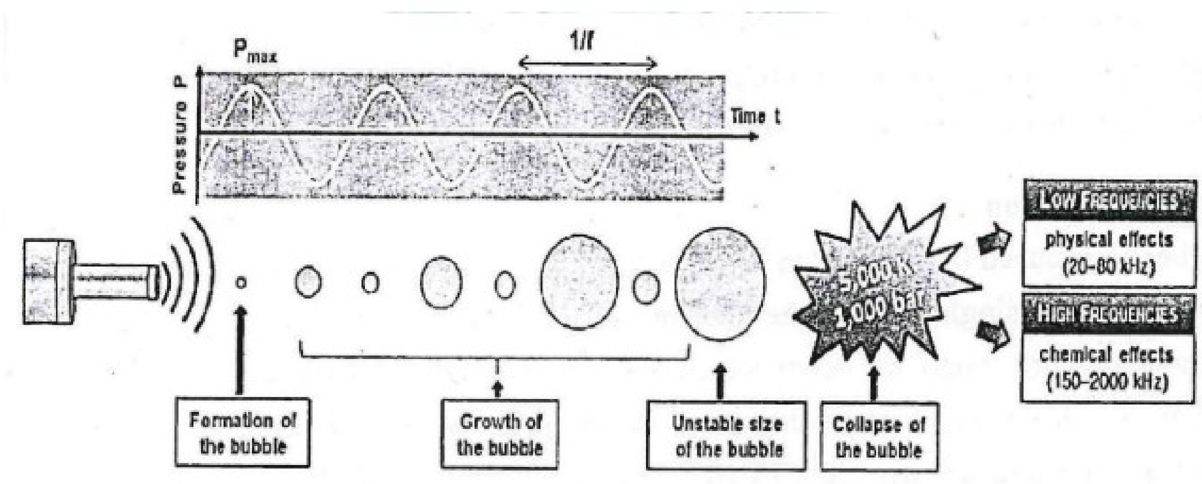
CAVITATION

Cavitation refers to an oscillation in the volume of a gas bubble in response to pressure fluctuations produced by an incident ultrasound wave. Cavitation is most likely to occur in vivo when microbubble contrast agents are employed or if the lungs are exposed to ultrasound. But most tissues contain small volumes of gas that can combine to form cavitation nuclei when exposed to ultrasound. Low intensity ultrasound typically produces harmless stable cavitation, in which gas bubbles are not disrupted. However, high intensity ultrasound can produce inertial cavitation, in which the rarefactional phase of the pressure wave expands the bubble to greater than its maximum stable volume, resulting in a sudden collapse of the bubble. The sudden collapse produces local heating of the order of 1000 – 10000 degree Celsius.



Schematic representation of the acoustic cavitation phenomenon

PIEZOELECTRIC RECEIVERS

A piezoelectric receiver is a device that converts acoustic or mechanical vibrations into electrical signals using the piezoelectric effect. These receivers are widely used in ultrasonics, medical imaging, sonar, and biomedical instrumentation for detecting ultrasonic waves.

Principle

Piezoelectric receivers work on the direct piezoelectric effect, which states that when certain crystalline materials are subjected to mechanical stress, an electric charge is produced across their surfaces. Incoming sound or ultrasonic waves exert pressure on the crystal, causing deformation and generating an electrical output proportional to the applied pressure.

Piezoelectric Materials Used

Common materials used in piezoelectric receivers are:

- Quartz
- Rochelle salt
- Barium titanate
- Lead zirconate titanate (PZT)
- Polyvinylidene fluoride (PVDF)

Construction

A typical piezoelectric receiver consists of:

- A thin piezoelectric crystal or ceramic
- Electrodes coated on both sides of the crystal
- Backing material to absorb unwanted vibrations
- Protective casing
- Matching layer to improve acoustic energy transfer

Working

When ultrasonic waves fall on the piezoelectric crystal:

1. The crystal undergoes mechanical deformation.
2. Mechanical stress produces electric charges on the electrodes.
3. A voltage signal is generated across the output terminals.
4. The electrical signal corresponds to the intensity and frequency of the received sound waves.

Frequency Response

Piezoelectric receivers are highly sensitive to specific frequencies.

Resonant frequency depends on:

- Crystal thickness
- Material properties

Used effectively in the ultrasonic frequency range (MHz).

Advantages

- High sensitivity
- Small size and light weight
- Fast response
- Wide frequency range
- Suitable for high-frequency applications

Limitations

- Fragile in nature
- Temperature sensitive
- Limited bandwidth near resonance
- Requires impedance matching

Applications

- Medical ultrasound imaging
- Doppler blood flow measurement
- Sonar systems

Ultrasonic flaw detection

Biomedical instrumentation

Acoustic sensors and microphones