

Instrumental technique

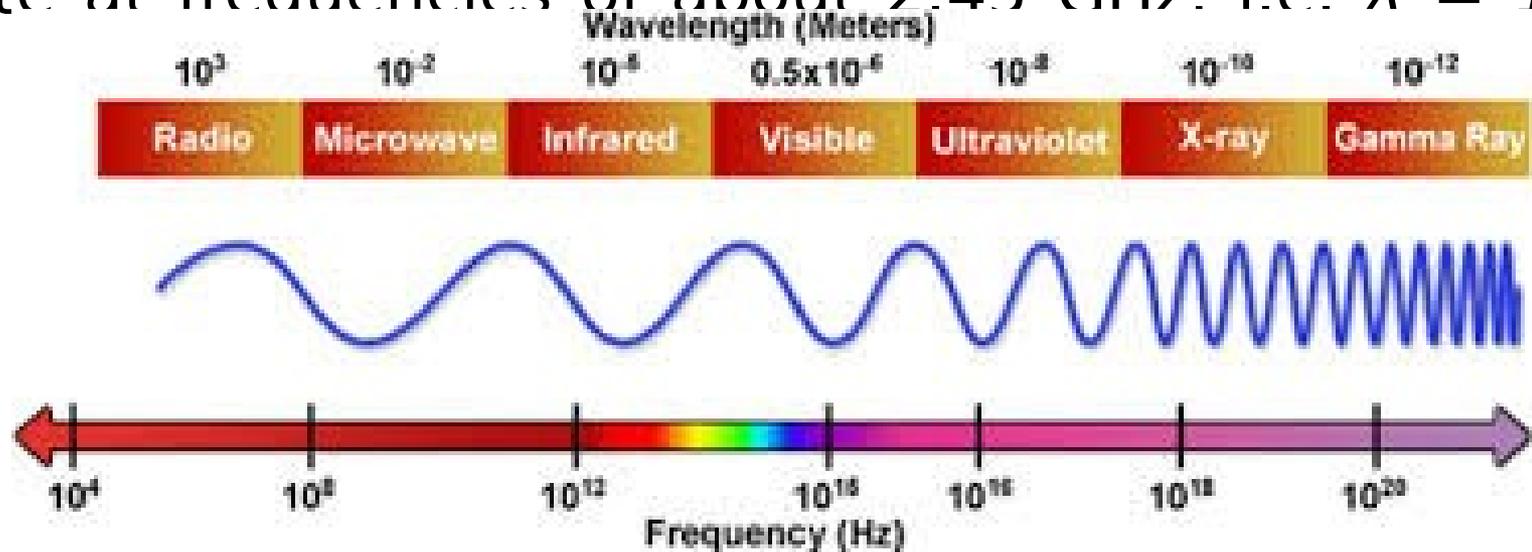
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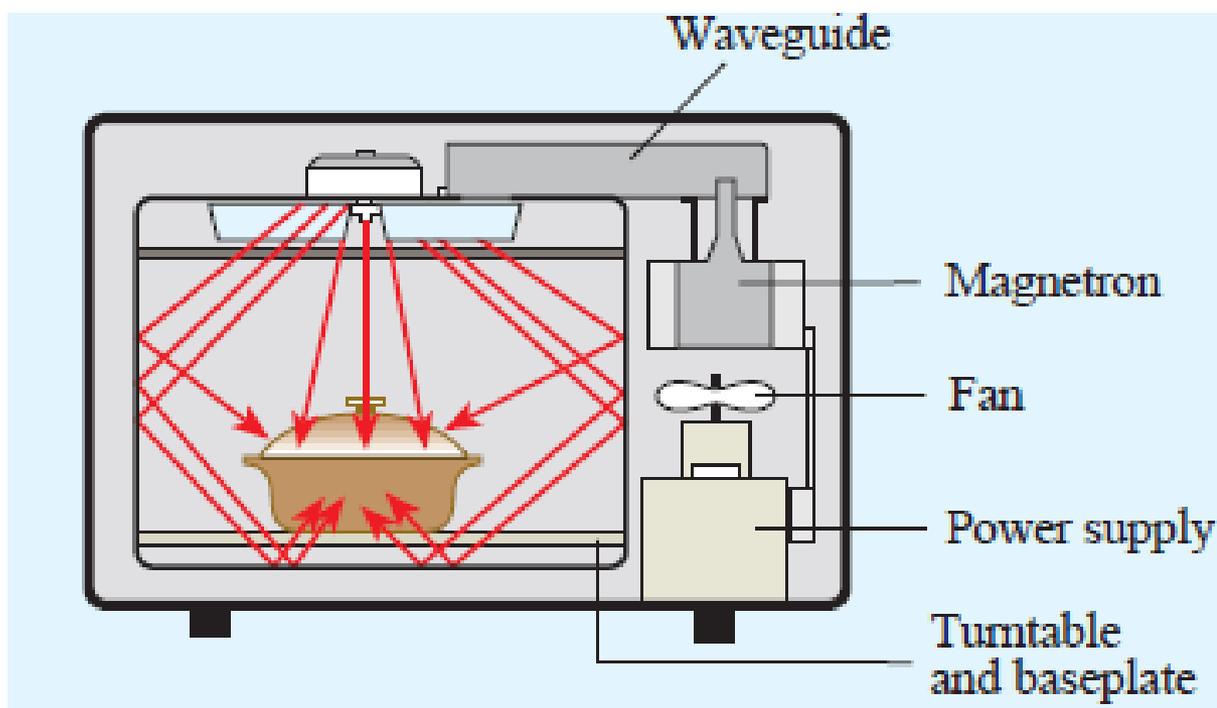
Microwave oven

A microwave oven, commonly referred to as a microwave, is a kitchen appliance that heats and cooks food by exposing it to microwave radiation.

What are microwaves?

Microwaves are electromagnetic waves. Their frequencies (wavelengths) are in the range from 300 MHz ($\lambda = 1\text{ m}$) up to 300 GHz ($\lambda = 1\text{ mm}$). Following international conventions, microwave ovens at home or in restaurants operate at frequencies of about 2.45 GHz. i.e. $\lambda = 12.23\text{ cm}$.





Schematic diagram of a typical

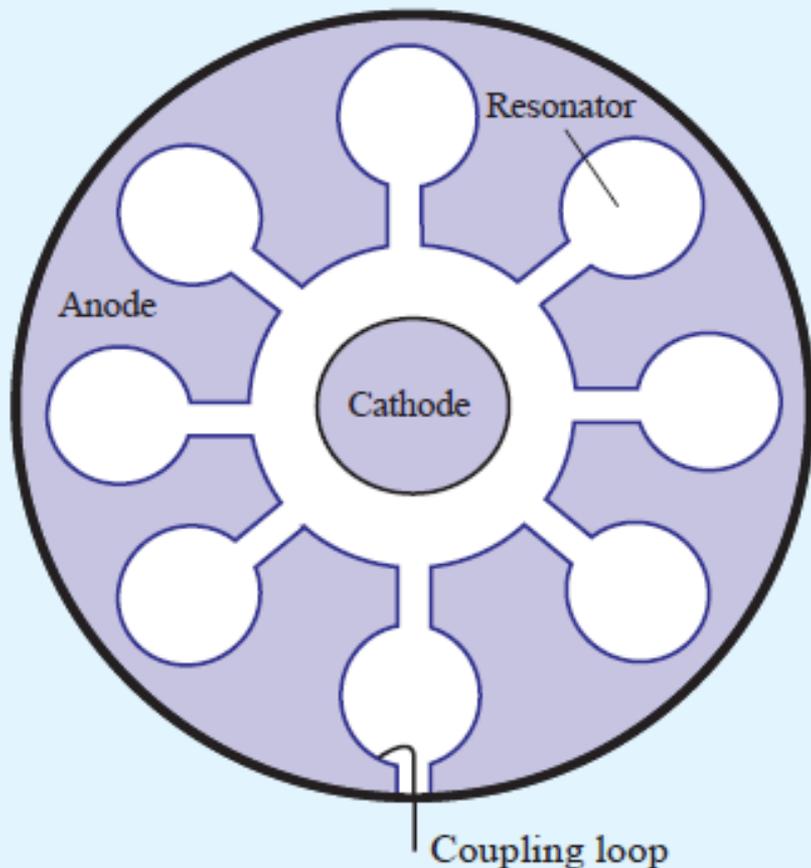
- ~~Microwaves are generated~~ ^{microwaves are} generated in a magnetron which feeds via a waveguide into the cooking chamber. This cuboid chamber has metallic walls.
- The front door, made of glass, and the light bulb cavity are both covered by metal grids. The holes in the grids are small compared with the wavelength of the microwaves, hence the grids act just like metal plates.

- Microwaves, incident on the metal walls of the oven, absorb very effectively, since the electric fields of the waves interact very strongly with the nearly free electrons of the metal. This electron behavior is described as a damped forced oscillation.
- These accelerated electrons re-radiate electromagnetic waves at the same frequency and in phase, hence the microwaves are perfectly reflected.
- This behavior is described by a complex dielectric constant $\epsilon(\omega)$, which is the square of complex refractive index.

$$\epsilon_1 + i\epsilon_2 = (n_1 + in_2)^2$$

- The penetration depth of electromagnetic wavelength λ is given by

Generating microwaves in magnetrons



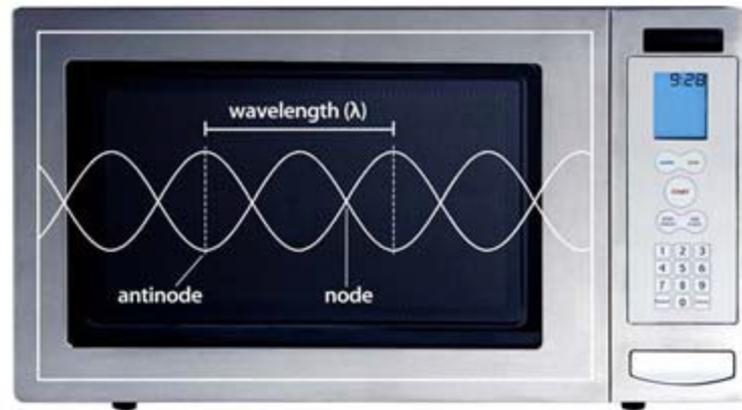
- Most microwave ovens use magnetrons. First invented in 1921 and strongly improved around 1940, magnetrons allow either continuous or pulsed microwave generation with powers up to megawatts and frequencies between 1 and 40 GHz. Efficiencies are around 80% and lifetimes about 5000 hours.
- Cathode in magnetron is a tungsten filament which emits electrons on the principle of thermionic emission, when an optimum voltage is applied.
- Anode in magnetron is a copper cup like structure

How does a microwave oven cook food?

- Microwave oven selectively make liquid water hot.
- The polar water molecules follow the oscillation of the electric field. They collide more frequently with the surrounding molecules and the temperatures

Why do they have turntables?

- Microwaves are reflected by the oven wall, forming “**standing waves**” in the cooking chamber.
- An ideal microwave oven cooks all food evenly but the nodes and antinodes of the standing waves can cause the food to burn in some places but to rema



Some historical facts about microwave ovens

- In 1945, Percy Spencer, working for Raytheon to develop magnetrons for active radar signals, noticed a chocolate bar in pocket melted while standing in front of an operating magnetron.
- He then tested popcorn in front of the magnetron and it quickly popped all over the room.
- In 1947, Raytheon made the first microwave oven – Radarange (6 ft tall, 3000 W power \$3K) but did not sell well.
- In 1965, a countertop version was developed for \$495 by Amana corporation.

Microwave assisted synthesis

- Since the first reports in 1986 the use of microwave ovens became an indispensable tool in modern organic synthesis.
- The early pioneering work on microwave-assisted organic synthesis was carried out in domestic microwave ovens.
- Nowadays, several manufacturers offer a large variety of reactor systems with different degrees of sophistication with respect to automation, database capabilities, safety features, temperature and pressure monitoring, as well as vessel design.
- Microwave chemistry is based on the efficient heating of matter by microwave dielectric heating, i.e., on the ability of a specific material (e.g. solvent and/or reagents) to absorb microwave energy and to convert it into heat.
- The heating mechanism involves two main processes, namely dipolar polarization and ionic conduction.

Biological Effects of Microwaves

- Non-ionizing radiation can produce non-mutagenic effects such as inciting thermal energy in biological tissue that can lead to burns. Recently, the International Agency for Research on Cancer (IARC) from the WHO (World Health Organization) released a statement indicating that radiofrequency electromagnetic fields (including microwave) are possibly carcinogenic to humans.
- Certain body organs are particularly sensitive to the thermal effect of microwaves. For example, if the lens of the eye were exposed to excessive heat from microwaves, its circulatory system would be unable to provide sufficient cooling, and it would cook like the white of an egg. Exposure to high levels of microwaves can cause cataracts. Also, the prostate and bladder are especially sensitive to thermal damage from high levels of microwaves.
- One characteristic of microwaves is that they disperse and dissipate very quickly in the atmosphere.
- For example, If you are standing 2 inches away from a microwave oven, and are being zapped by $5\text{mw}/\text{cm}^2$ of microwave energy, then you wisely step back to a distance of 20 inches or roughly an arm's length. Your level of exposure would drop by a factor of 100, (the square of the distance) to $0.05\text{mw}/\text{cm}^2$.

Safety Tips For Operation Of Microwave Ovens

- Do not operate oven when empty.
- Exercise extreme caution if you have a pacemaker implant. Microwave radiation may cause pacemaker interference.
- Do not put face close to door window when oven is operating.