blood vessels (Veins & arteries). In the twentieth century, heart disorders were responsible for ten percent of all deaths, and by the late twentieth century, the overall death rate from cardiac diseases had increased by twenty-five percent [4]. Men are more likely than women to acquire cardiovascular disease [5–7], particularly in middle or late age. CVDs are difficult to diagnose because of the multiple contributing factors that

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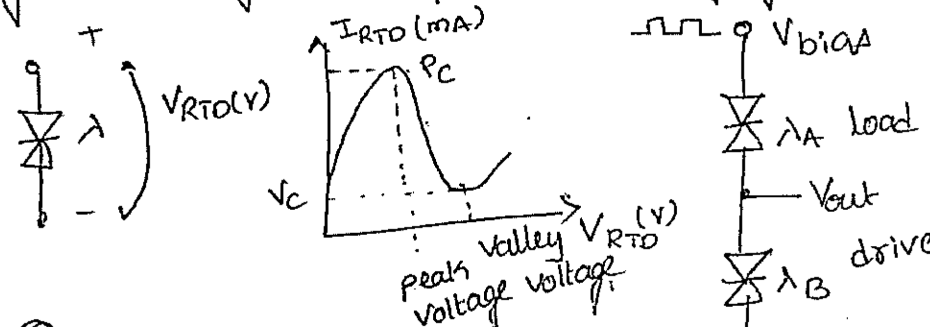
Published online: 05 January 2024

→ the MOBILE gate is a pseudo dynamic, clocked logic circuit & consists of two resonant tunneling diodes that operate in a monostable or bistable state depending on a clocked power supply voltage.

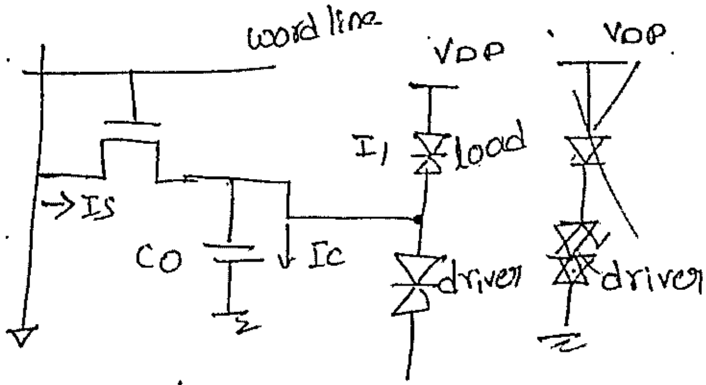
→ the term pseudo dynamic refers to the ~~special~~ special circuit style in the sense that a clock controls the logic transition of the gate, similar to dynamic circuits.

→ But in contrast to dynamic circuits, where the logic state is represented by the electrical charge on a capacitor, MOBILE ckts are in a static, self stabilizing state due to the inherent bistability of their devices. consequently they are more robust against charge leakage, & pre charging is unnecessary.



(a) RTD Mobile ckt (b) RTD I - V characteristics (c) basic dynamic logic gate

③ Memory application:—



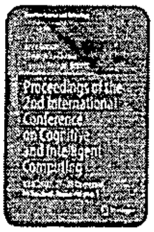
→ there are mainly many proposals for memory applications & logic circuits that make use of resonant tunneling diodes. fig shows a static memory cell that is composed of serially connected RTD's & a FET.

→ the FET selects the RTD combination for Read & write access. during the write operation the signal on the bit line drives the memory node to the desired state.

VIP Development of SPI Controller for Open-Power Processor-Based Fabless SOC

| Conference paper | First Online: 27 September 2023

| pp 11–22 | Cite this conference paper



Proceedings of the 2nd International Conference on Cognitive and Intelligent...

(ICCIC 2022)

D. Anu Priya, D. Vishnuvardhan, G. Mamatha, Fahimuddin Shaik & Shaik Karimullah

Part of the book series: Cognitive Science and Technology ((CSAT))

Included in the following conference series:
International Conference on Information and Management Engineering

Abstract

The SPI-Serial Peripheral Interface is considered as one of the most used bus protocols for attaching processors to associated devices with low/medium data transmission rates

Principle of SET :- (Single electron transistor)

→ these are devices operating at the quantum / nanoscale that have switching properities controlled by the removal & injection of a single electron, a device through which only one electron can be transported at a time.

→ the idea of the single electron transistor is based on the so called coulomb blockade. this effect only appears with very small device dimensions & is due to the quantization of charge.

The Coulomb Blockade :-

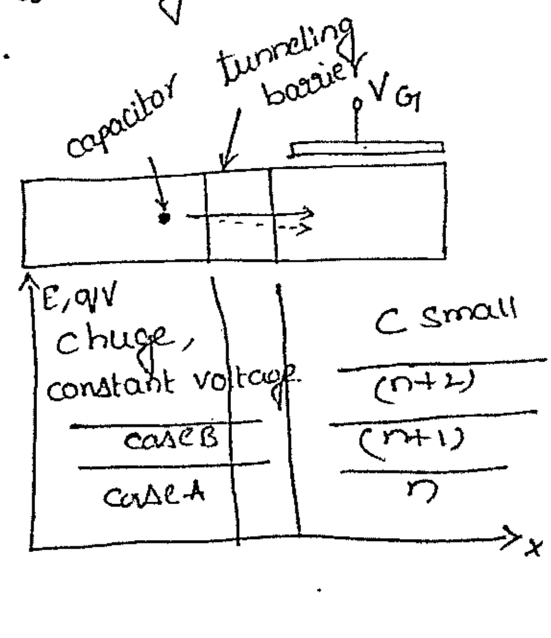
→ to explain the coulomb blockade we take a closer looks at fig ① at which the composition of a tunneling element & a capacitor. the capacitor is located on the right side of the tunneling element & has a very small capacitance due to its very small dimensions.

→ the energy level of electrons within the capacitor can be adjusted by an external gate voltage V_G. Electrons can tunnel from the right side of the barrier to its left side as long as the energy level on the right side remains lower than on the other side.

→ If this is not the case, the electrons get blocked by the coulomb blockade, since the charge of a single electron would cause an increase of the energy level.

→ case A : the electron cannot tunnel since its potential energy would be higher afterwards,

→ case B : the electron tunnels bcoz the electron's enery balance is +ve after tunneling, however a further electron gets blocked again by the coulomb blockade.



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Ain Shams Engineering Journal
Volume 15, Issue 3, March 2024, 102482

(44)

Application of multi agent systems for advanced energy management in cyber physical hybrid microgrid systems

P. Balachennaiah [a], J. Chinna Babu [b]

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Abstract

This paper develops a multi agent system in real time for hybrid microgrids as advanced energy management (ADEM) protocol using a Java agent development environment (JADE) frame work. The proposed system is configured with two micro-grids, each having 1kw solar photo voltaic power, 1.5Kw wind power, 24V, 150AH battery along with a local load, thus making it a hybrid Microgrid, modelled in MATLAB/Simulink. Due stability constraints while using MATLAB/Simulink, in a multi-threading environment, a middle ware called Multi agent Control Using Simulink with Jade Extension (MACSimJX) is adopted. The microgrid environment variables are captured through sensors, delivered to the agents operations in JADE, for the implementation of dynamic operation in hybrid microgrids. This results in maximizing operational efficiency of hybrid microgrids system. The simulation suggests that MAS can successfully manage dynamic loads, generated power in real time microgrids.

Previous

Next

Keywords

Micro-grids; Multi Agent systems (MAS); Real time simulation; Energy Management system (EMS); JADE; MACSimJX

1. Introduction

→ the energy shift from A to B is controlled by the gate voltage V_G. this remarkable increase is due to the very small capacitance of the capacitor. Electrons can only tunnel if the energy balance is positive after tunneling.

→ this effect can be explained within the boundaries of classical physics by coulomb's law, however, it assumes the quantization of the electrical charge. the tunneling element is needed for a galvanic isolation, but it nevertheless offers a voltage controlled tunneling probability.

→ the total energy E depends on the amount of charge on the capacitor & on the electrical potential V. the energy of a capacitor C that is charged with n electrons is equivalent to

$$Q = CV \rightarrow ①$$

→ the electrostatic energy stored in the conductor is given by

$$E = \frac{1}{2}CV^2 = \frac{Q^2}{2C} \rightarrow ②$$

$$E_n = \frac{1}{2}\frac{n^2 q^2}{C} \rightarrow ③$$

→ the energy difference on the capacitor C for the two charge situations of n & n+1 electrons correspond to

$$E_{n+1} - E_n = \frac{q^2}{2C}(2n+1) \rightarrow ④$$

→ An electron can only pass the barrier through tunneling if this energy difference is less than or equal to the energy of the electron. the energy of electron is expressed as

$$E = qV \rightarrow ⑤$$

→ this implies that the value of voltage 'V' should not exceed the value $V = \frac{q(2n+1)}{2C}$, $n = 1, 2, 3, 4 \ldots$ ⑥

→ for the normalized voltage the location of the steps is equivalent to $\frac{V_C}{q} = \frac{(2n+1)}{2} \rightarrow ⑦$.

Making Cell-Free Massive MIMO Using MRC Technique

| Conference paper | First Online: 27 September 2023

| pp 1–10 | Cite this conference paper

Proceedings of the 2nd International Conference on Cognitive and Intelligent...

(ICCIC 2022)

Sk. Khudsia Tabassum, D. Vishnuvardhan, G. Mamatha & Fahimuddin Shaik

Part of the book series: Cognitive Science and Technology ((CSAT))

Included in the following conference series:
International Conference on Information and Management Engineering

Abstract

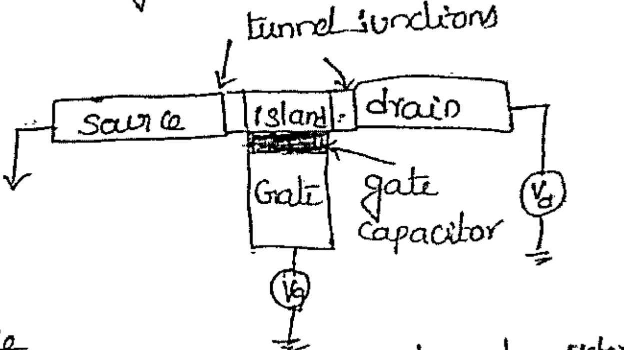
While demonstrating that partially or completely centralising signal processing at the central processing unit (CPU) improves spectral efficiency, this study advocates for the utilisation of maximum ratio trying to combine at each access point (AP) (SE). Cell-free massive MIMO is

Construction of the SET (or) performance of SET :-

→ the single electron transistor describes a single electron transport through a quantum dot. A quantum dot is a semiconducting nano particle whose electrons are confined in all three spatial dimensions.

→ there are many variations to the structure of the single electron transistor. the main components of the single electron structure are shown in the big.

→ the Island is the quantum dot which is connected to the drain & source terminals. Electron exchange occurs only with the drain & source terminals, which are connected to current & voltage meters.

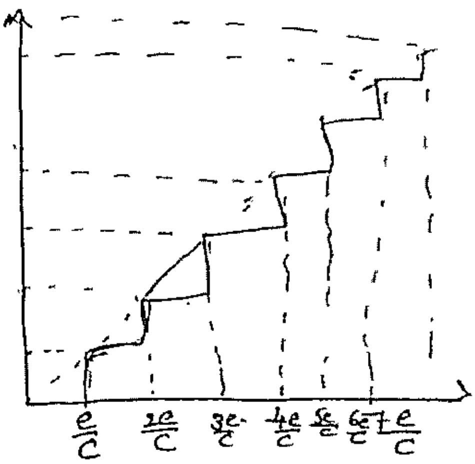


fig① single electron transistor (SET).

→ the gate terminal provides electrostatic or capacitive coupling. when there is no coupling to the source & drain, there is an Integer number N of electrons in the quantum dot (Island). the total charge on the Island is quantized & equal to qN.

→ the formulation of the coulomb blockade Model is only valid, if electron states are localized on Islands.

→ If tunneling is allowed b/w the Island, drain, & source terminals, then the no of electrons N adjusts itself until the energy of the total system is minimized.



coulomb stair case.

→ the electrostatically influenced electrons traveling b/w the source & the drain terminals need to tunnel through two Junctions (barriers). the Island is charged & discharged as the electrons cross it, & the relative

A hybrid model for lung cancer prediction using patch processing and deeplearning on CT images

Open access Published: 17 October 2023

Volume 83, pages 43931–43952, (2024) Cite this article

Multimedia Tools and Applications

Aims and scope

Submit manuscript

C. Venkatesh, J. Chinna Babu, Ajmeera Kiran, C. H. Nagaraju & Manoj Kumar

A Correction to this article was published on 15 April 2024

This article has been updated

Abstract

Cancer is a common disease with an increasing mortality rate in recent years. Lung cancer is the most common cancer in men and women alike. It is caused by uncontrolled cell development in the lungs. These cells are divided into two types: benign and malignant. Benign tumours are usually harmless, do not spread to other cells, and have a smooth and regular shape, whereas malignant tumours can be dangerous and spread to other body cells to form a new cancerous nodule with an uneven shape. If lung cancer is detected early, it can be treated. Lung cancer symptoms typically appear in the human body when it is in its final stage, but advanced technology and computer-aided systems can detect it at an early stage. Currently, numerous conventional and machine learning techniques are used for such automated detection systems to detect lung cancer in its early stages, but such automated detection systems do not provide accurate detection and the processing of lung cancer detection takes a long time. As a result, a

energies of the island containing zero or one extra electron depends on the gate voltage.

~~Single Electron transistor perb~~

~~Performance~~ Te of single Electron transistor (SET): -

technology SET circuit design:-

→ At first glance it seems to be difficult to fabricate SET's consisting of two tunneling elements & a small island. the following three concepts will reveal the feasibility of the SET technology.

→ the technological challenge is to find the appropriate way to bring one of these concepts into the mass production.

→ the first concept uses a batch process to coat small metal balls with an insulator. such a ball can be placed on top of an interrupted conductor. the gate might be integrated into the substrate. the objective of such concepts is to achieve some kind of self organization on the level of atoms or molecular clusters:

→ the second concept realizes the appropriate tunneling elements via different deposition angles. first 'Al' is deposited from the right side so that its oxide can directly be used as a tunneling barrier. In a second process step 'AL' is applied from the left side as depicted in the schematic view. the two applied 'AL' layers overlap & form the tunneling element.

→ In silicon SOI technique can also be used to implement SET's. As shown in fig reveals the essential elements such as tunneling barriers & islands can be realized within a very thin Si layer.

→ the use of the substrate as gate electrode is feasible, but is not suitable for fast circuit operations. this concept might be improved by an additional silicon layer that includes the gate electrode.

Deep concatenated features with improved heuristic-based recurrent neural network for hyperspectral image classification

Published: 06 November 2023

Volume 83, pages 49875–49904, (2024) Cite this article

Multimedia Tools and Applications

Marri Venkata Dasu, P. Veera Narayana Reddy & S. Chandra Mohan Reddy

Abstract

Hyperspectral remote sensing is one of the important approaches in the area of remote sensing owing to the latest enhancements in the Hyper Spectral Imaging (HSI) technology. The classification represents a direct approach in the HSI field that provides every pixel a particular semantic label based on its behavior automatically. Nowadays, deep learning-oriented techniques have gained wide attention in the area of HSI classification. Although Convolutional Neural Network (CNN)-oriented techniques are subjected to the HSI classification, their performances are not up to the expectation. This is because; the majority of the traditional techniques cannot utilize the intrinsic behavior of distinct pixels in HSI

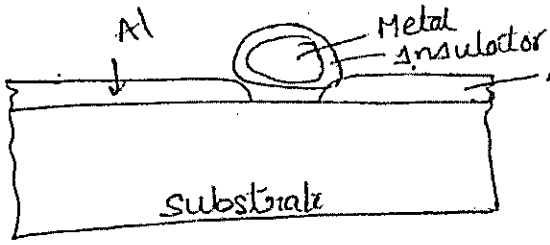
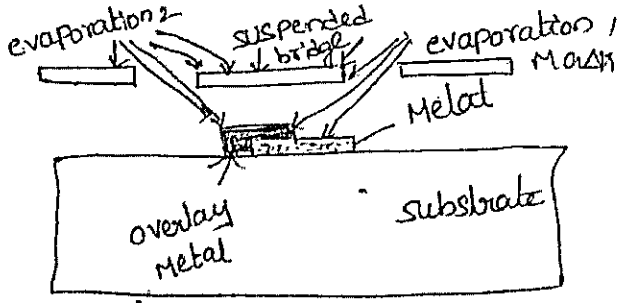


fig ⓐ Metal balls that are coated by an insulator



ⓑ different deposition angles result in two tunneling elements & an island.

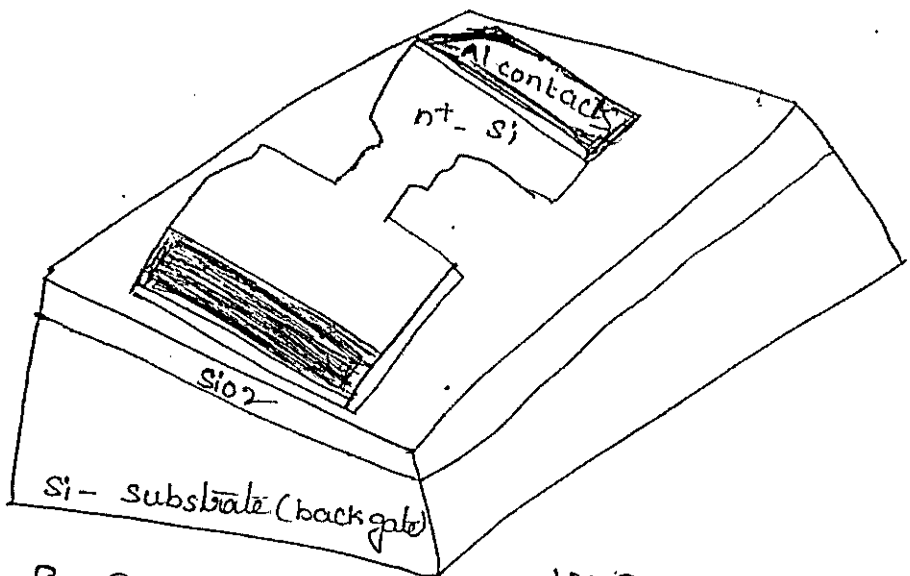


fig ⓒ SOI technique in silicon.

SET circuit Design - wiring, drivers, logic & Memory circuits :-

Wiring & Drivers:-

the charge of a single electron can not drive a metallic wire.

→ the charge of a single electron ... via a SET would take consequently the charging of a long wire via a SET would take a long time. A possible solution might be a shift register that acts a wire.

→ within such a shift register the data is represented by single electrons that are shifted from one node to the other as shown in the fig.

→ for such a configuration the (dis) charging of a long wire is not a issue. however, the shift register needs a clock supply for a fast data exchange, which consumes electrical energy.

(40)

Multi-region minutiae depth value-based efficient forged finger print analysis

M. Baskar, Renuka Devi Rajagopal, PRASAD B. V. V. S., J. Chinna Babu , Gabriela Pajtinková Bartáková, T. S. Arulananth

Published: November 16, 2023 • https://doi.org/10.1371/journal.pone.0293249

Abstract

The application of biometrics has expanded the wings to many domains of application. However, various biometric features are being used in different security systems; the fingerprints have their own merits as it is more distinct. A different algorithm has been discussed earlier to improve the security and analysis of fingerprints to find forged ones, but it has a deficiency in expected performance. A multi-region minutiae depth value (MRMDV) based finger analysis algorithm has been presented to solve this issue. The image that is considered as input has been can be converted into noisy free with the help of median and Gabor filters. Further, the quality of the image is improved by sharpening the image. Second, the preprocessed image has been divided into many tiny images representing various regions. From the regional images, the features of ridge ends, ridge bifurcation, ridge enclosure, ridge dot, and ridge island. The multi-region minutiae depth value (MRMDV) has been computed based on the features which are extracted. The test image which has a similarity to the test image is estimated around MRMDV value towards forgery detection. The MRMDV approach produced noticeable results on forged fingerprint detection accuracy up to 98% with the least time complexity of 12 seconds.

Citation: Baskar M, Rajagopal RD, B. V. V. S. P, Babu JC, Bartáková GP, Arulananth TS (2023) Multi-region minutiae depth value-based efficient forged finger print analysis. PLoS ONE 18(11): e0293249. https://doi.org/10.1371/journal.pone.0293249

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Data Availability: All relevant data are within the paper and Supporting Information.

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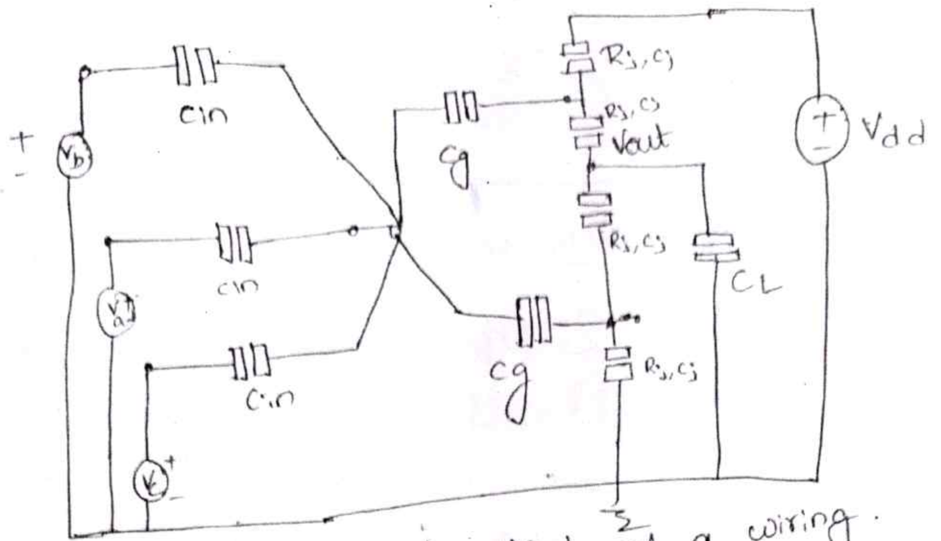
Competing interests: The authors have declared that no competing interests exist.

1. Introduction

Various organizations have used the development of information technology to meet their goals. As the organizations have a variety of information on their system, which belongs to different users and business partners, they are responsible for securing the data most effectively. Any organization faces various challenges against the data maintained through threats. The security measures which can be different are enforced to secure the data and handle the problem of illegal access. Access restriction is the most dominant one, which restricts the illegal user from accessing the available data. In this way, different approaches are used, like profile-based access and key-based access restriction methods. However, the performance of such methods is not efficient in meeting the system's security requirements as they can be tampered with easily by various adversaries. Using biological features is more effective in enforcing such security systems. The facial features and thumb features are more challenging for the adversary that can support such security systems. Fingerprints and palm prints can be used towards the problem effectively.

Human fingerprint has great independence among other features of biometrics. It has unique characteristics which vary between any number of users. It has components of Minutiae ending, bifurcation, islands, dots, and so on. These components can be common in all human fingerprints but vary in numbers and sizes. The components and their numbers can be obtained by processing the fingerprint image. These numbers will not correlate with any other numbers. So, by adopting such finger analysis in security systems, the performance of authentication and illegal access restriction can be enforced most strictly.

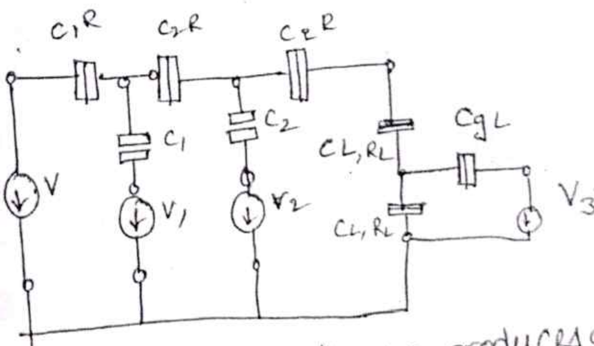
The picture of the sample fingerprint is presented in Fig 1, which has both original and altered fingerprints. The adversary or malformed user would try to breach the security walls by producing an altered print to the system. However the system should be capable of differentiating the original and altered one. So, the security system should consider various features from the ridge like dots, islands, ends, enclosure, and bifurcation. By considering such features in the authentication and verification process, the problem of forgery detection can be handled effectively.



shift register used as a wiring.

→ two clocked SET's can be operated as a current driver. they act as an electron pump. if the gate voltage is altered with freq f within each clock cycle one electron can pass from the left electrode via the two tunneling elements to the right side. therefore, the current I is proportional to the freq f.

$$I = qf \rightarrow (1)$$



electron pump: its O/P produces an active current.

→ An atomatic clock might control the freq f' so that a very precise control of the current is feasible. this is very interesting issue for measurement standards.

→ for circuit designers the driving capabilites are more interesting. the characteristic impedances of the ckts are relatively high, however, the capacitances are small & the pumped current increases with the frequency. the no of electrons can drive a CMOS interface circuit, in particular if the O/P's can be driven in a parallel way.

Logic & Memory circuits :-

→ According to fig the transistor toggles with the gate voltage b/w a conducting & an insulating state. two serial connected

An IoT Framework to Support Rural Population with Diabetic Related Issues via Optimization Algorithms

| Chapter | First Online: 08 December 2023

| pp 387–394 | Cite this chapter

Modern Approaches in IoT and Machine Learning for Cyber Security

Vinit Kumar Gunjan, Fahimuddin Shaik & Rashmi Pathak

Part of the book series: Internet of Things ((ITTCC))

Abstract

Currently, image processing and IoT technologies are notable in unravelling various challenges

SET's can exploit this effect in such a way that they operate as an Inverter. depending on the I/P signal only one of the two sets is in the conducting state. fig (b) illustrates a programmable logic gate. via the control I/P the gate operates as a logic NOR or NAND gate.

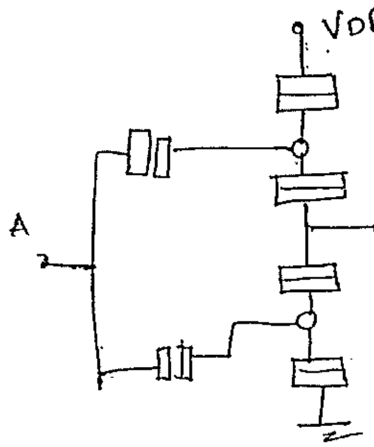


fig (a) Inverter

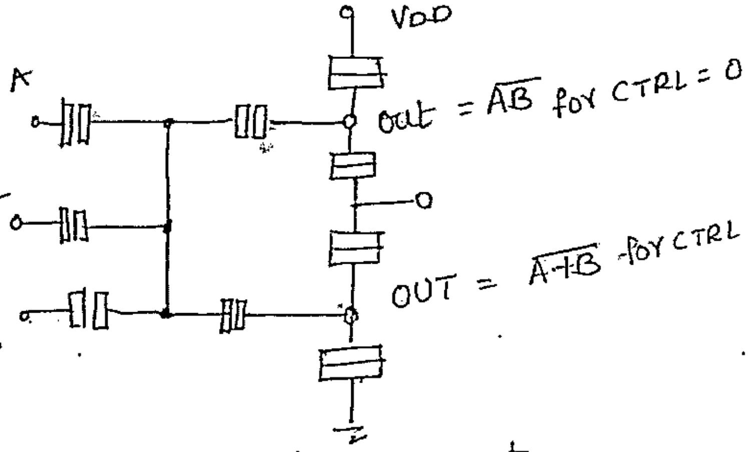
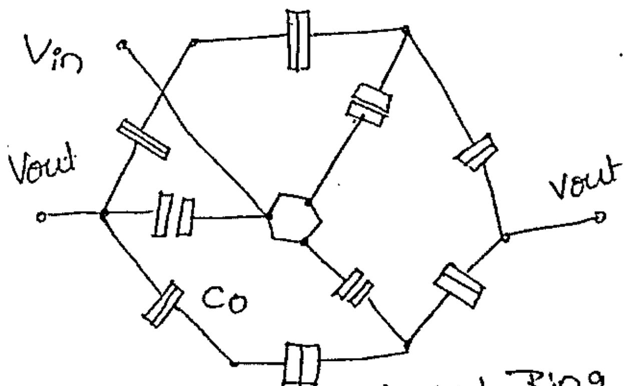


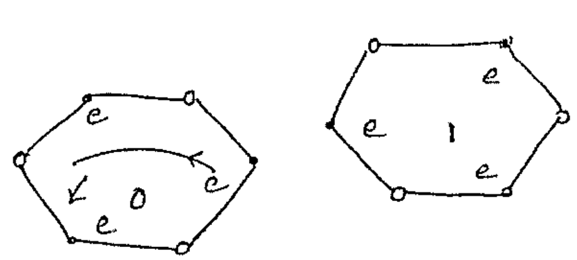
fig (b) programmable logic gate.

Ring Memory :-

→ A different Idea which is a generalization of the bistable Quantum cell for cellular automata is shown in the fig. on the ckt level it is similar to the electron trap memory, bcoz it is a trap connected to a ring, a so called ring memory cell. however the operation is different.



SET based Ring Memory



→ An even number n (in our case n=6) of tunnel Junctions is connected to a ring, & n/2 electrons are Inserted into the ring.

Design and implementation of a wireless communication-based sprinkler irrigation system with seed sowing functionality

Research Open access Published: 02 December 2023

Volume 5, article number 379, (2023) Cite this article

Bhupalam Venkatesh, Y. Suresh, J. Chinna Babu, N. Guru Mohan, C. Madana Kumar Reddy & Manoj Kumar

Abstract

This study addresses the critical health risks faced by farmers owing to the use of harmful chemical pesticides in agriculture. The primary objective is to create an effective solution to minimize these risks and reduce the use of pesticides. To achieve this, a smart irrigation system has been implemented by connecting various sensors, such as moisture sensors and thermal imagers through the Internet of Things. These sensors collect vital data on crop moisture levels and thermal images that are securely stored in a cloud-based

→ Due to their collulomb interaction, they will repel each other & thus can form two stable configurations.

→ Applying positive or negative voltage pulses at V_{in} will switch the state of the ring to either one of the stable configurations the capacitor C_0 should be a small compared to the capacitances of the tunnel junctions, so that the electrons have a large influence on their neighbors & keep their distance.

SET Adder:-

→ fig ① depicts the circuit diagram of a SET adder. the distributed ckt has been designed in a modular & repeating manner, which is of particular importance for nanoelectronic circuits.

→ the i/p data is fed into the adder by means of capacitive coupling. four individual clocks control the processing of the data. fig ② takes a closer look at a single adder cell.

→ the nodes A & B introduce the i/p data. if an electron is located in node A it is shifted to node B during the first clock cycle. this shift is only possible if node B is not occupied.

→ In this case the electron moves back to node A during the second clock cycle & switches the lower SET into the conducting states. As a consequence, the electron in node B disappears. the third & fourth clock cycle are reserved for the carry. this example shows that complex SET ckts without long wiring distances are feasible.

INDERSCIENCE PUBLISHERS
Linking academia, business and industry through research

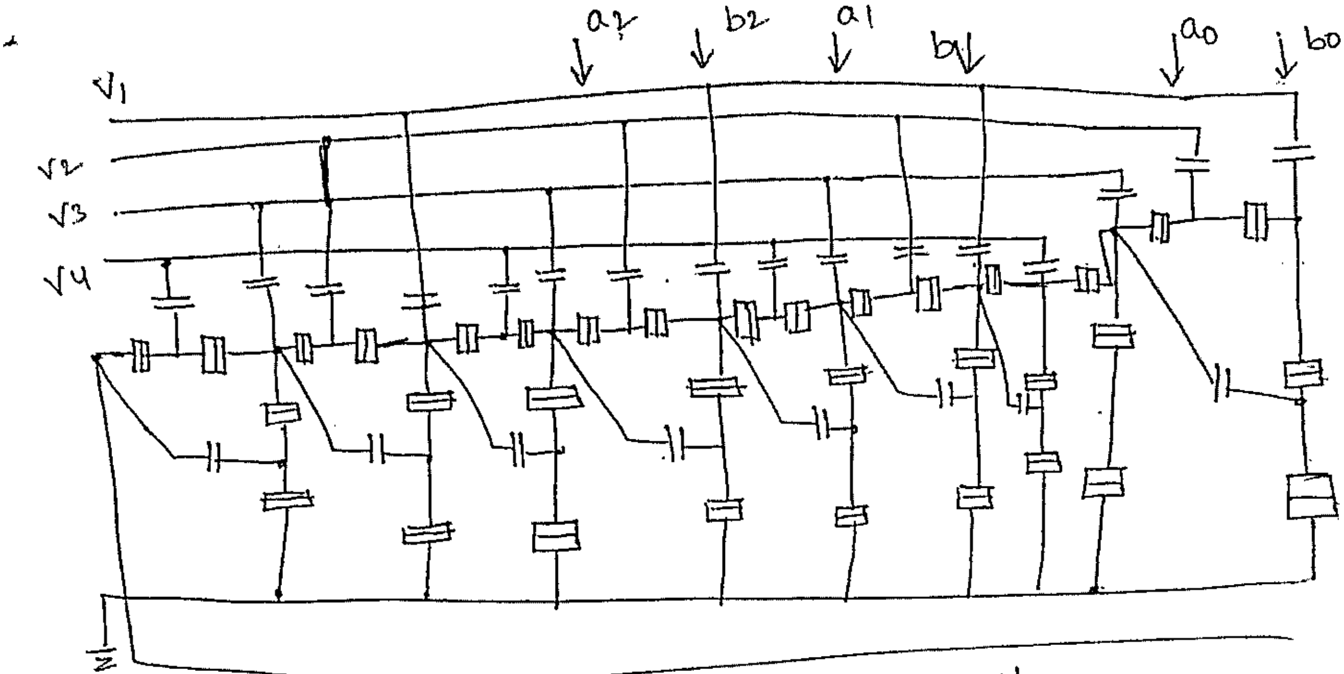
Detection and classification of COVID-19 using supervised deep learning on MRI images

by J. Chinna Babu; Mudassir Khan; Mallikharjuna Rao Nuka; C.H. Nagaraju

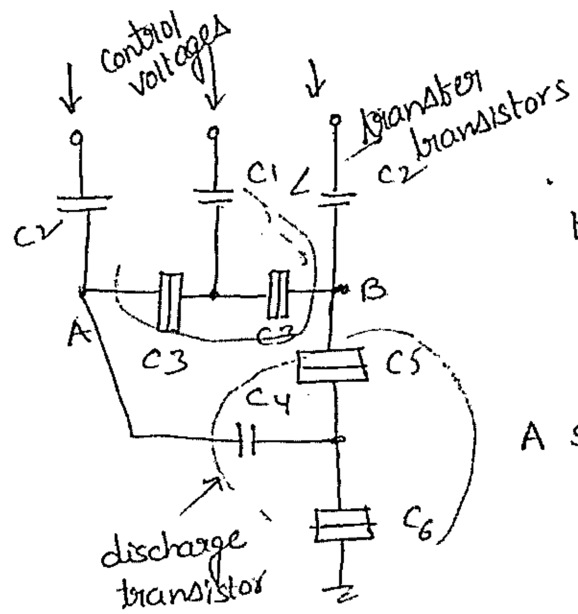
International Journal of Bioinformatics Research and Applications (IJBRA), Vol. 19, No. 4, 2023

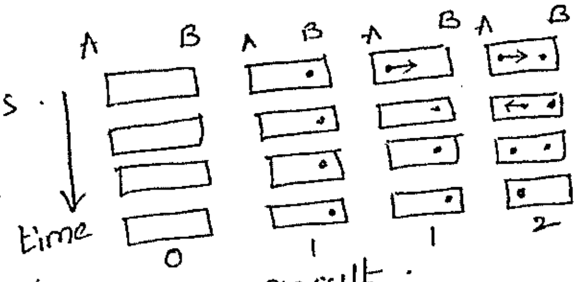
Abstract: Healthcare services in many parts of the world, but especially in emerging countries, have been made aware of the risks presented by the COVID-19 pandemic. In areas where bulk traditional testing is not practical, new computer-assisted diagnosis methods are clearly needed to provide speedy and cost-effective screening. Pulmonary ultrasonography can be used to diagnose lung disease since it is portable, easy to clean, inexpensive, and non-invasive. In recent years, computer-assisted analysis of lung ultrasound images has showed considerable promise for identifying respiratory disorders, including COVID-19 screening and diagnosis. Detecting COVID-19 infections from lung ultrasound images using deep-learning algorithms and comparing their results. It was possible to use a variety of pre-trained deep learning architectures to this problem. There are 3,326 lung ultrasound images in the POCUS dataset, which we used to train and fine-tune our algorithm. Computed tomography (CT) proved useful in the diagnosis of corona virus infection particularly in the pandemic of new corona virus (COVID-19). Radiation from patients who underwent CT scans experienced alterations that were comparable to those seen in MRI scans. A chest MRI should be performed if a CT scan is unavailable, according to the study's findings.

Online publication date: Wed, 06-Dec-2023



SET adder as distributed circuits.





A single adder cell of the SET adder.

Comparison between FET & SET Circuit Design :-

→ the comparison b/w FET & SET as well as their ckt design is a very interesting issue within the power delay diagram. Although the power delay diagram only offers a simplified view of both concepts the field for potential applications can be derived.

→ the switching energy of a FET decreases as the device dimensions decreases, bcoz the no of electrons in the channel as well as it capacitance. the scaling procedure can only be continued

RESEARCH ARTICLE VOLUME 9, ISSUE 12, E22844, DECEMBER 2023

Health Recommendation System using Deep Learning-based Collaborative Filtering

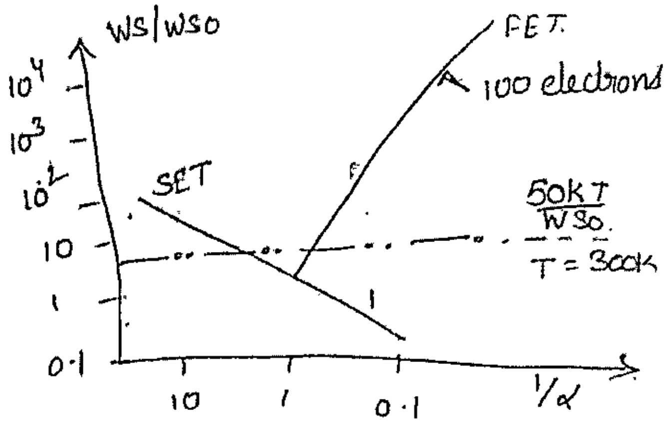
P. Chinnasamy • Wing-Keung Wong • A. Ambeth Raja • Osamah Ibrahim Khalaf • Ajmeera Kiran • J. Chinna Babu

Open Access • Published: November 24, 2023 • DOI: https://doi.org/10.1016/j.heliyon.2023.e22844 •

Abstract

The crucial aspect of the medical sector is healthcare in today's modern society. To analyze a massive quantity of medical information, a medical system is necessary to gain additional perspectives and facilitate prediction and diagnosis. This device should be intelligent enough to analyze a patient's state of health through social activities, individual health information, and behavior analysis. The Health Recommendation System (HRS) has become an essential mechanism for medical care. In this sense, efficient healthcare networks are critical for medical decision-making processes. The fundamental purpose is to maintain that sensitive information can be shared only at the right moment while guaranteeing the effectiveness of data, authenticity, security, and legal concerns. As some people use social media to recognize their medical problems, healthcare recommendation systems need to generate findings like diagnosis recommendations, medical insurance, medical passageway-based care strategies, and homeopathic remedies associated with a patient's health status. New studies aimed at the use of vast numbers of health information by integrating multidisciplinary data from various sources are addressed, which also decreases the burden and health care costs. This article presents a
nended intelligent HRS using the deep learning system of the Restricted Bol ... n
ie (RBM)-Coevolutionary Neural Network (CNN) that provides insights on ho ... a n

until the last electron is left in the channel. this is the point where the FET Model turns into the SET Model.



the power delay diagram reveals the Impacts of scaling on the SET.

FET / BJT	SET
→ ① Based on its I/P current (BJT) & I/P voltage (FET), a transistor allows a precise amount of current to flow through it.	→ the single electron transistor is a new type of switching device that uses controlled electron tunneling to amplify current & switching the state.
→ ② FET / BJT have PN Junction.	② SET have a tunnel Junctions
③ It has a channel regions i.e., P & N.	③ A small conducting Islands.
④ In this case the No of electrons are transfered through the channel regions at a time, here many electrons are participated.	④ the tunneling electrons are transfered one by one through the Island from source to drain due to the effect of coulomb blockade.
⑤ Drain current depends on the no of electrons Passed through channel.	⑤ It doesn't depend on no of electrons transferred through channel & fermi velocity. SET is periodical which shows particular drain current at a particular gate voltage.

Health and Technology
https://doi.org/10.1007/s12553-023-00807-6

ORIGINAL PAPER

Detection of Cardio Vascular abnormalities using gradient descent optimization and CNN

Ninni Singh[1] · Vinit Kumar Gunjan[1] · Fahimuddin Shaik[2] · Sudipta Roy[3]

Received: 28 September 2022 / Accepted: 5 December 2023

Abstract

Purpose The purpose of this study is to propose an advanced methodology for automated diagnosis and classification of heart conditions using electrocardiography (ECG) in order to address the rising death rate from cardiovascular disease (CVD).

Methods Buffered ECG pulses from the MIT-BIH Arrhythmia dataset are integrated using a multi-modal fusion framework, refined using Gradient Descent optimization, and classified using the K-Means technique based on pulse magnitudes. Convolutional Neural Networks (CNNs) are used to detect anomalies.

Results The study achieves an average accuracy of 98%, outperforming current state-of-the-art methods. Sensitivity, specificity, and other metrics show significant improvements. The results also show the type of Cardiovascular disease detected using Confusion matrix plots.

Conclusion The proposed methodology demonstrates the utility of advanced machine learning, particularly deep learning, in the assessment of cardiovascular health. Based on the MIT-BIH Arrhythmia dataset, this study contributes to the development of accurate and efficient diagnostic tools for addressing urgent cardiac health challenges.

Keywords Cardio vascular · ECG · Fusion · CNN · Gradient descent

1 Introduction

Out of the various ailments the Cardiovascular disease is considered to be the major reason for the death without any alarming also, conferring to the Centers for Disease Control & Prevention (CDC) as well as American Health Monitoring Organization [1]. Sometimes called as silent killer the Cardiovascular disease (CVD) is widely regarded as the significant factor of mortality worldwide [2]. The heart is considered to be the most important component of the circulatory system. The human heart is a muscular organ that pumps blood throughout the body to ensure that a person continues to have a beating heart. It achieves this goal by transporting oxygen and various other nutrients to the tissues, as well as by ridding the body of waste materials and carbon dioxide through the various pathways that make up the circulatory system [3]. The blood arteries that supply the heart muscle are being impeded by a blockage at this time. A heart attack is a catastrophic medical condition that has the potential to end a person's life.The absence of blood causes tissue to perish due to an inadequate supply of oxygen. Myocardial infarction is what medical professionals refer to as a "heart attack." A problem known as cardiovascular disease (CVD) is one that has an impact on both the heart and the blood vessels (Veins & arteries). In the twentieth century, heart disorders were responsible for ten percent of all deaths, and by the late twentieth century, the overall death rate from cardiac diseases had increased by twenty-five percent [4]. Men are more likely than women to acquire cardiovascular disease [5–7], particularly in middle or late age. CVDs are difficult to diagnose because of the multiple contributing factors that

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Published online: 05 January 2024

UNIT-5

Limits of Integrated Electronics

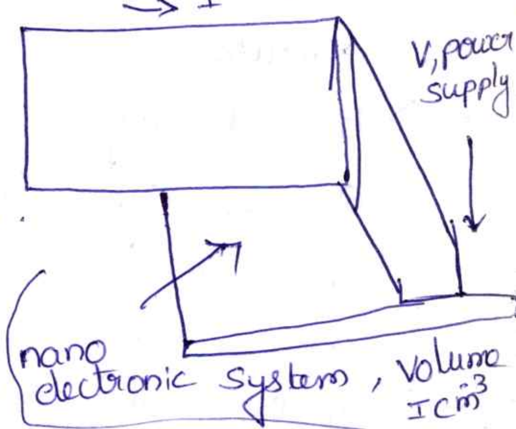
Energy supply & Heat Dissipation :-

→ For Microelectronics, & in future for nanoelectronics, heat generation in Integrated ckts is of great Importance. heat conduction can Limit the performance of a system.

→ A functional block contains 10^{12} nanostructured switching elements in a volume of $1cm^3$. If each element requires a switching energy of 1fJ & is operated at a clock freq of 1GHz a switching current of 1000000A flows through the block with the dimension of 1cm.

→ If the devices are operated at a voltage of 1V the power dissipation is 1000kW. Assuming a switching energy of 1aJ, which seems to be attainable for nanoelectronics, the switching current is still 1000A. If only 0.1% of the devices are active at the same time the switching current is 1A.

→ this Idea shows the Important role of a good system design concerning aspects like heat conduction & low standby power dissipation.



→ Heat conduction is a diffusion process. the power that can be dissipated as heat can be expressed with the diffusion equation.

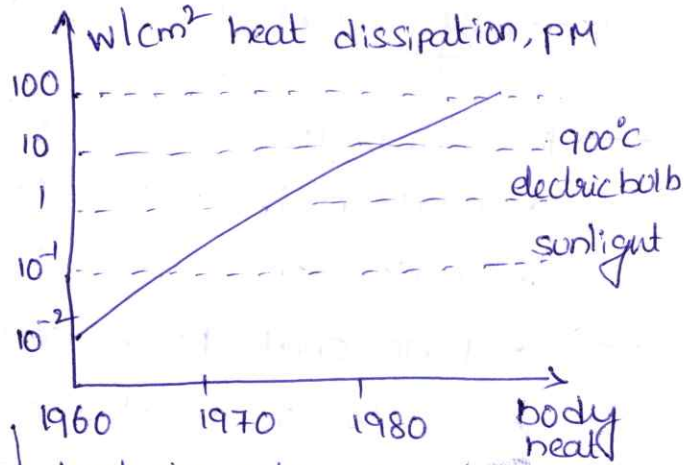
$$P_{th} = -k \frac{dT}{dx} \rightarrow (1)$$

→ P_{th} is the power of the heat flow, T is the temperature, & k denotes the thermal conductivity, which corresponds to the diffusion constant.

→ Assuming a device with the temperature T_1, the thermal resistance of R_{th}, & an ambient temperature T_2 we can write according to ohm's law $P_{th} = \frac{(T_1 - T_2)}{R_{th}}$

→ the ambient temperature & the max working temperature are given, so the thermal resistance R_{th} determines the heat flow, ie, heat dissipation.

→ the power dissipation has its originate in the transistor itself. from there the power dissipation or heat has to pass through the chip & the module before the working environment is reached.



heat dissipation PM of a module.

→ At the beginning the improvement was due to improved printed circuit boards & packaging. the next step in the development was fin cooling where the chips on a module are cooled with water from the backside.

Parameter spread as limiting Effect :-

→ Due to the diffusion of particles, layers with different ele-
ctrical characteristics can be built. on the other hand, diff-
usion is not a equally distributed process which can cause
problems inside an electrical circuits. A very important appli-
cation of the diffusion process is the production of integrated
circuits.

→ the starting point is a p-type substrate that is covered with a SiO_2 layer. the part of the SiO_2 layer that is opened by an oxide window is covered with n-type phosphorus atoms as shown in fig.

→ If this structure is exposed to temperatures above 1000°C the phosphorus atoms diffuse into the p-type substrate, which results in a doped layer with a different polarity. fig shows that some of the particles diffuse under the adjacent oxide.

→ when the diffusion process is maintained the layer continues growing. the doping profile depends on the time & shown in fig (b) & can mathematically be formulated by

$$n = \frac{Q}{\sqrt{\pi D t}} e^{-x^2/(4Dt)} \rightarrow (1)$$

where Q denotes the initial density of phosphorus atoms &

D - Diffusion constant.

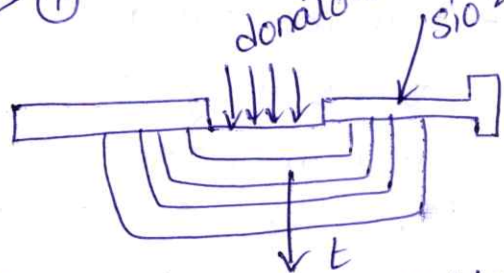


fig (a) Diffusion process in a semiconductor.

→ If the temperature is lowered the diffusion process does not stop but reduces its speed.

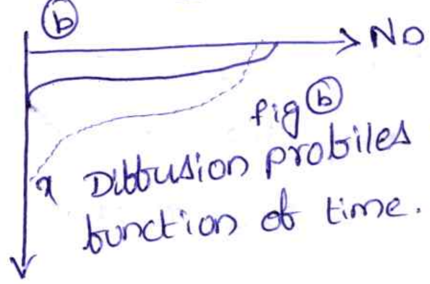


fig (b) Diffusion profiles as a function of time.

→ this also indicates that the electrical parameters that are adjusted during the manufacturing process can vary with time & can sometimes cause device failures. therefore the diffusion process is very important when the realibility of a device or system is of concern.

→ this results in a spread of the electrical & technological characteristics of the devices. In the following steps we estimate the parameter spread of the diffusion process with the help of a simple example.

→ the starting point is a volume 'V' that is divided into N cells each containing 'n' particles let probability 'p' that 'n' particles stay in one half of the volume & average n' equals n/2. due to thermal motion sometimes more & sometime less than n/2 particles are inside half of the volume.

→ to derive the spread mathematically we calculate the number 'm' of possibilites to put 'n' particles in one half of the volume.

$$m(n') = \frac{(\frac{N}{2})!}{n'!\,(\frac{N}{2} n')!} \left(\frac{n}{N}\right)^{n'!} \left[1 \left(\frac{n}{N}\right) \left(\frac{N}{2} n'\right)\right] \rightarrow (2)$$

in the case of n = N/2 eq (2) can be simplified to

$$m(n') = \frac{(\frac{N}{2})!}{n'} \, 0.5^{N/2} \rightarrow (3)$$

→ this equation is evaluated for a very small number of particles N. the higher the no of cells & particles the higher the no of possibilities.

→ If the characteristic curves are standardized on the max value of n/2 we get the chart as shown in fig ⑥. It follows from this that the normalized standard deviation decreases with an increasing number of particles.

$$\frac{\sigma}{\mu} = \frac{\sqrt{0.5N\frac{n}{N}\left(1-\frac{n}{N}\right)}}{0.5N\frac{n}{N}} \approx \frac{1}{\sqrt{n}} \rightarrow (3)$$

→ this result explains why the spread of the values can be neglected in the field of classical thermodynamics.

Limits Due to thermal particle Motion:-

→ these stochastic processes result in temporal & spatial fluctuations. parameter variations are related to spatial fluctuations. temporal fluctuations arise due to noise, the extension of a doped region or due to the reliability. all these effects have a limiting effect on microelectronics.

① the Debye length:-

→ the Diffusion of charge carriers can cause a potential difference inside a semiconductor. As an example, an inhomogeneous doped semiconductor is investigated. Due to the inhomogeneous doping profile diffusion of mobile charge carriers occurs resulting in an electric field within the semiconductor. this condition can be explained with the differential equation

$$q D \frac{dp}{dx} = p q \mu_p E \rightarrow (1)$$

→ the potential ϕ of each point inside the semiconductor can be found by integrating eq ①. with it the voltage b/w two points can be calculated $V_{12} = (\varphi_1 - \varphi_2) = V_T \ln \frac{P_2}{P_1} \rightarrow (2)$

→ this voltage is Independent of the doping profile $N_A(x)$ within the semiconductor. the potential along the semiconductor can be derived from the solution of the poisson equation

$$\frac{d^2\varphi}{dx^2} = \frac{1}{\varepsilon_0 \varepsilon_{si}} q (P - N_A) \rightarrow (3)$$

→ In this case of an Intrinsic semiconductor & with $P = n_i \exp(\varphi/V_T)$ we get eq (4) after standardization.

$$\frac{d^2\left(\frac{\varphi}{V_T}\right)}{dx^2} = \frac{1}{L_D^2}\left[e^{\varphi/V_T} - \frac{N_A}{n_i}\right] \rightarrow (4)$$

→ the term 'L_D' is so called "Debye length". It determines the standardization of the x-axis & can be stated to be

$$L_D = \sqrt{\frac{\varepsilon_0 \varepsilon_{si} V_T}{q n_i}} \rightarrow (5)$$

→ the lower the temperature & the smaller the relative permittivity ε_{si} & smaller the Debye length L_D. the debye length is a first Indicator for the thermal motion, results in an Increased resistance & in a noise voltage that can be Measured along a semiconductor.

→ the noise voltage is usually derived from the harmonic oscillator, which is excited by the thermal energy. such an oscillator is a Model for a short circuited line with the wave Impedance $Z = R$.

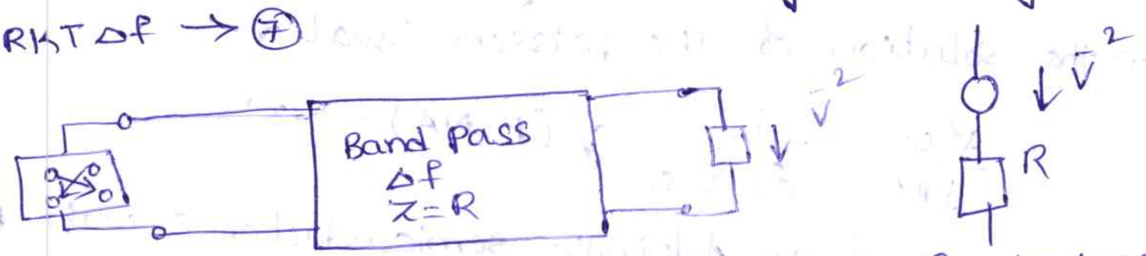
→ Here a simplified, quantitative derivation is shown. we calculate the thermal noise power at an ohmic resistor, which can be Measured with a band pass filter as shown in the fig.

→ According to the Nyquist theorem the signal must be sampled with $\Delta t < 1/2\Delta f$ to obtain a complete waveform. Δf corresponds to the bandwidth of the band pass filter.

→ from thermodynamics it follows that for each degree of freedom, the average energy of $\Delta E = \frac{1}{2}KT$ & therefore for each amount of energy, is related. from the view point of Information theory the mean transmissible power is $\overline{P} = \frac{1}{2} K T_2 \Delta f = KT\Delta f \rightarrow (6)$

→ this mean noise voltage at a noise free resistor R can be calculated with the help of the four pole theory according to

$\bar{V}^2 = 4RKT\Delta f$ → (7)



(a) Noise source (b) noise less.

→ the noise voltage is proportional to the resistance, the temperature & the bandwidth. In general, this voltage has a negative effect for electronic ckts & particularly in the processing of analogous signals.

→ If a ckt is scaled down the switching energy & therefore the signal power becomes lower. the effect of thermal power increases with the bandwidth.

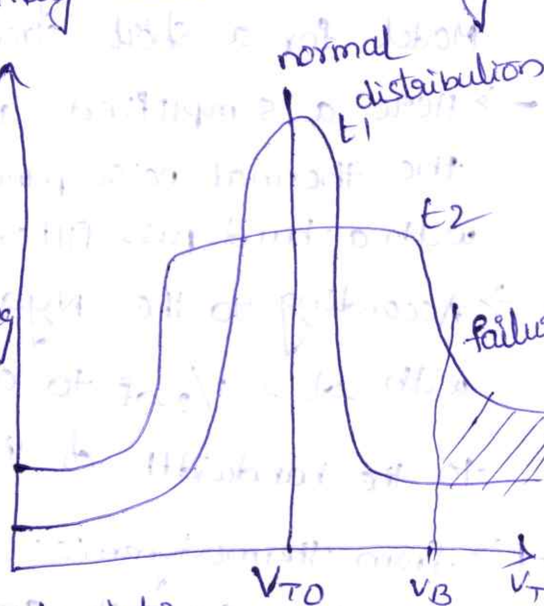
Reliability as a limiting factor :-

→ the distribution of the parameters as shown in the fig previously is only valid for the initial state of the devices. devices with a threshold voltage V_T above V_B fail. As a result of this the device yield is reduced.

→ During the operation of the devices the distribution widens; which in turn causes additional failures, these failures determine the reliability of the devices. the reliability describes the avg time a device is able to work.

→ the diffusion process always occurs at temperature above & increases with rising temperatures. the latter is advantageously used in the manufacturing of integrated circuits.

→ If a device is operated at working temperature the diffusion process is small enough that the lifetime of a device is hardly reduced.



$t_1 \rightarrow t_2$ the failure rate increases.

→ on the other hand, some failure mechanisms are based on the diffusion process. the lapse of time for this mechanism is very fast so further unwanted failures occur.

→ the distribution widens with time, so the no of failures increases with the time constant for this process can be approximated to $\tau_x = \frac{x_0^2}{D} c' e^{E} E_A / KT$ → ①

→ In the above equation x_0 is a fixed quantity. x_0 corresponds to V_{BO}. c' is a constant & E_A the activation Energy.

→ Now we compare this time constant to the time constant that describes the failure rate in relation to time. In the realibility theory a first approximation of the failure rate is described by for the power $P_V \geq \frac{h}{t_s^2}$ → ②

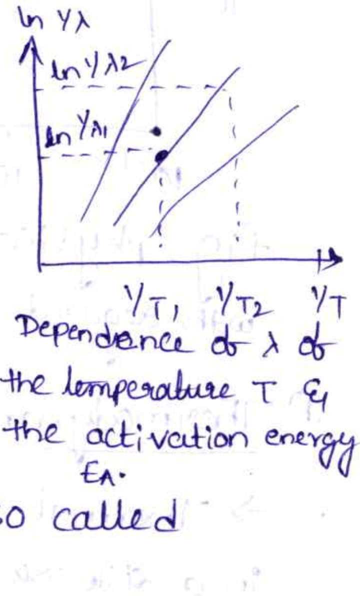
these values can not be reduced by any further. they are an exponential function $N = N_0 e^{-\lambda t}$ → ②

→ N_0 describes the no of devices at the initial state, N the no of devices during operation, t the time & λ the failure rate. this equation can be derived from the differential equation with the condition that the relative failure rate per unit time is constant

$$\frac{1}{N}\frac{dN}{dt} = -\lambda \rightarrow ③$$

$1/\lambda$ as a time constant $\propto t_x$. from eq① can be derived if λ is set proportional to $1/t_x$.

$$\lambda = C_A e^{-E_A/(KT)} \rightarrow ④$$



Dependence of λ of the temperature T & the activation energy E_A.

→ If the failure rate λ_1 & λ_2 are measured at two different temperatures T_1 & T_2 we get the activation energy E_A.

→ A graphical Interpretation of this is shown in the so called arrhenius plot as shown in the fig.

$$E_A = KT_1 \frac{T_2}{T_2 - T_1} \ln \frac{\lambda_2}{\lambda_1} \rightarrow ⑤$$

→ Most of the device failure Mechanisms have an activation energy around 1ev. In practice usually more than one failure mechanism occurs at the same time.

physical limits :-

→ the preceding effects of classical physics permit a derivation of physical limits of micro & nano electronics. In this the most Important limits from thermodynamics, the theory of relativity & from Quantum mechanics are presented.

→ A graphical overview of these limits is shown in the fig. for a better orientation the straight line characteristics for 1fJ = 10^{-15} WS is shown in power delay chart. Some of these limits might be overcome in future, the more quantum mechanical aspects are used.

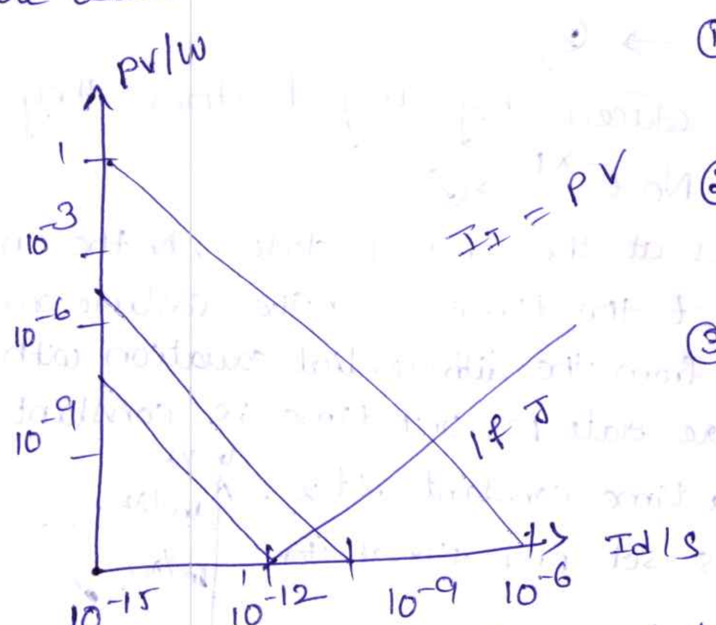


fig: physical limits of microelectronics with regard to power & delay.

Quantum Mechanical limit :-

① Quantization PV thermodynamical limits

② minimal voltage $V_{min} = \gamma V_T$.

$P_{min} = \frac{V_{min}^2}{Z_{LO}}$

③ thermal fluctuations $E_S = P_V I_d = cK_T$

relativistic limits.

④ delay $I_L = \sqrt{\frac{\epsilon_1 \epsilon_1}{\epsilon}} \; I_L$

⑤ wave Impedance

$Z_L = \sqrt{\frac{\epsilon_r}{\epsilon_0}} \; Z_{LO}$

$Z_{LO} < \sqrt{\frac{\mu_0}{\epsilon_0}}$.

① Thermodynamic limits :-

→ Thermal Movement of charge carriers Impedances the current flow in a ~~stiw~~ switching device. the dependence of the current through a P-N junction due to an applied voltage is reduced at higher temperatures. the higher the temperature the smaller the curvature of the diode characteristics.

→ If we want to take the advantage of the non linear behaviour of the device the working voltage should not be too small.

→ the smallest value of this voltage is

$$V_{min} = \gamma V_T = \gamma\, KT/q \rightarrow (1)$$

with $\gamma = 4-8$, the higher the temperature T the higher the voltage V_{min}. to reduce scattering inside the device during a switching event dozens of electrons should be involved. therefore the lower limit for this value W_s is about 25KT.

→ Actually this value is mostly too small, so thermal fluctuations would occur inside the device.

(2) Relativistic Limits :-

→ Some important limiting effects for microelectronics can be derived from the theory of relativity. If information is coupled to discrete energy quantities we must assume that these quantities can not propagate faster than the speed of light 'c'.

→ the switching times can not be reduced below a certain limit bcoz the devices can not be scaled down as one would like. let us assume that the active area of classical devices can not be smaller than the Debye length.

(3) Quantum Mechanical limits :-

→ the interaction of light with a solid can only be explained by quantum mechanics. In the case n=1 we get the energy per switching event according to $W_s \geq \frac{h}{t_s} \rightarrow (1)$

for the power $P_V \geq \frac{h}{t_s^2} \rightarrow (2)$

→ these values can not be reduced any further. they are termed as Quantum Mechanical limit.

→ In the same way, failures of switches occur due to thermal fluctuations, failures due to tunneling of charge carriers inside the switches is possible. tunneling is an effect of Quantum Mechanics.

④ Equal failure rates by tunneling & thermal Noise :-

→ the derivation of the failure probability due to thermal fluctuations assumed that a failure occur each time the energy of the charge carrier is above Ws.

→ If we consider failures by tunneling, the probability that a charge carrier can tunnel through a barrier is dependent on the energy Ws of the barrier & on the depth d.

→ Now we estimate the probability that failures due to tunneling & thermal fluctuations equal. with the assumption $P_{th} = P_{tu}$.

we get $$\frac{W_s}{KT} = \frac{2d}{h}\sqrt{2m(W_s - E)} \rightarrow (1)$$

→ If the mean kinetic energy E of the electron is half the energy Ws of the barrier we get the first order estimation.

$$d = h\sqrt{\frac{W_s/m}{2KT}} \rightarrow (2)$$

→ If we assume $W_s = 50KT$ the depth of the barrier can be calculated as d = 2nm at T = 300°K at this depth the failures caused by tunneling equal to those caused by thermal fluctuations. therefore the dimension of a device is a limit for the micro miniaturization of classical devices.

→ this limit is almost reached by semiconductor memories where the oxide thickness is around 5nm. the charge flow due to tunneling has to be taken into account.

Nano systems as Information processing Machines:-

① Nanosystems as functional Blocks:-

→ Various realizations of microelectronic systems already exist. most of them can be reduced to the block diagram as shown in the fig ⓐ this figure outlines a system that comprises sensitive sensors, effective actuators at the Interface to the outside world, low noise amplifiers, accurate A/D & D/A converters, CPUs, & effective Interfaces to the communication networks.

→ the functional description has to be realized partially in hardware & pationally software. the hardware - software codesign is relatively complicated & needs much Intuition, since the partioning is not easily predetermined.

→ the algorithms have to be mapped in a safe & reliable fashion into the system. In general, the costs of the hardware components are low in comparison to the overall system. however, the hardware is a key component of the system.

→ Besides safety & realiability the overall system performance is of general Interest. to a first approximation, it can be described as Information processing per unit time. today, high performance is only attainable with Integrated circuits, since they are fast, small, ~~reali~~ reliable & ~~rin~~inexpensive.

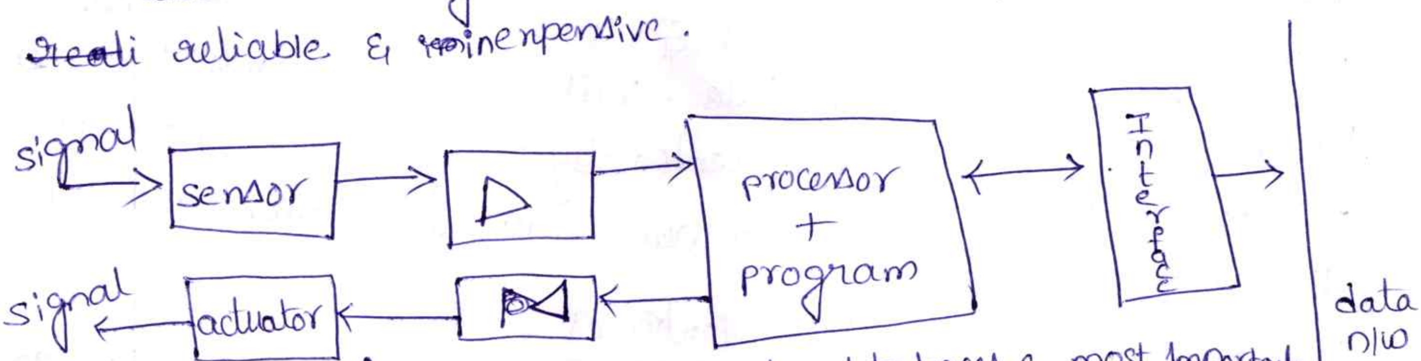
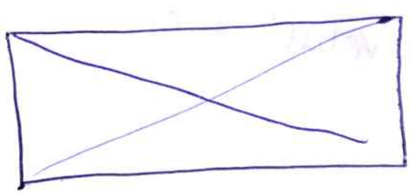


fig ⓐ system with its Interfaces & most Important functional blocks



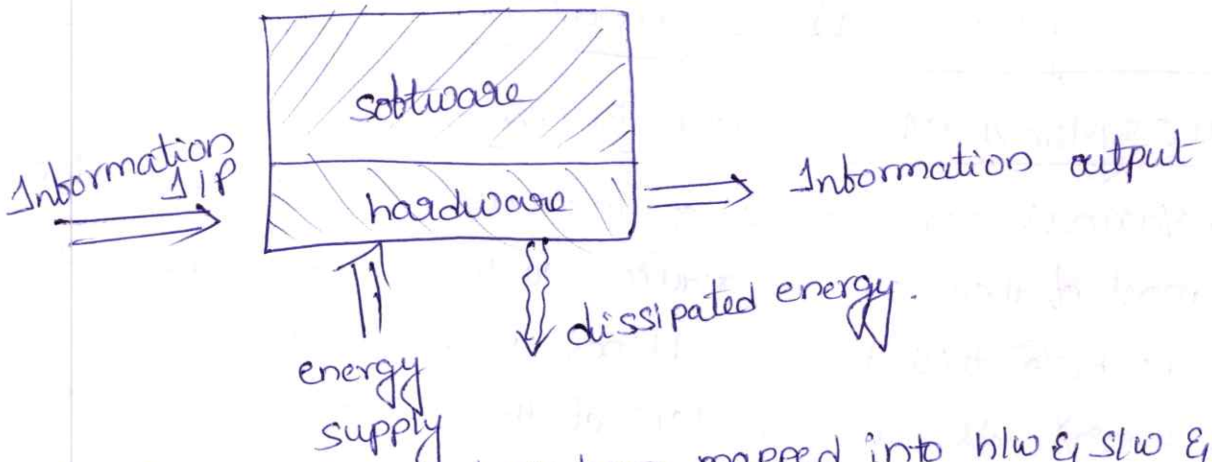
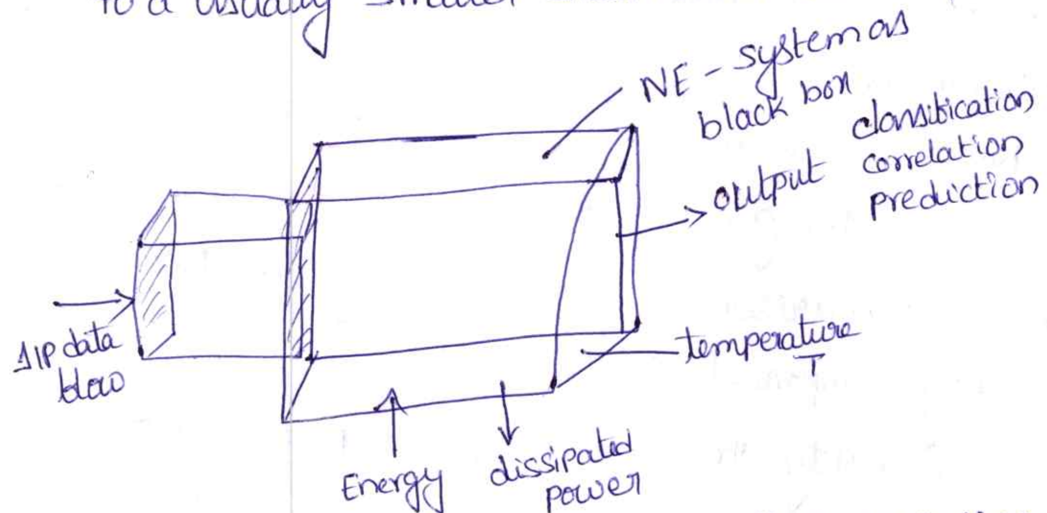


fig ⓑ system that has been mapped into h/w & s/w & energy flow.

② Information processing as Information Modification :-

→ According to the Model, the system transforms the Information cube to a usually smaller Information cube.



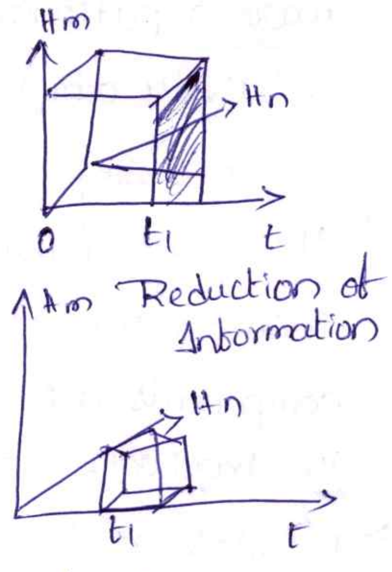


fig: Information cube of Information processing systems.

→ let us take 2 I/P NAND gate comprises four I/P combinations (2 bit) where as O/P has only two O/P states. the states of the O/P are not uniformly distributed (0.8 bit) & it is Impossible to reconstruct the I/P data from the output data. thus Information gets lost. In this example Information is represented by energy, which has to be dissipated when it comes to comes to Information destruction.

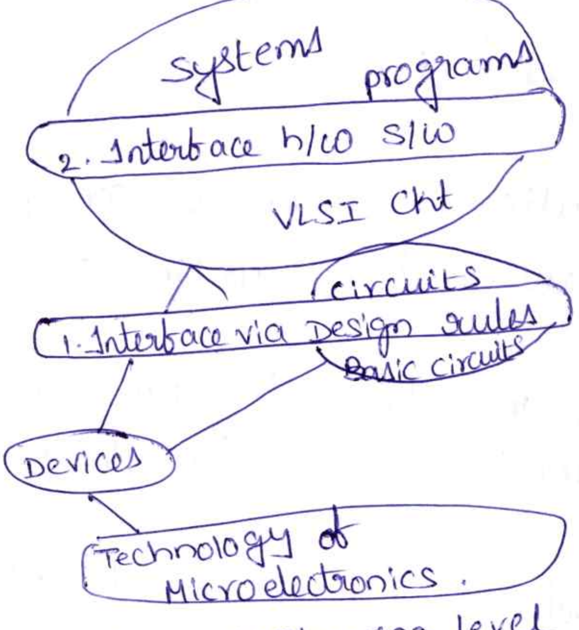
System Design & its Interfaces :-

→ the history of electronics reveals that each technological phase has bought a revolution on the system engineering level.

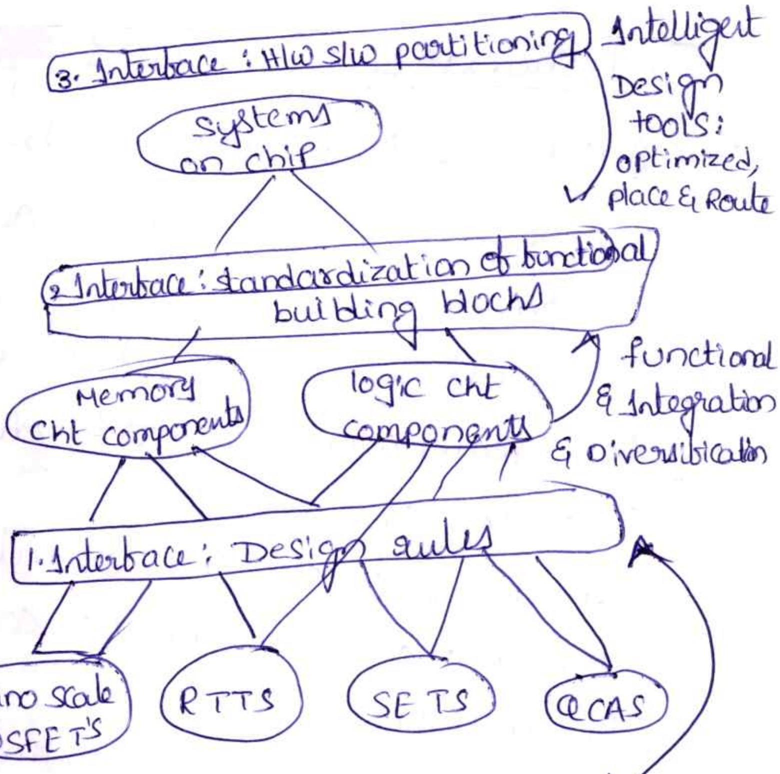
→ for instance, large scale integration (LSI) came up with the integrated ckts like transistor - transistor logic (TTL) & emitter coupled logic (ECL), whereas microprocessor units appeared with the very large scale integration (VLSI). therefore, the transistion from millions of integrated devices to billions of devices will probably result in a new system engineering level.

→ Methods for a global performance classification of nanosystems are needed. their values have to be linked to technological data. Nano electronics has to offer considerably more than the already existing silicon technology in order to be successful. thus, billions of integrated devices are needed.

→ New design methods have to be developed for the overall design that starts from the single device & ends with complex systems. technology invariant interfaces have been introduced to micro & nano electronics.



fig① system engineering level



Nano scale technology

3D nanolitho-graphy & Self assembled fabrication

Expected interfaces in nano-electronics.

→ A considerable milestone of Microelectronics was Introduced in 1980, when mead & conway separated technology from circuit design. In this content, the Introduction of design rules is fundamental relevance, geometric design rules describe the lateral dimensions of the devices.

→ Electric design rules reveal for Instance, the resistance & the capacitance of the structures, whereas the technological design rules describe the dimensions & the doping of the structures.

→ the seperation of the system engineering level from the process technology via technology invariant Interfaces has formed the basis for the extraordinary fast development & widespread use of Integrated systems.

→ the compiler is a very Important Interface b/w processor h/w & the s/w. this Interface has been adopted from computer science to the world of microprocessors.

Evolutionary Hardware :-

→ Another Interesting approach Investigates hardware concepts that develop with their hardware resources & demands in an autonomous fashion.

→ Research focuses on both evolutionary hardware concepts & their realization. one has to differentiate b/w off line evolution & on-line evolution.

→ In terms of off-line evolution, the structuring process is simulated on a mainframe computer before it is mapped into the hardware.

→ on the contrary, the on-line evolution take place on the h/w level. bcoz of the lack of adequate h/w, up to now, research makes use of field programmable gate arrays (FPGA'S).

→ the evolutionary hardware units rely on an appropriate wiring structure & activate adjacent units to solve complex tasks. once again, the overall structure has to be stored in each individual cell.

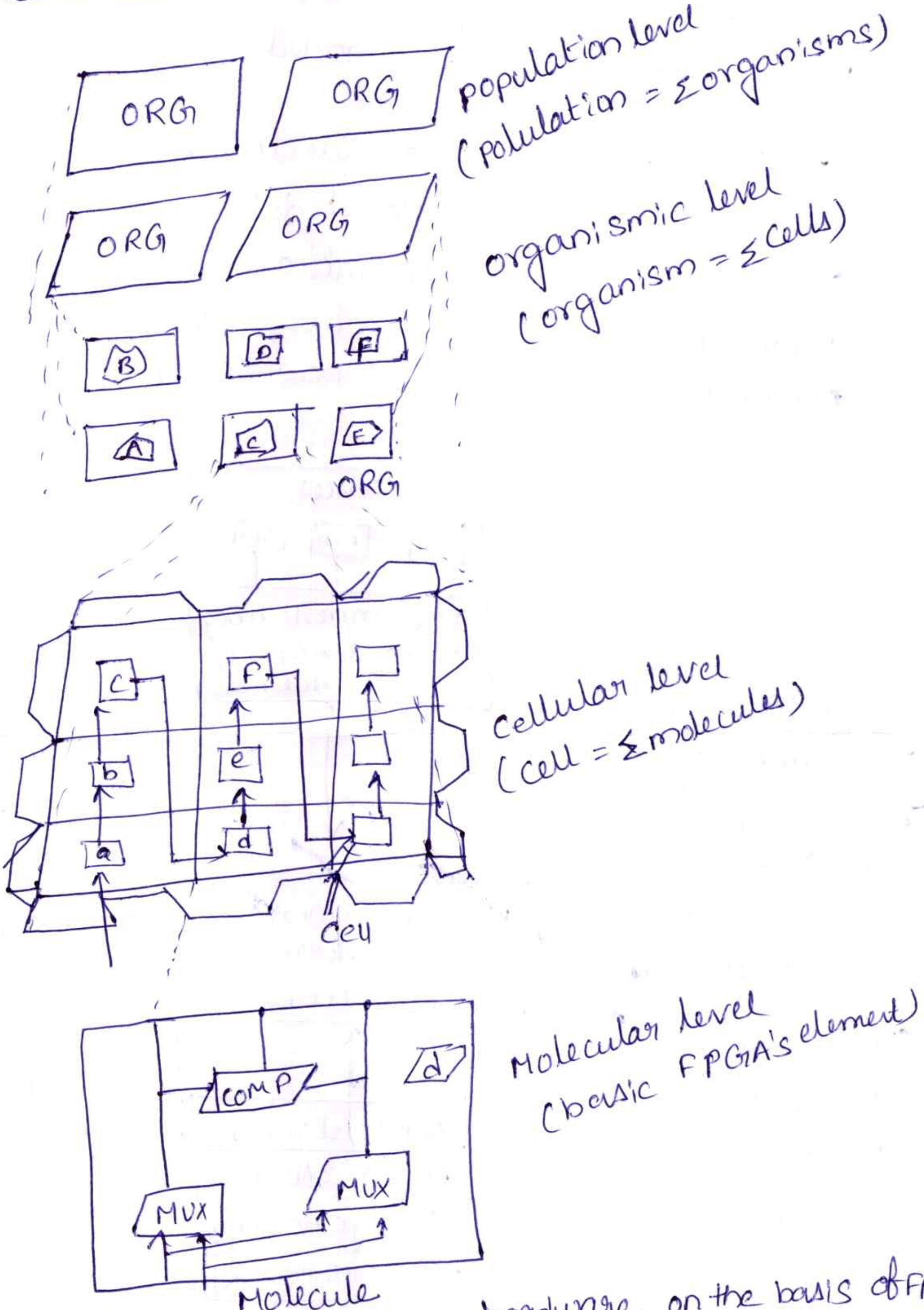


fig: concept of an evolutionary hardware on the basis of FPGA's.

Requirements of Nano systems:-

→ fig @ deals with architectures of some nanoelectronics systems from today's point of view & describes their implementations.

the following applications might be realized in future. Demanding process control, strategic modeling, autonomous systems, self assembling systems. this means more Intelligence must be Integrated into the systems via Increasing numbers of devices. this is challenging for nanoelectronics.

→ Interms of system architecture, the data processing performance, the degree of parallel data processing, the power consumption, & wiring constraints are major concern. Another promising approach comes from the fields of soft computing, since artifical neuronal networks leads to new concepts.

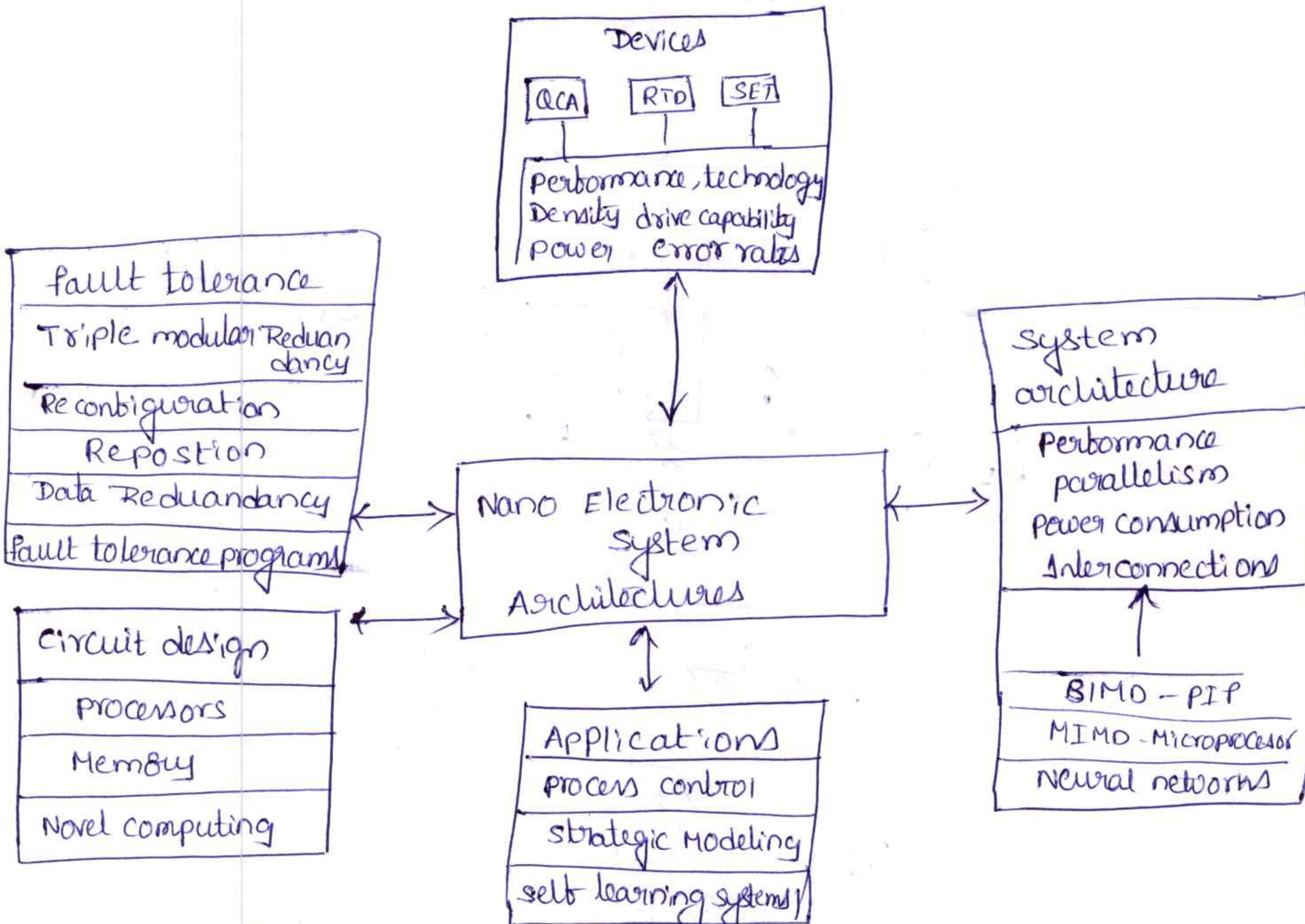


fig @ Integration of system architecture in the field of nano electronics.

→ fault tolerance is an Important Issue when it comes to systems that comprise such a huge number of devices.

→ the concrete h/w realization needs new concepts on the processor & memory level as well as a new data processing fashion that might be based, for example on fuzzy sets.

→ the system engineering level has to deal with the challenging implementation of the huge number of devices. the high complexity has to be cut down in some kind of functional blocks.

→ from the architectural point of view, regular & modular arrangements are advantageous. the high packing densities require a very low power dissipation.

→ the system should be self testable & fault tolerant. Additionally the system should be adaptive, self optimizing in order to auto-adapt itself to the environment.

→ However, the design of complex systems comprises many areas. the system concepts of nanoelectronics are at their early stage, they are still under investigation. therefore, it is impossible to deliver complete architectures, merely visions.

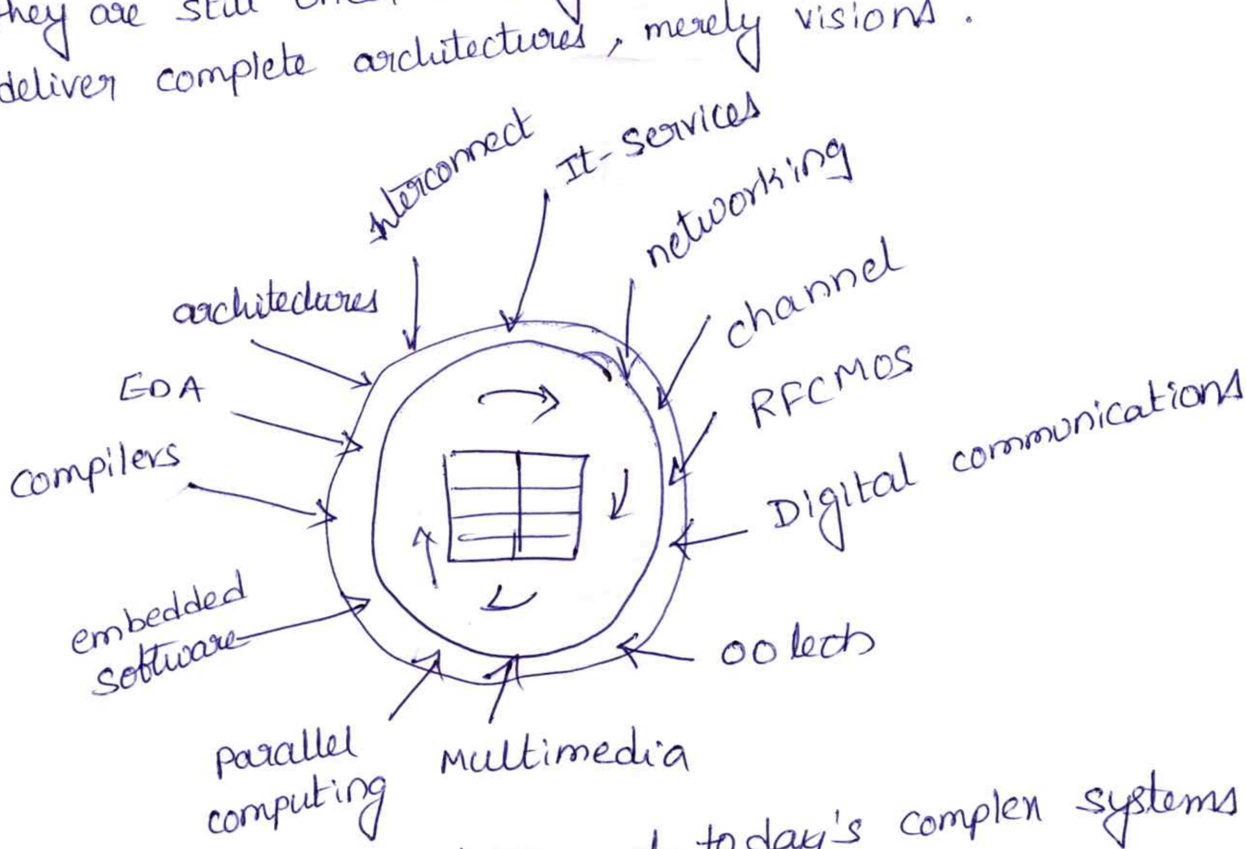


fig ⑥ the design of today's complex systems.

→ Vibrational spectroscopy is used to derive information on the vibrational excitation of molecules. most of the time, the excitation is limited to the fundamental vibrational frequency.

(5) X-Ray Diffraction:–

→ Although the method of x-ray diffraction is quantitative in general, it is used for qualitative analysis. this form of analysis extends to all crystalline solids including ceramics, metals, insulators organics, polymers, thin films, powers etc.

→ x-ray diffractometers can be used either for single crystals or for powders with both significantly different infrastructures. while single crystal diffractometers are used for the study of molecular structure, ~~powder~~ powder diffractometers are used for the analysis of phases,

→ x-rays corresponds to electromagnetic radiation in the wavelength range of 1A°. the wavelength range is below that of ultraviolet light & above that of gamma rays.

→ x-rays are generally produced when electrons of several thousands of electron volts are decelerated or stopped by metals. this will produce a white radiation up to a threshold freq corresponding to the kinetic energy of the particle. this threshold corresponds to a wavelength λ = 12399/V where V is the accelerating voltage of the electrons. the wavelength of a given x-ray line depends on the atomic number.

Synthesis & purification :–

→ carbon nanotubes were first noticed in the graphitic soot deposited on the negatively charged electrode used in the arc-discharge synthesis of fullerenes.

→ the graphite rods are evaporated in a dynamic atmosphere of helium. ~~is used~~ helium is leaked in while the vaccum system is pumped.

→ Typically a pressure of 130 torr of helium is used & the arc is run at 30V dc with current being maintained at ~180A.

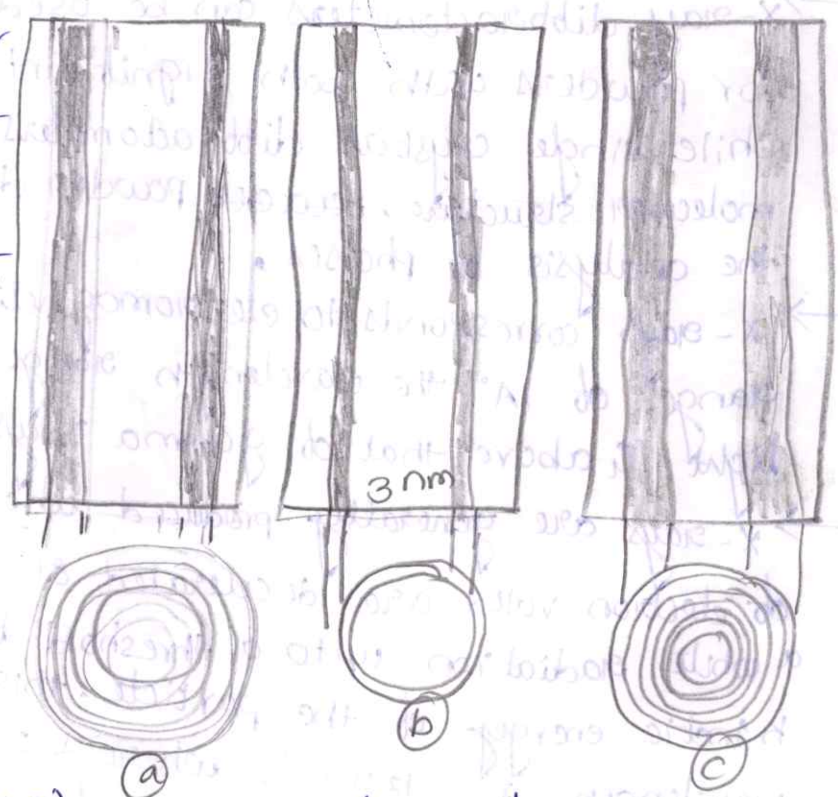
→ the carbon deposited on the cathode has a soft inner core & a hard outer cover. the core containing MWNT's is entracted & suspended in suitable solvents.

→ the tubes are seen as empty cylinders lying perpendicular to the electron beam along with amorphous carbon material. the interlayer gap is 0.34 nm, close to the spacing found in graphite.

→ the tube's inner diameter, interlayer spacing, length as also chiral angle θ can be determined from the TEM images.

→ Nanotubes are mostly found with closed ends on either side, though open tubes are also seen.

→ thus these are three-dimensional closed-cage objects & may be considered as elongated bullerenes.



carbon nanotubes of various diameter

→ various modifications to the arc-discharge process. ie in the process a smaller diameter (typically 3nm) anode evaporates on the face of a larger diameter (6nm) cathode in a direct current arc discharge apparatus.

→ Laser evaporation is another way in which a large yield of SWNT's can be produced. it is possible of synthesize SWMT's by heating a mixture of graphite with Fe & Ni catalysts at a temperature of 1200°C & irradiating the material with laser.

→ chemical vapour deposition is another useful way in which the synthesis of SWNT's & MWNT's can be achieved. here an organo-metallic precursor is mined with a carbon containing feed gas, it is pyrolyzed in a quartz tube & the nanotubes are collected from the cooler end of the reaction vessel.

Filling of Nanotubes :-

→ the nanotubes obtained directly from the synthetic processes are closed on both the ends. the ends can be opened by suitable chemistry. one of the Methods used is acid treatment which oxidizes the ends & leaves behind the oxide containing functionalities.

→ the common functional groups are COOH & OH. these may be removed by heating the tubes at 600°c in blowing Air. other methods such as treating with liquid bromine followed by heat treatment are also used.

→ there are also other ways of filling nanotubes. the simplest one is to use the arc evaporation process with graphite anodes filled with appropriate metals. this produces metals or metal carbides inside the tubes.

→ A selective purification method is thus required to remove the filled materials from the outer surface of the nanotubes.

Mechanism of Growth :-

→ the presence of MWNT's & SWNT's in uncatalyzed & catalyzed conditions, respectively, Indicate that two different growth mechanisms may be operative.

→ In an open-end mechanism, in which atoms are continuously added to the growing end, the dangling bond energy is stabilized by Interaction b/w the adjacent layers. the bond may be breaking & forming at the periphery of an open ended tube.

→ the nucleation & growth of the graphene layers occur along with the dynamic formation & restructuring of mono-atomic step edges at the nickel surface. the surface diffusion of carbon & nickel atoms take place during the growth of nanotubes.

Electronic structure :-

→ Nano tubes can have distinctly different electronic properties depending on the chirality. Early calculations predicted that they can be semi conducting or mettallic depending on the type of structure.

→ while armchair tubes are always metallic, others can be semiconducting or metallic. obviously as the diameter increases, tubes resemble graphite, which can be metallic.

→ the curling of the graphite layers & a decrease in the number of layers cause changes in the electronic structure of the metallic tubes, as compared to those of graphite.

→ the presence of defects on the body of the tube can alter the electronic structure & can make regions of specific electronic properties, such as metallic & semiconducting.

~~Fan~~ Properties of Nano:-

① Transport properties:-

→ Scanning tunneling spectroscopy has shown that the band gaps of the nanotubes vary from 0.2 to 1.2eV. the gap varies along the tube body & reaches a min value at the tube ends. this is due to the presence of localized defects at the ends due to the Extra states. the measurements on SWNT's show the helicity & size dependent changes in the electronic structure.

→ the transport properties of MWNT's & SWNT's have been measured. however, the principal problem in these measurements relates to the need for making proper contacts, due to large contact resistances. it is not possible to obtain information without four probe measurements.

→ the conductive behaviour of MWNT's was consistent with the weak two dimensional localization of the carriers. the inelastic scattering of carriers from lattice defects is more significant than carrier-carrier or carrier-phonon scattering.

② Mechanical properties:-

→ the strength of the carbon-carbon bond is among the highest & as a result, any structure based on aligned carbon carbon bonds will have the ultimate strength. Nanotubes are therefore the ultimate high strength carbon fibres. It is difficult to carry out measurements on Individual nanotubes. the measurement of young's modulus gave a value of 1.8 TPa. the theoretical prediction is in the range of 1-5 TPa.

→ It is possible for Individual SWNT's to slip from a bundle, there by again reducing the experimentally measured young's modulus. Measurements based on vibration spectroscopy, AFM & transmission electron microscopy can be used in determining estimates, & all of them come up with nearly the same numbers.

→ one of the Important properties of nanotubes is their ability to withstand extreme strain in tension (upto 40 percent). the tubes can recover from severe structural distortions. the resilience of a graphite sheet is manifested in this property, which is due to the ability of carbon atoms to rehybridize.

→ Any distortion of a tube will change the bonding of the nearby carbon atoms & in order to come back to the planar structure, the atoms have to reverse to sp^2 hybridization.

→ If the tube is subjected to elastic stretching beyond a limit, some bonds are broken. the defect is then redistributed along the tube surface.

③ physical properties :-

→ Nanotubes have a high strength to weight ratio (density of 1.8 g/cm³ for MWNT's & 0.8 g/cm³ for SWNT's). this is Indeed useful for light weight applications. this value is about 100 times that of steel & over twice that of conventional carbon fibres.

→ Nanotubes are highly resistant to chemical attack. it is difficult to oxidize them & the onset of oxidation in nanotubes is 100°c higher than that of carbon fibres. As a result, temperature is not a limitation in practical applications of nanotubes.

→ the surface area of nanotubes is of the order of 10-20 m²/g, which is higher than that of graphite but lower than that of mesoporous carbon used as catalytic supports where the value is of the order of 1000 m^2/g.

→ Nanotubes are expected to have a high thermal conductivity & the value increases with decrease in diameter. the thermal conductivity of single nanotubes were shown to be comparable to diamond & in plane graphite.

Applications of Nanotubes :-

① electrical application :- the use of nanotubes as electrical conductors is an exciting possibility. A nanotube based single molecule field effect transistor has already built.

② Electromagnetic application :- It is possible to construct hetrojunction by having junction b/w nanotubes of different helicities. this approach facilitates the creation of a device with one molecule.

one area of immediate commercial application of nanotubes is CNT based field emission displays.

③ Nano tips can be used as nano probes.

④ Nanotubes are used as b/w sensors.

⑤ chemical applications

⑥ Mechanical applications

⑦ electro acoustic application

⑧ Bio Medical application.

→ this voltage is independent of the doping profile $N_A(x)$ within the semiconductor. the potential along the semiconductor can be derived from the solution of the poisson equation

$$\frac{d^2\varphi}{dx^2} = \frac{1}{\epsilon_0 \epsilon_{Si}} q(P - N_A) \rightarrow ③$$

In this case of an intrinsic semiconductor & with $p = n_i \exp(\varphi/V_T)$ we get eq ④ after standardization.

$$\frac{d^2\left(\frac{\varphi}{V_T}\right)}{dx^2} = \frac{1}{L_D^2}\left[e^{\varphi/V_T} - \frac{N_A}{n_i}\right] \rightarrow ④$$

→ the term L_D is the so called Debye length. It determines the standardization of the x-axis & can be stated to be

$$L_D = \sqrt{\frac{\epsilon_0 \epsilon_{Si} V_T}{q n_i}} \rightarrow ⑤$$

→ the lower the temperature & the smaller the relative permittivity ϵ_{Si} & smaller the Debye length L_D. the Debye length is a first Indicator for the thermal motion results in an increased resistance along a semiconductor & in a noise voltage that can be measured

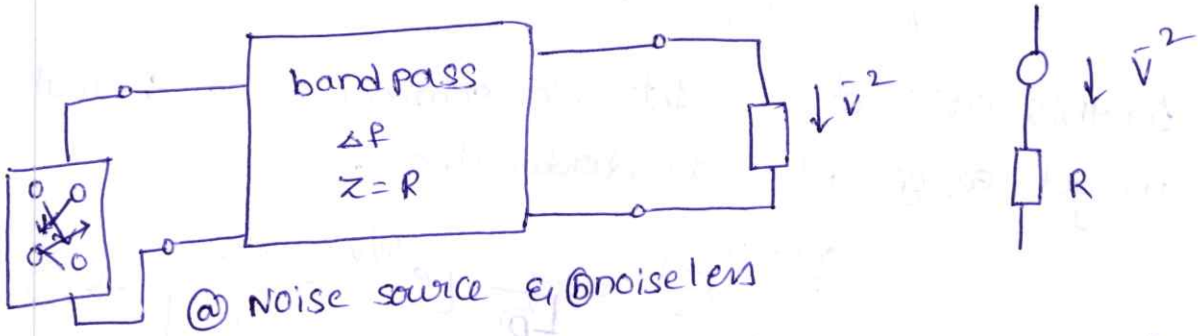
→ the noise voltage is usually derived from the harmonic oscillator, which is excited by the thermal energy. such an oscillator is a model for a short circuited line with the wave impedance $Z=R$.

→ Here a simplified, quantitative derivation is shown. we calculate the thermal noise power at an ohmic resistor, which can be measured with a band pass filter as shown in the fig.

→ According to the Nyquist theorem the signal must be sampled with $\Delta t < 1/(2\Delta f)$ to obtain a complete waveform. Δf corresponds to the bandwidth of the band pass filter.

→ from thermodynamics it follows that for each degree of freedom, & therefore for each amount of energy, the average energy of $\Delta E = 1/2\, KT$ is related. from the view point of information theory the mean transmissible power is $\bar{P} = \frac{1}{2} KT 2\Delta f = KT\Delta f \rightarrow ⑥$

→ the mean noise voltage at a noise free resistor R can be calculated with the help of the four pole theory according to $\bar{v}^2 = 4RKT\Delta f$ → (7)



(a) Noise source & (b) noiseless

→ the noise voltage is proportional to the resistance, the temperature & the bandwidth. In general, this voltage has a negative effect for electronic ckts & particularly in the processing of analogous signals.

→ If a ckt is scaled down the switching energy & therefore the signal power becomes lower. the effect of thermal power Increases with the bandwidth.

(2) Relativistic limits :-

→ some Important limiting effects for Microelectronics can be derived from the theory of relativity. If Information is coupled to discrete energy quantities we must assume that these quantities can not propagate faster than the speed of light c.

→ the switching times can not be reduced below a certain limit bcoz the devices can not be scaled down as one would like. let us assume that the active area of classical devices can not be smaller than the Debye length.

(3) Quantum Mechanical limits :-

→ the Interaction of light with a solid can only be explained by quantum mechanics. In the case n=1 we get the energy per switching event according to $W_s \geq \frac{h}{t_s}$ → (1)

→ for the power $P_V \geq \frac{h}{t_s^2}$ → (22)

these values can not be reduced any further. they are termed as Quantum - Mechanical limit.

→ In the same way, failures of switches occur due to thermal fluctuations, failures due to tunneling of charge carriers inside the switches is possible. tunneling is an effect of Quantum mechanics.

(4) Equal failure Rates by Tunneling & thermal Noise:-

→ the derivation of the failure probability due to thermal fluctuations assumed that a failure occur each time the energy of a charge carrier is above W_s.

→ If we consider failures by tunneling, the probability that a charge carrier can tunnel through a barrier is dependent on the energy W_s of the barrier & on the depth d.

→ Now we estimate the probability that failures due to tunneling & thermal fluctuations equal. with the assumption $P_{th} = P_{tu}$ we get

$$\frac{W_s}{KT} = \frac{2d}{h}\sqrt{2m(W_s - \bar{E})} \rightarrow (1).$$

→ If the mean kinetic energy $\bar{E}$ of the electron is half the energy W_s of the barrier we get the first order estimation.

$$d = h\sqrt{\frac{W_s/m}{2KT}} \rightarrow (2)$$

→ If we assume $W_s = 50KT$ the depth of the barrier can be calculated as d=2nm at T=300K. at this depth the failures caused by tunneling equal to those caused by thermal fluctuations. therefore the dimension of a device is a limit for the micro-miniaturization of classical devices.

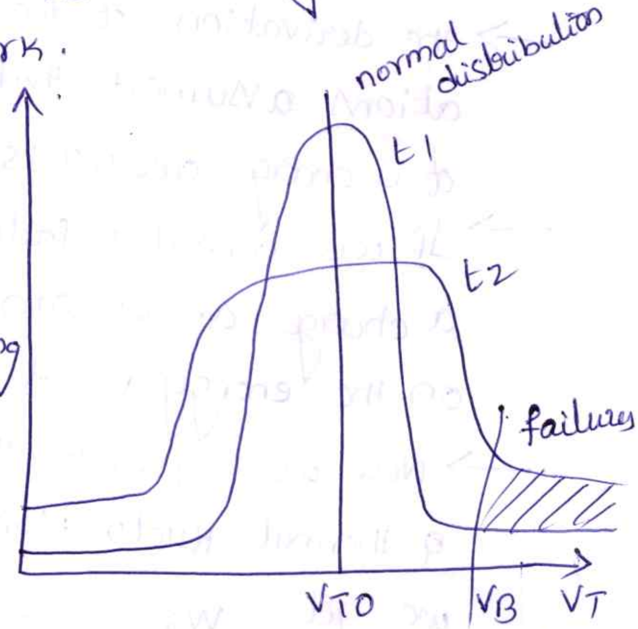
→ this limit is almost reached by semiconductor memories where the oxide thickness is around 5nm. the charge flow due to tunneling has to be taken into account.

~~Relaab~~

Reliability as a Limiting Factor: -

→ the distribution of the parameters as shown in the fig previously is only valid for the Initial state of the devices. devices with a threshold voltage V_T above V_B fail. As a result of this the device yield is reduced.

→ During the operation of the devices the distribution widens, which in turn causes additional failures, these failures determine the reliability of the devices. the reliability describes the avg time a device is able to work.



$t_1 \to t_2$ the failure rate Increases.

→ the diffusion process always occurs at temperatures above 0K & Increases with rising temperatures. the latter is advantageously used in the manufacturing of Integrated circuits.

→ If a device is operated at working temperature the diffusion process is small enough that the lifetime of a device is hardly reduced.

→ on the other hand, some failure mechanisms are based on the dibbusion process. the lapse of time for this mechanism is very fast so further unwanted failures occur.

→ the distribution widens with time, so the no of bailures Increases, with the time constant for this process can be approximated to

$$\tau_z = \frac{x_0^2}{D} = c' e^{E\, E_A/(KT)} \rightarrow (1)$$

→ In the above equation x_0 is a fixed quantity. x_0 corresponds to V_{B0}. c' is a constant & E_A the activation Energy.

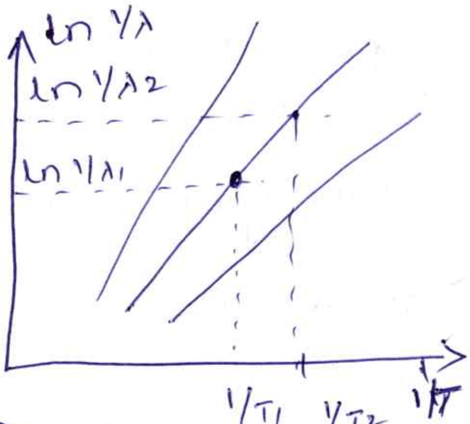
→ Now we compare this time constant to the time constant that describes the bailure rate in relation to time. In the realibility theory a first approximation of the failure rate is described by an exponential function. $N = N_0 e^{-\lambda t}$ → (2)

→ N_0 describes the no of devices at the initial state, N the number of devices during operation, t the time, & λ the failure rate. this equation can be derived from the differential equation with the condition that the relative failure rate per unit time is constant $\frac{1}{N}\frac{dN}{dt} = -\lambda$ → (3) $1/\lambda$ as a time constant of t_z.

from eq(1) can be derived if λ is set proportional to $1/t_z$.

$$\lambda = C_A e^{-E_A/(kT)} \rightarrow (4)$$

→ If the failure rate λ_1 & λ_2 are measured at two different temperatures T_1 & T_2 we get the activation energy E_A. A graphical Interpretation of this is shown in the so called Arrhenius plot as shown in the fig.



Dependence of λ of the temperature T & the activation energy E_A.

$$E_A = kT_1 \frac{T_2}{T_2 - T_1} \ln \frac{\lambda_2}{\lambda_1} \rightarrow (5)$$

→ Most of the device failure mechanisms have an activation energy around 1eV. In practice usually more than one failure mechanism occurs at the same time.

Physical Limits :-

→ the preceding effects of classical physics permit a derivation of physical limits of micro & nanoelectronics. In this the most important limits from thermodynamics, the theory of relativity, & from Quantum mechanics are presented.

→ A graphical overview of these limits is shown in the fig. for a better orientation the straight line characteristics for $1fJ = 10^{-15}$ WS is shown in power delay chart. some of these limits might be overcome in future, the more quantum mechanical aspects are used.

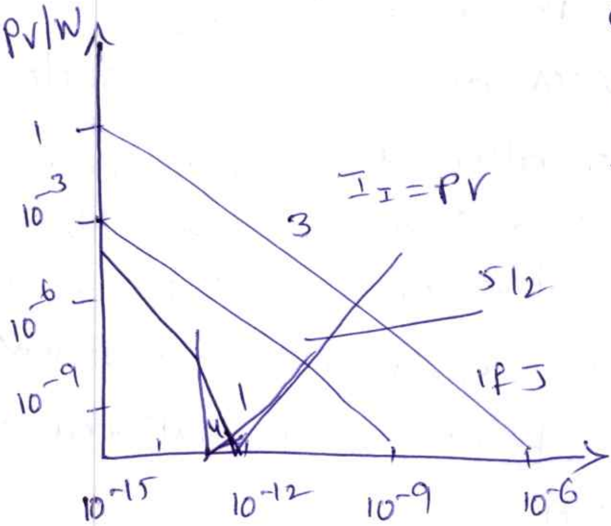


fig:- physical limits of Microelectronics with regard to power & delay.

quantum Mechanical limit

① quantization Pv

thermodynamical limits

② minimal voltage $V_{min} = \gamma V_T$

$P_{Min} = V_{min}^2 / Z_{LO}$

③ therm fluctuations $E_S = P_V I_d = C k_T$

relativistic limits

④ delay $I_L = \sqrt{\frac{\epsilon_1}{\epsilon}}\ I_L$

⑤ wave Impendance

$Z_L = \sqrt{\frac{\epsilon_r}{\epsilon_0}}\ Z_{LO}$

$Z_{LO} < \sqrt{\frac{\mu_0}{\epsilon_0}}$.

① thermodynamic limits :-

→ thermal Movement of charge carriers Impedes the current flow in a switching device. the dependence of the current through a pn-junction due to an applied voltage is reduced at higher temperatures. the higher the temperature the smaller the curvature of the diode characteristics.

→ If we want to take advantage of the non-linear behaviour of the device the working voltage should not be too small. the smallest value of this voltage is $V_{min} = rV_T = rkT/q$ → ①

→ with $r = 4-8$. the higher the temperature T the higher the voltage V_{min}. to reduce scattering Inside the device during a switching event dozens of electrons should be Involved. therefore the lower limit for this value W_s is about 25KT. Actually this value is mostly too small, so thermal fluctuations would occur inside the device.