NOORUL ISLAM COLLEGE OF ENGINEERING, KUMARACOIL

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

SUBJECT CODE**: CO1652**

MICROWAVE INTEGRATED CIRCUIT
(FOR SECOND SEMESTER ME COMMUNICATION SYSTEMS)

TWO & 16 MARK QUESTIONS-ANSWERS

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SECOND SEMESTER ME COMMUNICATION SYSTEMS
TWO MARKS

SUBJECT**: MICROWAVE INTEGRATED CIRCUITS**
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UNIT: I

1. What are Hybrid MIC's? In which frequency range it is used?

A MMIC, which consists of combination of two or more integrated circuit types such as monolithic or film or one IC together with discrete elements is referred to as Hybrid MIC.

2. Give the feature of substrate material used in fabrication of MMICS?

High resistive material giving good isolation and low losses

3.What are the three basic developments that led to the present MIC technology?

1. Introduction of mew microwave tubes
2. Development of semiconductor devices operating at microwave frequencies
3. Rapid strides made by integrated circuit technology at lower frequencies.

4.What do you understand by thick and thin film technologies?

Hybrid technology itself can be divided into two parts namely, thin film and thick film technology. Thick films are usually deposited as conductive, resistive or insulating layers, through a screen-printing process. Thin films are generally deposited in vacuum by evaporation or sputtering. The thickness can be further augmented by electroplating.

5.Give any two characteristics of an ideal substrate material

Characteristics of Ideal Substrate Material:-

1. High dielectric constant
2. Low loss tangent
3. High resistivity and dielectric strength
4. High thermal conductivity

6.Give any two characteristics of an Ideal Conductor material

Characteristics Ideal Conductor Materials:-

1. High conductivity
2. Low temperature coefficient of resistance
3. Good adhesion to the substrate
4. Easily deposited or electroplated.

7.List the advantage of MIC's compared to traditional circuits using printed circuit technology.

1. Low cost
2. Small size
3. Light weight
4. High reliability
5. Improved reproducibility
6. Improved performance

8.**What is meant by Hybrid technology?**

Hybrid technology: -

In Hybrid technology, the active devices are in the form of chips which are added to a substrate that carriers the rest of the circuit.

9. Explain the concept of effective dielectric constant (Єreff):-

Єreff is the effective dielectric constant of the micro strip line, the effective because some of the field lines are in the dielectric and some are in air. Therefore Єe lies between unity (or air) and Єr for dielectric. The Єreff depends on the thickness t of the metal strip and the w/b ratio. Since the propagation field lines in a microstrip lie partially in air and partially inside the homogeneous dielectric substrate, the propagation delay time for a quasi TEM mode is related to Єreff.

10.Mention the type of diode packages that are commonly used in encapsulation of devices.

1. Passivated chips
2. Beam lead devices
3. LID's (Leadless Inverted Devices Package)

11.Mention the etchants for any four selected deposited films.

Deposited film:-	Possible etchant:-
1. Aluminum	Ferric Chloride
2. Gold	Aqua regia
3. Silver	Ferric nitrate
4. silicon	Ferric chloride, concentrate nitric acid and concentrated hydrofluoric acid

12.What is meant by Surface finish Capability?

Losses at microwave frequencies are heavily dependent on the degree of surface finish, the fineness of finish required increasing with increasing frequency.

13.What is meant by the parameter adherence qualities of deposited film?

Adherence becomes more difficult as the surface becomes more highly polished. Higher degree of polish is required is necessary in case of thin film.

14.What is the parameter Dielectric constant for dielectric substrate?

Dielectric constant value is to be low in order to ensure the stability of the circuit over arrange of operating temperature.

15.What is the need for leveling of the paste?

The need of the leveling of the paste is to remove the marks of the mask wires.

16.What the need of photo resist layer in the silk screen?

The photo resist layer is used in which the pattern is transferred from the original artwork.

17.Where the micropill or pill form is used?

It is used in the shunt mounting in micros tip circuits on the alumina substrate.

18.What is meant by LID package?

Leadless Inverted device or ceramic carrier package is a rugged carrier for semiconductor chips.

19.What are the types of Mounting of Active devices?

1.Mounting of chips
2.Mounting of beam lead devices

20.What are the various techniques used in mounting of chips?

1.Thermocompression bonding
2.Ultrasonic bonding
3.Parallel gap or step welding

UNIT 2

1. Mention the process involved in fabrication of MMICS?

a) Epitaxial growth
b) Growth of oxide layer
c) Diffusion
d) Metallization
e) Photolithography

2. Give the feature of substrate material used in fabrication of MMICS?

High resistive material giving good isolation and low losses

3. Why dielectric layers are used in MMIC technology?

a) For protection and surface passivation of device.
b) As a mask against diffusion of impurities

4. Give the advantage of liquid phase epitaxy over vapor phase epitaxy?

For VPE highly doped epitaxial films are needed

5. What are the commonly used dielectric layers for fabrication of MMICS?

Silicon dioxide and silicon nitride

6. Mention the techniques used for preparation of silicon dioxide layers?

a) Thermal oxidation
b) Chemical deposition
c) Reactive sputtering
d) Electro chemical oxidation of silicon

7. What are the properties of dielectric layer?

a) Thick enough to act as an effective mask against diffusion
b) Must have a high break down strength and a high resistivity

8. Give the expression for diffusion coefficient of an impurity?

$$D = Do \exp\{-Eac/KT\}$$

Do- diffusion coefficient as T = infinity
Eac-activation energy of diffusing impurity

9. Give the steps involved in ion implantation?

a) Generation of a beam of ions of desired element
b) Acceleration of beam to required energies
c) Exposure of target material to the ion beam
d) Annealing of substrate to counter act the lattice damage caused by ion beam

10. List the main features of ion implantation?

a) Doping is possible at low temperature
b) Very close control over doping is possible
c) Very little lateral spread of impurity ions

11. Mention the applications of ion implantation?

a) Double drift region avalanche diodes.
b) Fabrication of MOS devices for accurate control of threshold voltage and in bipolar transistors

12. Give the advantage of EBT over photolithography?

In photolithography diffraction effects limits resolutions. By using EBT higher degree of resolution is possible

13. Give the applications of EBT:

Fine resolution possibilities of an EB pattern delineation have been exploited for junction field effect transistors in gallium arsenide and for transducers for acoustic wave amplifiers

14. Give the materials used for fabrication of MMICS?

Substrate materials, conductor materials, dielectric materials, resistive materials

15. Mention thin film resistor Materials used for fabrication of MMICS?

Aluminum, copper, gold, nichrome, titanium

16. Give different configurations of planar inductor film?

Meander line, sline, square spiral, and circular spiral

17. Give different types of planar capacitor film?

i) Metal oxide metal capacitor
ii) Inter digitated capacitor

18. what is Inter digitated capacitor?

Inter digitated capacitor consists of a single layer structure and it can be fabricated easily on substrates

19.What is meant by monolithic technology?

Monolithic MIC's: -

In case of monolithic technology, various active devices and their implementation patterns are formed simultaneously in single crystal substrates of semiconductor materials

20. Summaries the reasons for increase in MMIC research and development

The developments of MIC's were primed mainly by requirements of phased array radar. MIC's are now finding substantial use in the field of microwave communications also. Use of MIC's in the front end of augment TV receivers for direct reception of broadcast from satellites will mean a sizeable new requirement.

21.What are methods of testing in MMIC fabrication?

1. Bulk parameters such as thickness can be tested by conventional methods.
2. For examination of film on a microstrip scale, scanning electron microscopes have been used.

To evaluate the overall performance of a given type of film deposited on a substrate a standardized resonant circuit can be used

UNIT 3

1.Define residual.

The relaxation method is one of the numerical methods for the analysis of microstrip line. It starts with an assumed distribution of potential at every unknown point. The amount by which assumed value is different from the computed value is known as residual.

2.Define Relaxation.

It is the process of changing the assumed value of the potential at each net point in a systematic manner to obtain smaller residual values at each net point.

3.Define 'rate of correction'.

In relaxation method, the rate at which the potentials are changed or corrected is determined by the residual calculated at that point. This can be illustrated as

$$\text{New } V_o = \text{old } V_o - \alpha R_o$$

R_o is residual at that point

α is rate of correction.

4.Discuss the results obtained from numerical method analysis of microstrip line.

*The characteristic impedance for a microstrip line in box is lower than for open micostrip structure.

*The presence of enclosure increases the capacitance between two conductors.

5.What are the methods used for the analysis of microstrip line.

1.Method of conformal transformation.
2.Numerical analysis using relaxation method.
3.Hybrid mode analysis.

6.Define Hybrid mode.

The components of both the electric and the magnetic field along the direction of propagation are non-zero; the resulting mode is hybrid mode.

7.Define 'capacitance between electrodes'.

The ratio of total electric flux from one electrode to other to potential difference between them.

8. What are the scalar potentials of TM and TE field configuration?

The TM and TE field configurations are derivable from scalar potentials which are linearly related to Ez and Hz respectively.

9.Give the various techniques for determining the dispersion characteristics of microstrip line.

*Fourier analysis method
* Singular integral equation approach.
- Numerical method

10.Give the size of Integral equation method and Fourier analysis method.

Integral equation 2*2 matrix
Fourier analysis 100*100 matrix

11.Define coupled mode.

In this method it takes into account the coupling between quasi-TEM mode along the microstrip line and TM10 surface wave mode on the dielectric substrate with metallaisation on the bottom surface.

12.What is upper cutoff frequency in coupled mode analysis?

An upper cutoff frequency is defined as the frequency at which the phase velocity of the quasi-TEM mode along the microstrip line is equal to phase velocity of TM10 surface wave on the substrate.

13Give the effective dielectric constant in terms of uncoupled modes $\in_{eff0}$ and $\in_{effrm}$ using coupled mode theory.

$$\in_{eff1,2}= [(\sqrt{(\in_{eff0}+\in_{effTM})}/2+\sqrt{\{\in_{12}+\in_{21}+(\sqrt{\in_{eff0}}-\sqrt{\in_{effTM}})^2\}}/4]^2$$

14.What is two-dimensional Greens function?

The potential distribution resulting from a single line charge is calculated by using Coulomb's law and is known as two dimensional Greens function.

15.Give the expression for image coefficient 'k' in the method of images.

$K=(\in_0-\in_1)/(\in_0+\in_1)$

16.Give the step for computing capacitance in the method of images.

1. Calculate Greens functon G(p,q).
2. Solution of integral equation, $V(X,Y)=\int\sigma(Q)G(P,Q)dQ$

17.What are the losses in micro strips.

1.Conductor Loss
2. Insulator loss.

18. What are the types of modes in the mircostrip line?

The modes in the microstrip line may be be divided into

1.(Hz)odd-(Ez)even mode
2.(Hz)even-(Ez)odd mode

19.Give some advantages of singular integral equation method.

The computational effort is at least ten times smaller than numerical and Fourier analysis method. Apart from the numerical efficiency , the simplicity makes it possible to solve conveniently for higher order modes that affect the high frequency behavior of microstrip lines.

20.What is the final result of singular integral equation method?

The final result is a determinantal equation which has the property of more rapid convergence as compared to the determinantal equation corresponding to the original set of equation.

UNIT 4

1. **What are the two types of directional couplers used in micro strip applications?**

    1. Coupled micro strip directional coupler
    2. Branch line coupler

2. **What is coupled micro strip directional coupler?**

    A coupled micro strip line coupler is made of the natural coupling that exists between two micro strips placed side by side.

3. **What is branch line coupler?**

    A branch line coupler is made of two parallel micro strips coupled through a number of branch lines. The length of branch lines and their spacing are all one-quarter wavelength.

4. **What do you mean by even mode?**

    If equal and in phase voltages are applied to ports one and two a voltage maximum will occur along the line of symmetry. Thus an open circuit (magnetic wall) may be located at this plane.

5. **What do you mean by odd mode?**

If equal and opposite voltages are applied to ports one and two a voltage minimum will occur along the line of symmetry. Thus a short circuit (electric wall) may be located at this plane.

6. Give the expression for input impedance for even mode coupled line.

$Z1e = Zoe [(Zo+ jZoe \tan \theta e)/ (Zoe+ jZo \tan \theta e)]$

Zoe = even mode characteristic impedance.

7. Give the expression for input impedance for even mode coupled line.

$Z1o = Zoo [(Zo+ jZoo \tan \theta o)/ (Zoo+ jZo \tan \theta o)]$

Zoo = odd mode characteristic impedance.

8. Give the Electrical length of microstrip for even and odd mode

$\theta e = 2\Pi fL/Ve$
$\theta o = 2\Pi fL/Vo$

L---------- Physical length of coupled lines.
Ve, Vo-------- Propagation velocities for even and off mode.

9. Give the expression for Even and Odd mode impedances in terms of midband coupling

$Zoe = Z0\sqrt{} [(1+C)/ (1-C)]$

$Zoo = Z0\sqrt{} [(1-C)/ (1+C)]$

Where $C = [(Zoe/ Zoo)-1] / [(Zoe/ Zoo) +1]$.

10. Give the Condition for forward coupling to be zero

Electrical length of even and odd modes must be equal (i.e.) $\theta e= \theta o$.
And $Z0 = \sqrt{} (Zoo\ Zoe)$. Port 3 is perfectly isolated and so forward coupling is zero.

11. Write the Disadvantage of coupled line.

Symmetric multisection couplers are not optimum in the sense of having maximum bandwidth for a given coupling tolerance.

It is not possible to realize tight coupling over a large bandwidth using symmetric couplers.

12. What are the Properties of branch line couplers?

1. Coupling between the lines is through joining branch lines gives flexibility.
2. Couplers are capable of handling high RF powers.
3. Better suited for weight coupling than for weak coupling.

13. Write the Coupling coefficient of matched couplers cascaded together.

$$P1comb = 20 \log10 \left[\cos \left(\sum_{i=1}^{N} \theta i\right)\right] dB$$

$$P2comb = 20 \log10 \left[\sin \left(\sum_{i=1}^{N} \theta i\right)\right] dB$$

N = number of cascaded stager
θi = phase shift of the ith stage.

14. What is mean by Periodic branch line coupler?

When the main lines of a branch line coupler remain uniform and all the branches are identical, the coupler is called a periodic line coupler.

15. What is mean by Synchronous branch line coupler?

When the main line admittances of a branch line coupler are not uniform, the coupler is called synchronous branch line coupler.

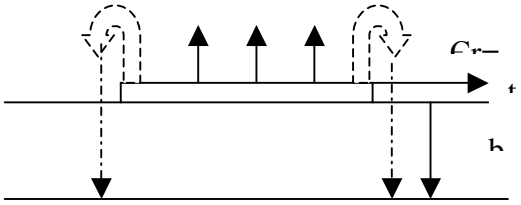
16.Give the expression for the characteristic impedance of a microstrip?

Characteristics impedance Zc of microstrip line depends upon the w/b ratio

When w/b>1, $Zc=120\Pi/ (\sqrt{\epsilon}e[w/b+1.4+0.667\ln (w/b+1.444)])$ ohms

When w/b≤1, $Zc= (60/\sqrt{\epsilon}e)*\ln (8b/w+w/4b)$ ohms

17.Sketch the electric and magnetic field distributions in a microstrip.



Ground

-------- H lines

——— E lines

18.Describe how characteristic impedance, guide wavelength and effective dielectric constant are defined and expressed for microstrip lines of large width w>>height(h)

For w/h>1, $Zc=120\Pi/(\sqrt{\epsilon e}[w/b+1.4+0.667\ln(w/b+1.444)])$ ohms

$\lambda g=2\Pi/\beta=\lambda 0/\sqrt{\epsilon e}$

$\epsilon e=(\epsilon r+1)/2+(\epsilon r-1)/2(1+12h/w)-1/2-.217(\epsilon r-1)t/\sqrt{wh}$

UNIT 5

1. What are the characteristics of 3 port circulator?

The 3-port circulator is formed by a 120 degree H plane wave guide. The characteristics are

i) Insertion loss<1 db

ii) Isolation loss=30to40db

iii) VSWR<1.5

2.Give the scattering matrix of 3-port microstrip circulator?

$$[s]=\begin{pmatrix} 0 & 0 & S13 \\ S21 & 0 & 0 \\ 0 & S32 & 0 \end{pmatrix}$$

S13=S21=S32=1

3. What are reciprocal and nonreciprocal components?

Reciprocal component:-

The response between any two ports I and j of a component did depend on the direction of the signal flow (Sij = Sji). This is applicable if the component consists of passive isotropic materials.

Non-Reciprocal components:-

It is a an isotropic component. Most practical materials for microwave applications are ferromagnetic compounds such as YIG (Yttrium Iron Garnet) and ferrites composed of iron oxides.

are that which can allow signal in both direction which allow signal in forward direction. eg, Circulator.

4. .Give the properties of ferromagnetic substrate?

i)RF loss should be minimum

ii)dielectric and magnetic losses should be minimum

iii)conductor and radiation losses should be minimum

5. .Design criterion for selecting ferromagnetic substrate:

i)(r*4*3.14*Ms)/w =0.6

ii)W>(r*4*3.14*Ms+Hanis)r

6. Give the modes of operation of microstrip circulators?

i)fixed bias operation(uses permanent magnet)

ii)switched bias operation(uses electro magnet)

7.What are the methods of incorporating ferrimagnetic components?

i) Plug in type

ferrimagnetic disk is cemented into usual ceramic substrate.

ii)All ferrimagnetic substrate

Active ferrimagnetic area I equal to that of magnetized portion.

8. Give the advantages of thin film technology?

1. By using thin film technique, the size of elements can be reduced.
2. Used upto X-band frequencies

9. Given the induction of a rectangular strip?

The induction of the rectangular strip is given by

L.l = 5.8*10^-2 l [ln (l/w+h)) +1.193 + 0.2235(w+h)/l]

L.l is in nanohenries, and all dimensions in mils.

10. Give some consideration in design of inductance?

1. Large W with less diameter (d0)
2. Some space should be at the center of spiral inductor to allow flux lines to pass through.
3. Rs increases as f^1/2, the Q of the inductors increase with square root of frequency

4. Multiturn coils have higher Q, but have lower resonance frequencies.

11. What are isolators? Give its scattering matrix?

Isolator is obtained by terminating one part of a there port circulator in a matched load. It is two port non-reciprocal devices that produce thin attenuation to wave propagation in one direction and high attenuate in other direction.

$$S = \begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix}$$

12. What are phase shifters? What are its types?

Phase shifters change the phase (or) propagation constant of the incoming wave. There are two types of phase shifters.

1. reciprocal
2. non-reciprocal

13. Give the specification of the substrate used in microstrip circulators?

The performance of the microstrip circulator depends on the substrate. The YIG substrate specifications depend on frequency. For frequency of 8.5 to 9.9GHz,& 0.055 thickness and isolation greater than 20dB a VSWR less than .2 and insertion loss less than 0,8 dB is used.

14. How can the peak power threshold be improved in microstrip circulators?

The peak power threshold is improved by

1. Increasing the intrinsic line width
2. Decreasing the 4ΠIMs of the material

15. How can latching circulator are used as single pole double throw switch?

If the ferromagnetic material subjected to bias (ie) magnetic field pulse it get magnetized to max value and falls to remanent value when bias removed. Thus it can act as single pole double throw switch.

16. Differentiate distributed elements and lumped elements?

Distributed elements	Lumped elements
1. can be used at high frequencies	At microwave frequencies difficult to be used
2. size is acceptable at high frequencies	Size is comparable with the wavelength at high frequencies.

17. What is the input impedance of a transmission line?

$Z_{in} = Z_0 \gamma l$

$= (r+jwl)\, l$

r = resistance

L = inductance

l = length

18. Give the geometry of the interdigital capacitors and comment on it?

The interdigital capacitor has both the conductors of the capacitors of the capacitors in the same plane which is the top surface of dielectric substrate.

The dielectric substrate is alumina and no additional dielectric required. It requires a large area and it can be used for application upto 3GHz.

19. Give two advantages of the lumped elements?

1. Circuit design and optimization techniques for low frequency may be extended to microwave frequency.
2. Distributed element circuit may be transformed to lumped element circuit.

20. Give the inductance and Q of a spiral coil?

Ls = a^2n^2 / (8a+11c)

n = turns

c = (d0-di) / 2

a = (d0+di)/ 4

Where di = min. diameter

d0 = max.diameter.

Q = 2*10^-9 fwna / k` Rs (8a+11c)

k` correction factor.

R = k` ΠnaRs/W

Where Rs = sheet resistance.

W = width of ribbon.

16 MARKS

1.Explain in detail main process steps involved in selective epitaxial growth?

Chemically polished si GaAs substrate, masking film, masking film with etch holes, etched holes in substrate, epitaxial growth of semi conducting GaAs

2.Explain epitaxial process for silicon?

Hydrogen reduction of halide, b) pyrolisis of silane

3.Explain fabrication process of MMICS?

a). Epitaxial growth
b) Growth of oxide layer
c) Diffusion
d) Metallization
e) Photolithography

4.An Inter digitated capacitor Fabricated on a GaAs substrate has following parameters:

N =8
Relative dielectric constant = 13.10
Substrate height = .254 cm
Finger length = .00254cm
W = .051 cm

Compute the capacitance?

Hint. C = (εr+1/w) l [(N-3) A1+A2] PF/cm

AI = .089, A2 = .10

Big Questions:

5.Discuss the various losses in microstrip.

Conductor loss
Dielectric loss

6.With the help of suitable diagrams, explain the concept of conformal transformation.

Z-plane to t-plane
t-plane to W-plane

7.Explain hybrid mode analysis.

Fourier analysis
Singular integral equation
Numerical method

8.Explain numerical method of analysis.

Relaxation method

9.Explain Even and Odd mode analysis.

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10.Explain the Coupled- microstrip directional coupler.

A coupled micro strip line coupler is made of the natural coupling that exists between two micro strips placed side by side.

$Z1e = Zoe\ [(Zo + jZoe \tan \theta e)/ (Zoe + jZo \tan \theta e)]$

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Electrical length,

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L---------- Physical length of coupled lines.
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11.Explain the Branch line couplers.

A branch line coupler is made of two parallel microstrips coupled through a number of branch lines. The length of branch lines and their spacing are all one quarter wavelength.

Properties of branch line couplers.

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14.Write Short notes on Thick film and thin film Technology.

1. Thick film Technology: -
   Block Diagram
   Refer book: - Gupta
   Thin film Technology: -
   Thickness less than 5 minutes.

15.Explain Encapsulation and mounting of devices.

Encapsulation of devices:-

2. Diode package
3. Passivated chips
4. Beam lead device
5. LID (Leadless Inverted Device)

Mounting of devices: -

Classified into 3 types

1. Mounting of chips
2. Mounting of beam lead device

16.What are the different characteristics must be taken into account in choosing the substrate for MIC's?

Parameters

17. A microstrip is to be designed and its specifications are

Strip thickness t≤0.005h
Substrate board Alumina
Substrate relative dielectric constant Ɛr=10
Ratio of w/h w/h=. 95
Calculate 1. The effective relative dielectric constant
2. The characteristic impedance
3. Phase velocity and
4. The wavelength

Ans:-

1. The effective relative dielectric constant= 6.709
2. The characteristic impedance= 50 ohm
3. Phase velocity = 1.158*10^8 m/s
4. The wavelength= 5.79 *10^-3 m

18. For a microstrip line with w/h=1, Ɛr=10, and t/h=0, calculate at f~0 the effective width, effective dielectric constant and characteristic impedance of the line.

Ans:-

1. The effective relative dielectric constant= 6.748
6. The characteristic impedance= 48.74 ohm

19.Explain in detail about the types of non reciprocal components?

1.Circulator
2.Isolator
3.Phase shifter

20.Explain the fabrication of capacitor?

1.Interdigital capacitor
2.Sandwitch capacitor

21.Explain the other method of analysis?

1.Coupled mode analysis
2.Mehod of analysis

22.Explain the impurity distribution in detail?

1.PN junction formation
2.Two step diffusion

23.Explain in detail the design of lumped elements?

1.Capacitor
2.Resistor
3.Inductor

24.Explain the electron beam technology in detail?

Beam technology
Pattern delineation

25.What are the techniques followed for the preparation of Silicon Nitride?

Chemical deposition
Reactive sputtering