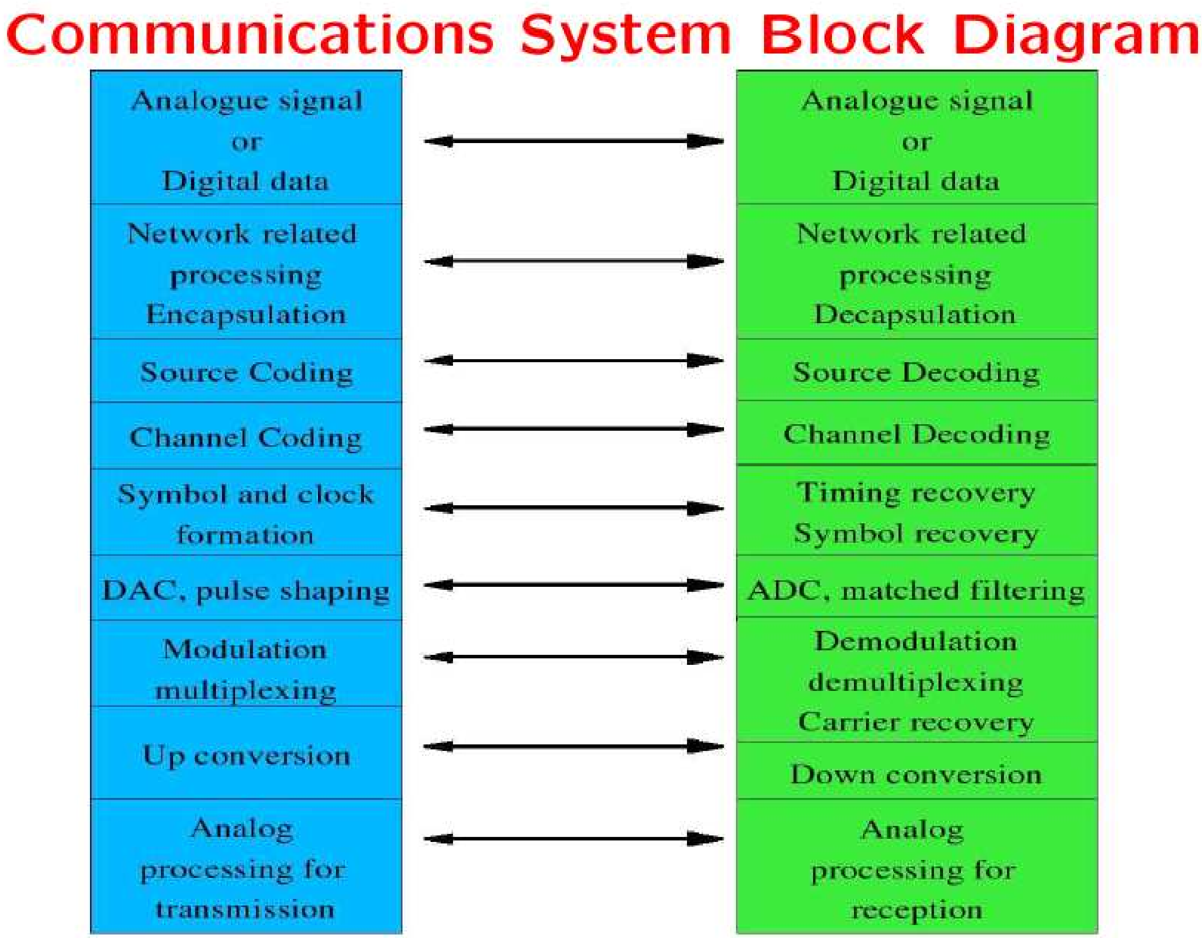
Applications: Wireless communications 1



Applications: Wireless communications 2

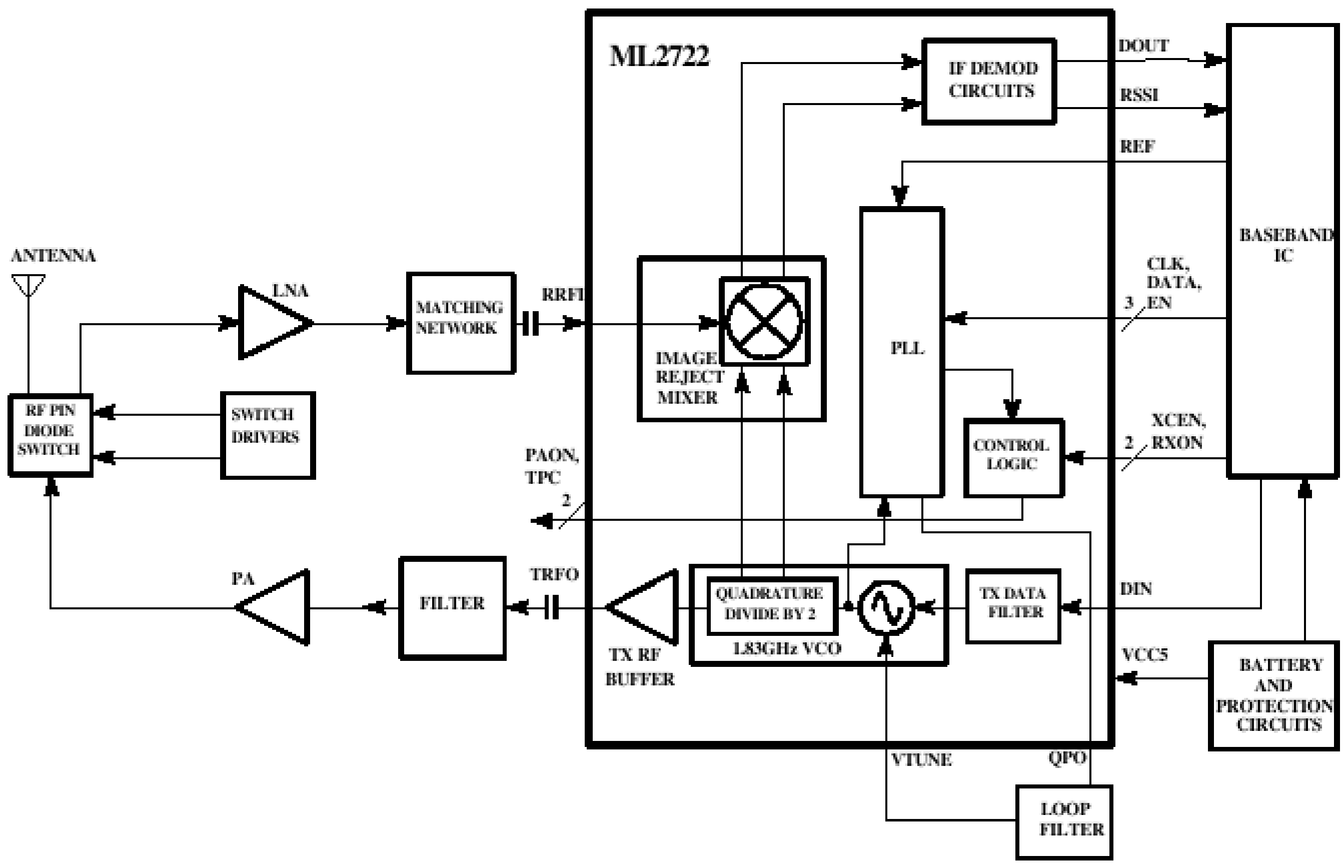
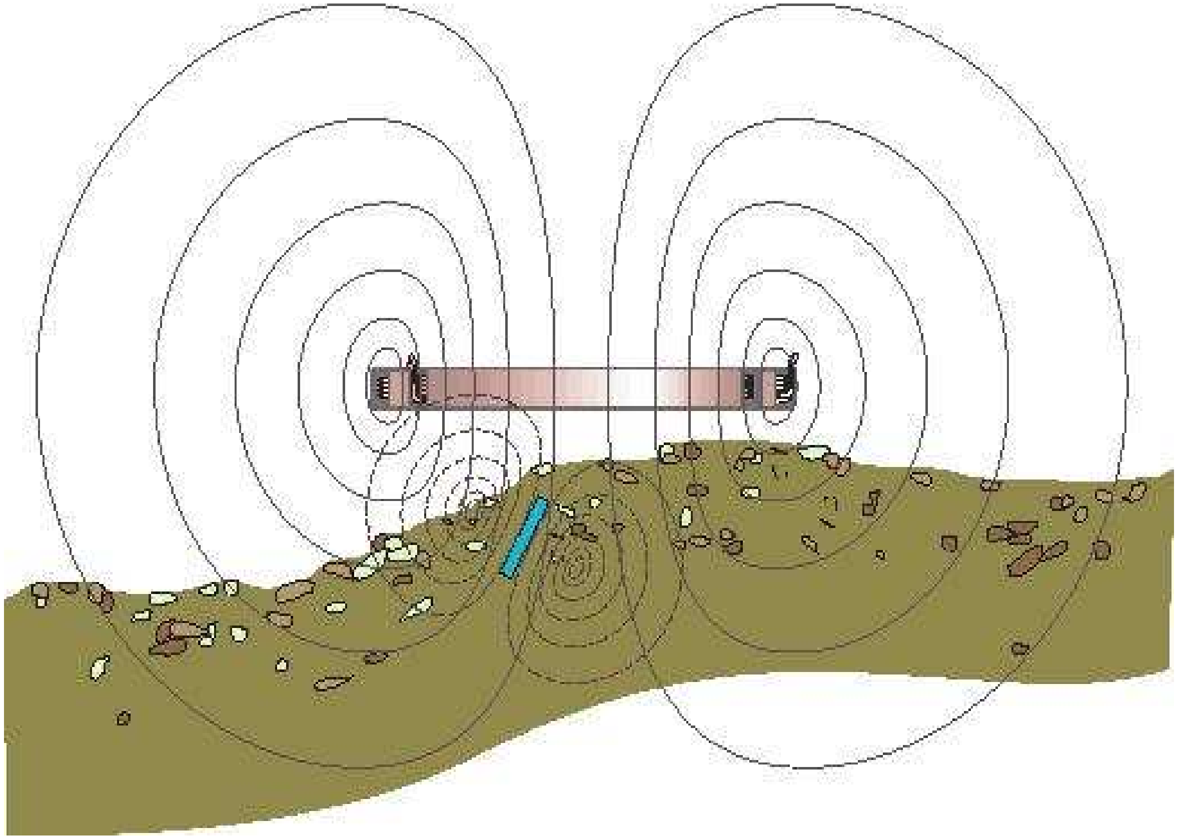


Figure 1. Simplified Application Diagram

Applications: Metal Detectors



Applications: Radar 1

Three common types

1. Pulse - doppler radar,
2. FM and,
3. CW radars.

Applications: Radar 2

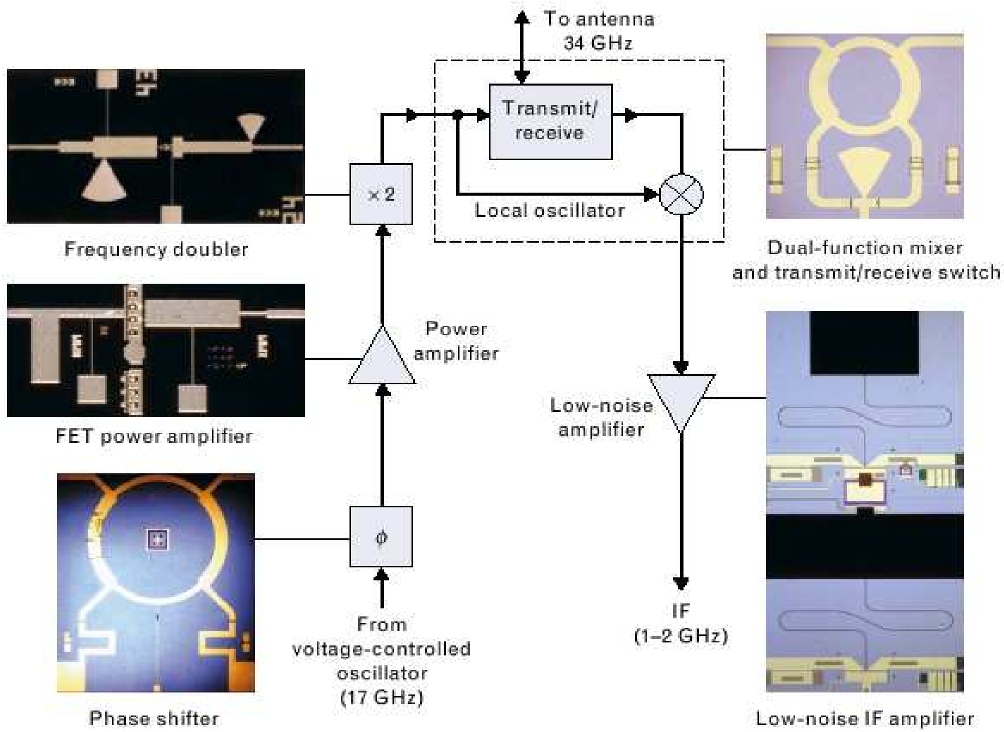
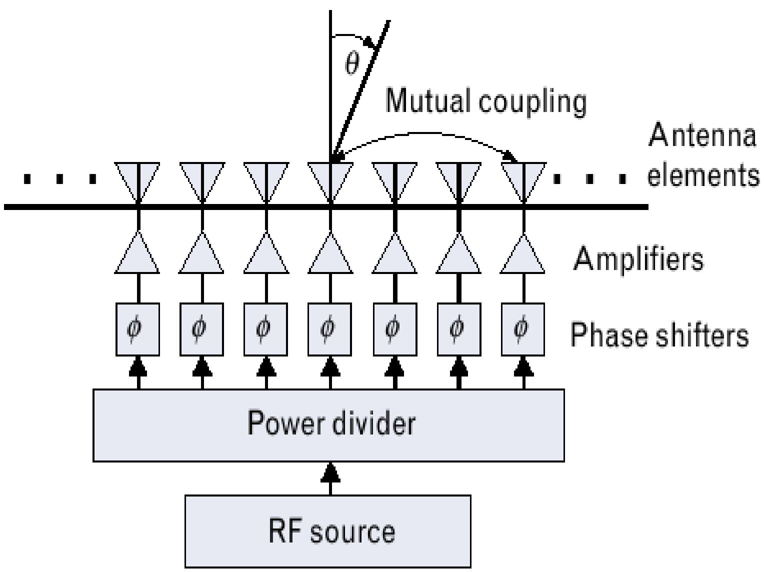
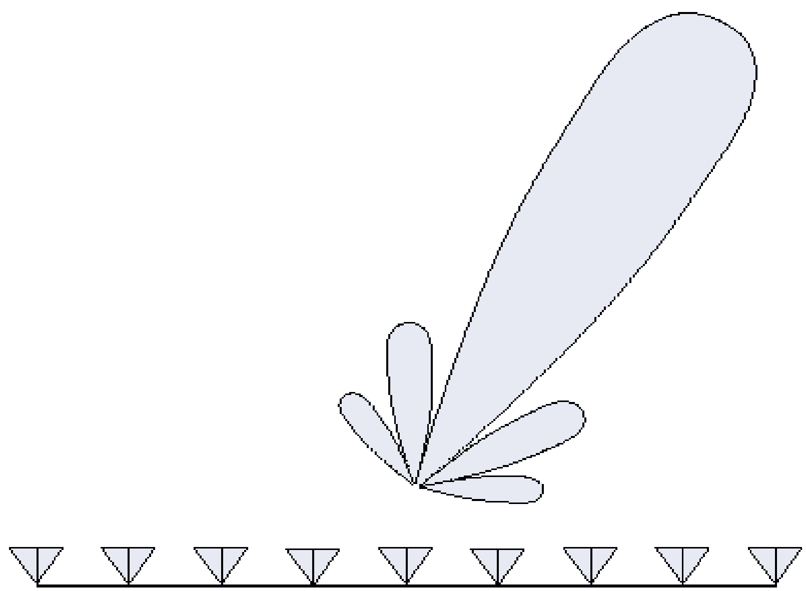


FIGURE 15. Module configuration and organization of component chips for a gallium-arsenide active-element transmit/receive circuit. The transmit side includes phase control and field-effect transistor (FET) power amplification at 17 GHz, and a frequency doubler. On the receive side, a dual unit incorporates a transmit/receive switch and a mixer that produces the intermediate frequency (IF) at 1 to 2 GHz. This dual unit is followed by a low-noise output amplifier.

Applications: Radar 3

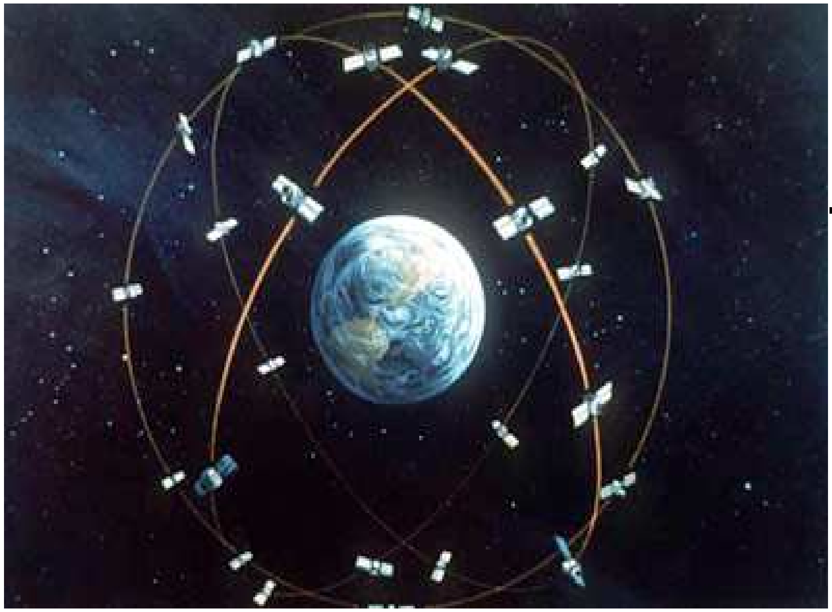


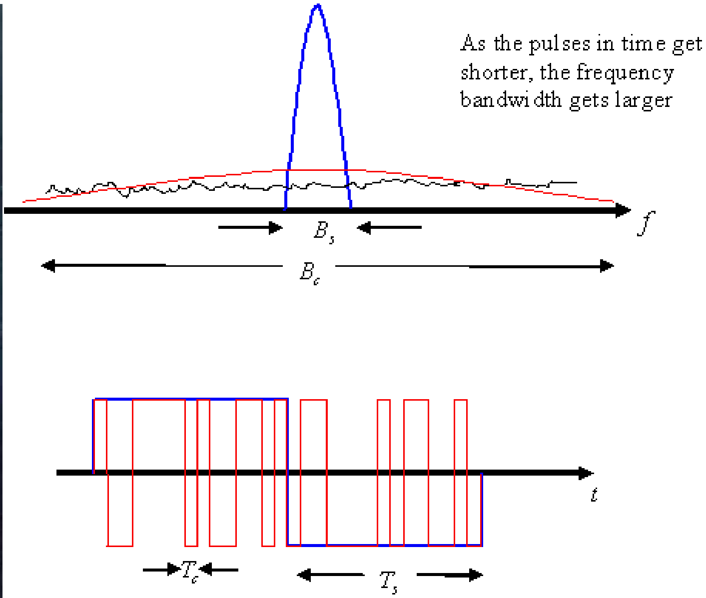


Applications: Radar 4

- AWACS CEAFAR (3D)

Applications: Location Measurement (GPS)





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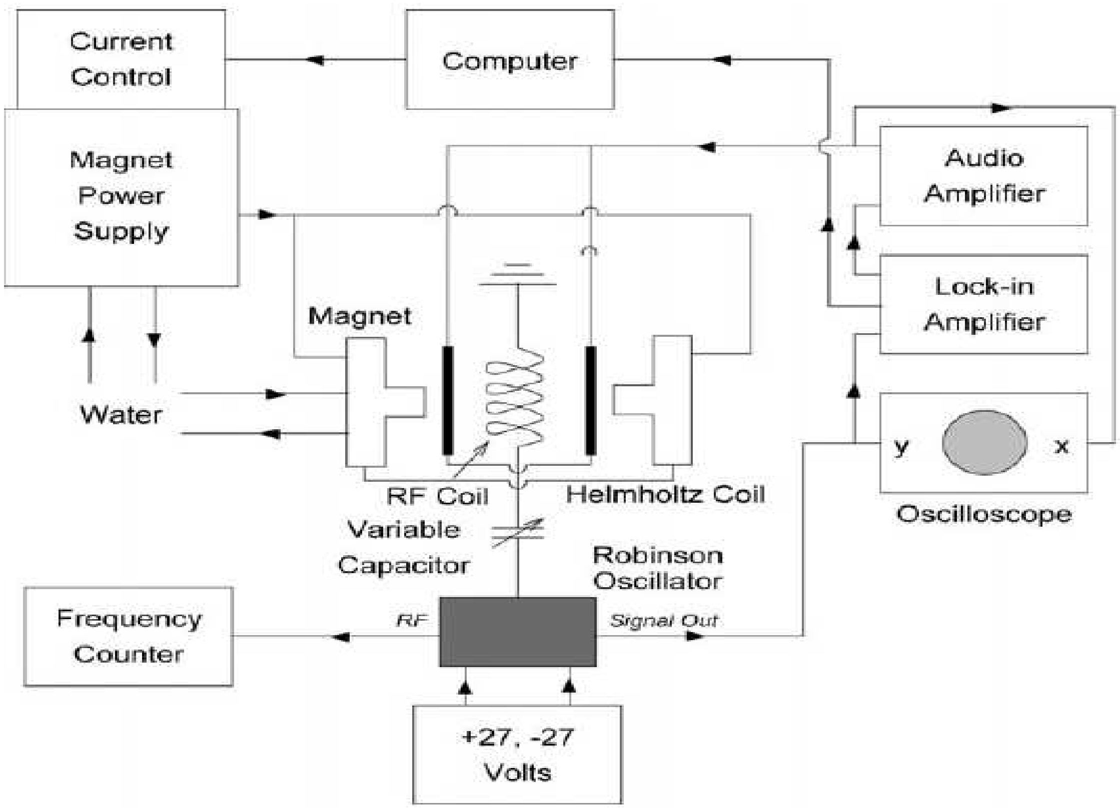
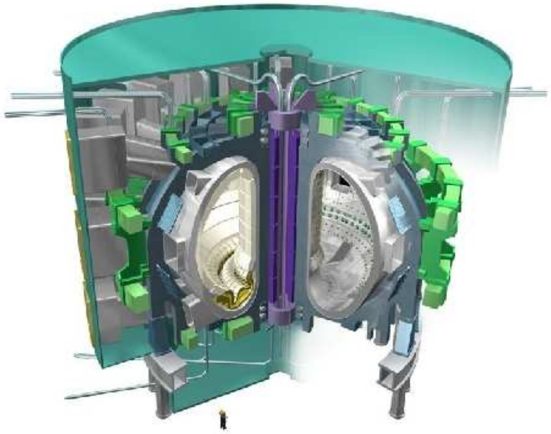
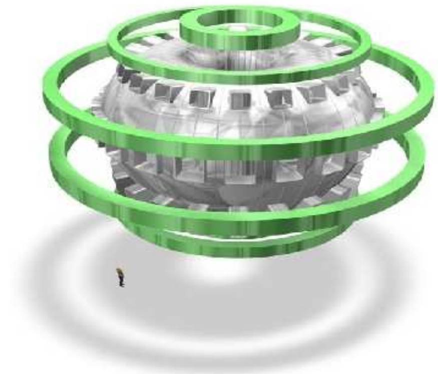
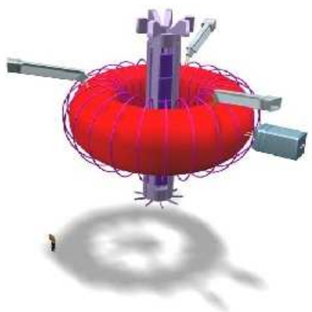
Applications: Nuclear Magnetic Resonance (M.R.I.)

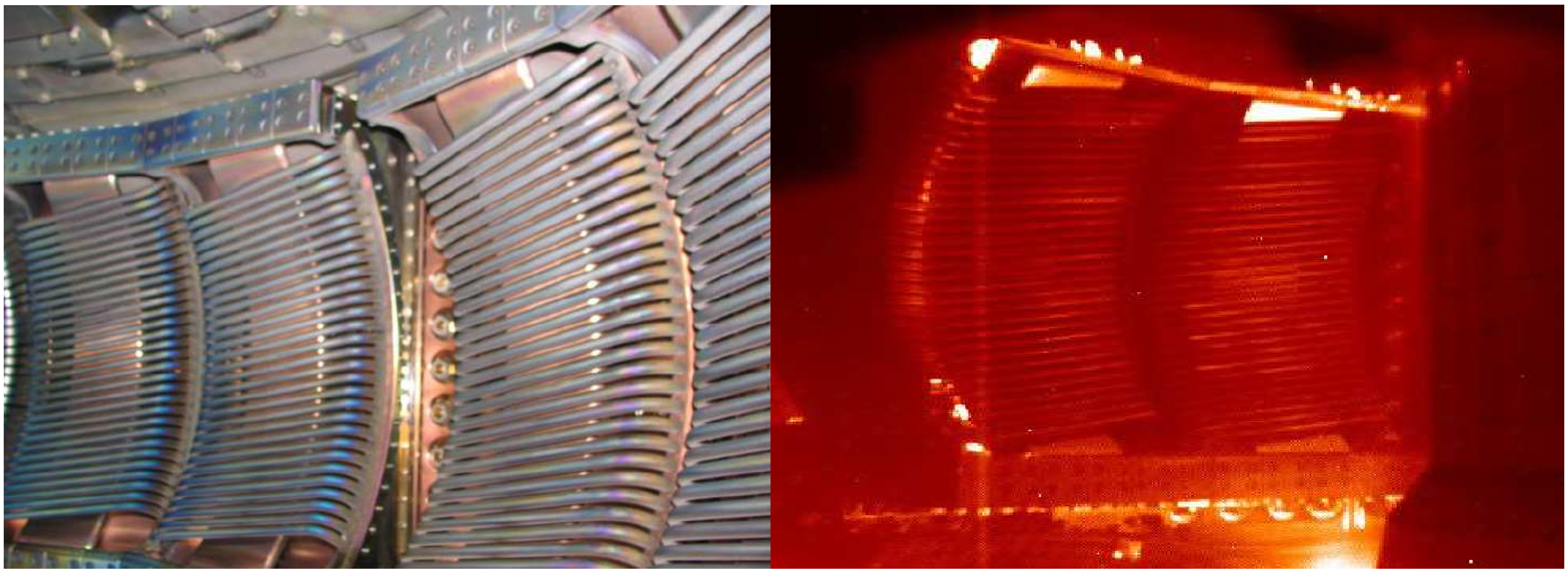


Applications: Plasma Fusion



Applications: Fusion Plasma Heating



Applications: Plasma Processing

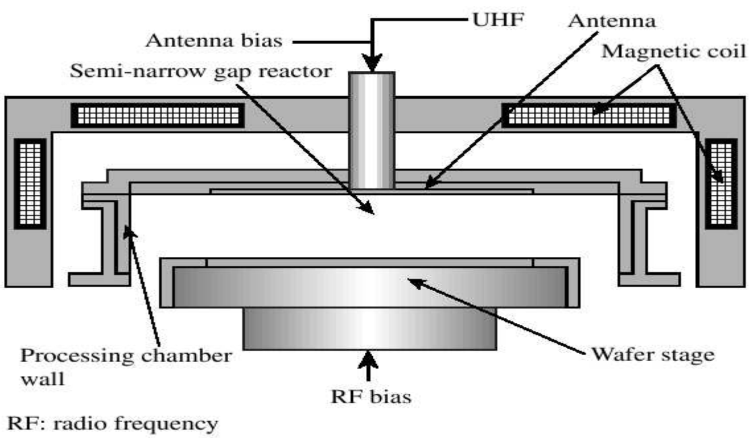


Fig. 2—Schematic Representation of Insulating Layer UHF-ECR Etching Chamber.
Stable, uniform plasma is produced in a semi-narrow gap by UHF waves from a flat antenna coupled with magnetic field.

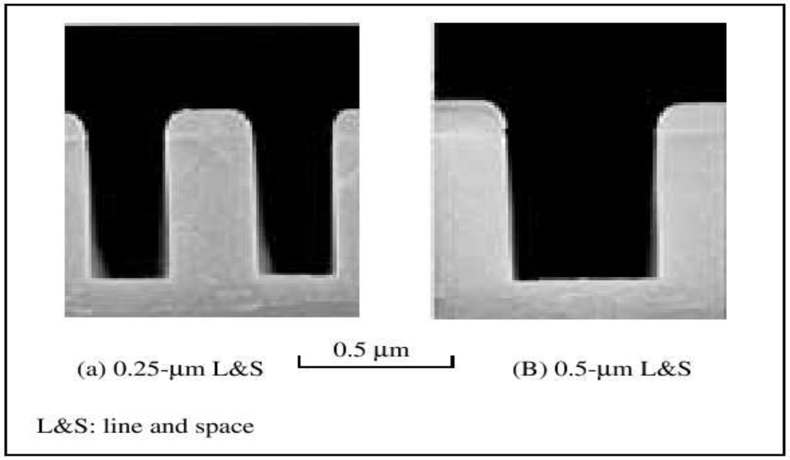
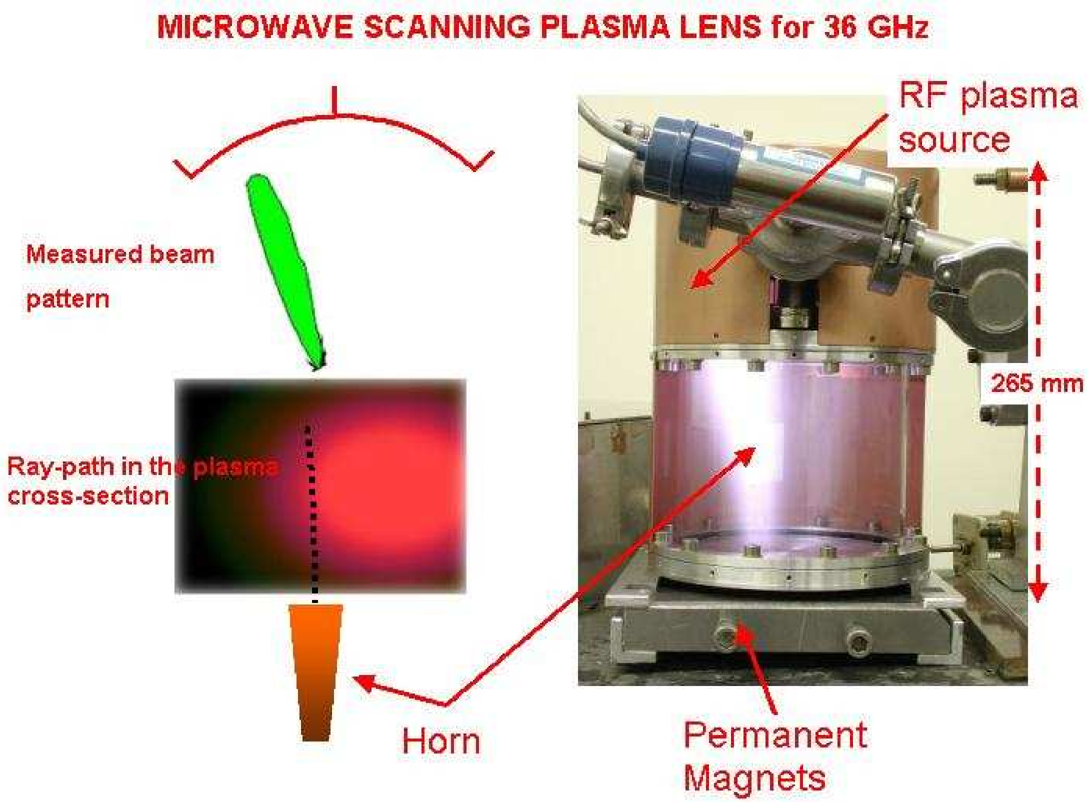


Fig. 8—Examples of Organic Film Etching.
By controlling the antenna bias and wafer bias, excellent vertical profile, mask selectivity, and non residue etching are obtained.

Applications: Plasma Lens



Applications: Sundry

- Microwave EM wave devices, klystrons, magnetrons, gyrotrons, travelling wave tubes, EM accordions (plasma based DC to RF upconverters)
- Ground penetrating radar
- Nuclear Quadrupole Resonance
- Biological imaging
- Autolocation
- Cosmology
- EMP. The electromagnetic bomb.

New devices exploiting radiowaves are still emerging that are quite separate to semiconductors... e.g. Left handed metamaterials, photonic band gap crystals,

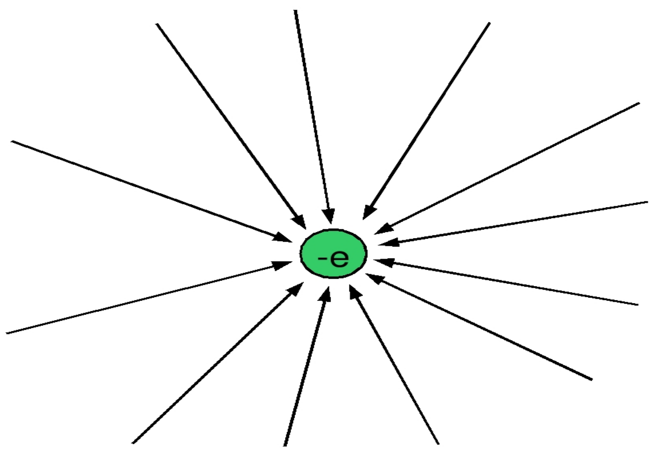
to mention a few.

Electrostatics: The Case of Stationary Charge

- The source of all electromagnetic fields is ultimately the charge.
- When there are no time variations, charge is the source of electric field.
- For a point charge we have Coulomb's law:

$$E_r = \frac{q}{4\pi\epsilon_0 r^2}$$

where the free space permittivity, $\epsilon_0 = 8.85 \times 10^{-12}$ Farads/m and q is in *Coulombs*.

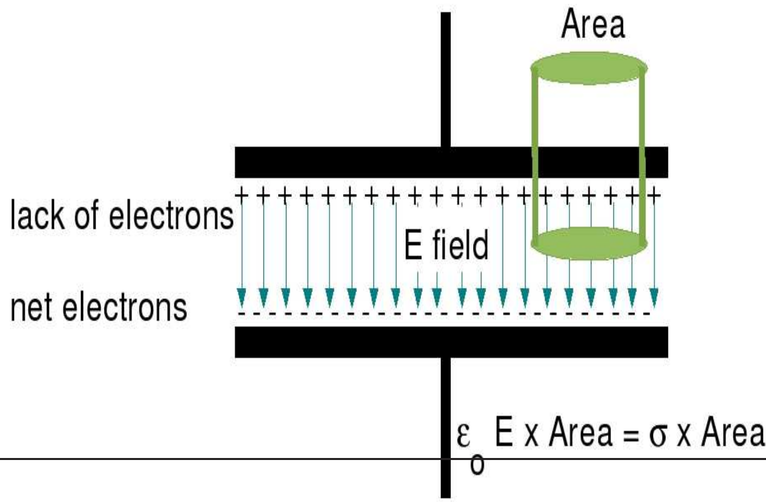


Electrostatics: The static electric field

- In general we have the following closed integral form (Gauss's law):

$$\int_A \mathbf{E}.\mathbf{dA} = \frac{q}{\epsilon_0}$$

- This explains electrostatic shielding.
- Electric field exerts the force on a charge, **F** = q **E** where **F** is in Newtons.
- Example: a charged capacitor. $E = \sigma/\epsilon_o$...



Electrostatics: The Electrostatic Potential

- Definition: The potential difference between two points $\mathbf{x_1}$ and $\mathbf{x_2}$ is given by,

$$\Phi = -\int_{\mathbf{x_1}}^{\mathbf{x_2}} \mathbf{E.dl} = -\int_{\gamma} \mathbf{E.dl}$$

- Since the path γ can be any which connects the points x_1 and x_2 we may conclude that $\mathbf{E} = -\nabla\Phi$.
- Kirchhoffs voltage law.

Charge Conservation

- When current flows out of a region in space, it depletes the charge in that region then the current per unit area j is given by,

$$\int_A \mathbf{j}.\mathbf{dA} = -\frac{\partial q}{\partial t}$$

where the current I is, $I = \int_A \mathbf{j}.\mathbf{dA}$

- If q is in **Coulombs** and the time in seconds then I is in **Amperes**.
- Always applies... not just electrostatics.
- If current flows round in a closed loop, then there need be no change in the charge: Kirchhoffs current law.

Ohms law

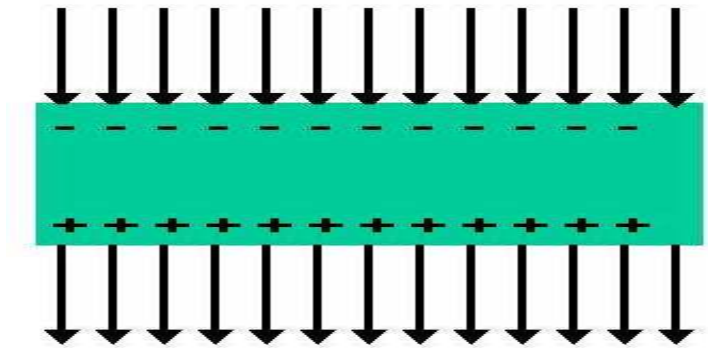
- Ohms law: The current density in a conductor is proportional to the electric field.

$$\mathbf{j} = \sigma \mathbf{E}$$

  where σ is the conductivity.
- Accurate law for metals at all radiofrequencies :).

Dielectrics 1

- Dielectrics are insulating materials that do not allow D.C. current to flow through them.
- Electrons and nuclei in the atoms and molecules of dielectrics experience opposing forces in the presence of an imposed electric field.
- Electrons move opposite to the field and nuclei move in the direction of the field. This is **polarisation**
- Note that the charge separation induced by the field, acts to **reduce** the electric field within the dielectric.



Dielectrics 2: Relative dielectric constant

- The polarisation **P** is given by,

$$\mathbf{P} = \epsilon_0(\epsilon_r - 1)\mathbf{E}$$

where ϵ_r is the relative permittivity and $\mathbf{E}$ is the local elecric field in the dielectric. For dielectrics, $\epsilon_r > 1$ and for a vacuum, $\epsilon_r = 1$.

- The Electric Displacement

$$\mathbf{D} = \epsilon_0\mathbf{E} + \mathbf{P} = \epsilon_r\epsilon_0\mathbf{E}$$

- Main advantage of the definition of D is that its source is the free charge only and not the induced polarisation charge,

$$\int_A \mathbf{D}.\mathbf{dA} = q$$

Magnetostatics: The static magnetic field

- Gauss's law for the magnetic field:

$$\int_A \mathbf{B}.\mathrm{d}\mathbf{A} = 0$$

- There is no static sink or source of the magnetic field. Also generally true.
- However **current** is a source of the static magnetic field,

$$\int_\gamma \mathbf{B}.\mathbf{dl} = \mu_0 I$$

  The line integral of **B** around a closed circuit γ bounding a surface **A** is equal to the current flowing across **A**.
- Magnetic field exerts a force on a **charge if it is moving**: **F** = q **v x B** or on a **current element**: **F** = I **dl x B** or , where **F** is in Newtons if I is in Amperes and B in **Tesla**.