UNIT V

PRINCIPLE & APPLICATIONS OF SOUND IN MEDICINE

5.2 GENERATION OF ULTRASOUND

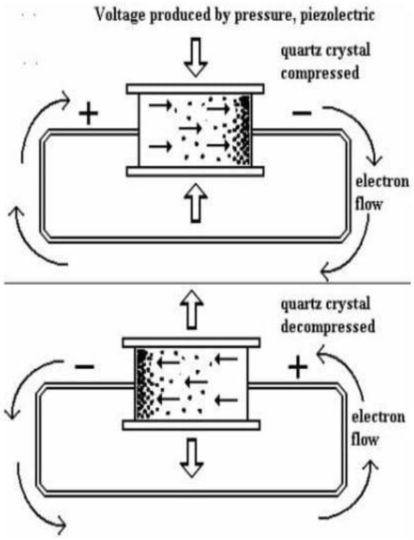
Generation of ultrasound relies on the reverse (converse) piezoelectric effect.

Piezoelectric effect

Piezoelectric materials are materials that can produce electricity due to mechanical Stress, such as compression. These materials can also deform when voltage (electricity) is applied,

Those materials include crystals, ceramics, polymers, wood (cellulose fibers)- etc

Examples:Lead zirconate titanate (Pb(ZrTiOs) ,Barium Titanate (BaTiO)



A piezoelectric crystal is placed between two metal plates. At this point, the material is in perfect balance and does not conduct an electric current.

Mechanical pressure is then applied to the material by the metal plates, which forces the electric charges within the crystal out of balance

The reverse piezoelectric effect is used in a variety of application Take a speaker for example, which apples a voltage to a piezoelectre ceramic, causing the material to vibrate the an as sund waves

Pielectricity being used in electronic applications such as actuators, buzzers. ww and motora etc

Even medical ultrasound and sonar transducers use reverse piezoelectric effect

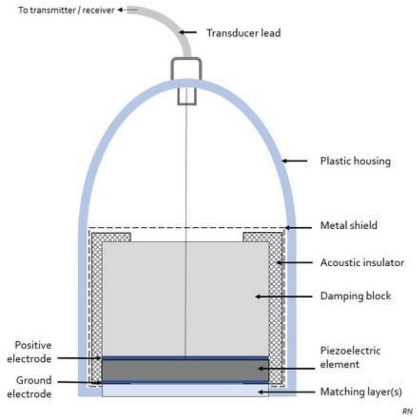
ULTRASOUND TRANSDUCER

Ultrasound waves are generated from tiny piezoelectric crystals packed within the ultrasound transducers

Single crystal transducer

The essential components of the single crystal transducer are shown below

It consists of five main components



1 Crystal/ceramic element with piezoelectric properties

[The most commonly used material is lead zirconate titanite (PZT)

It may consist of a single element or multiple elements

The crystal thickness is determined by what resonance frequency is used.

A thicker element produces a lower frequency oscillation while a thinner element produces a higher frequency oscillation.

2 Positive and ground electrodes on the faces of the element

This allows for electrical connection . Positive electrode is in the back of the element and ground electrode is on the front of the element

3. Damping (backing) block

It is adhered to the back of the crystal behind the positive electrode

It absorbs ultrasound energy directed backward and attenuates (reduces) stray ultrasound signals from the housing.It reduces the resonant vibrations in the element which creates a shorter spatial pulse length; this allows for better axial resolution for imaging of organs and high bandwidth to receive reflected echoes

4 Matching layer

Matching layer is the interface between the transducer element and the tissue

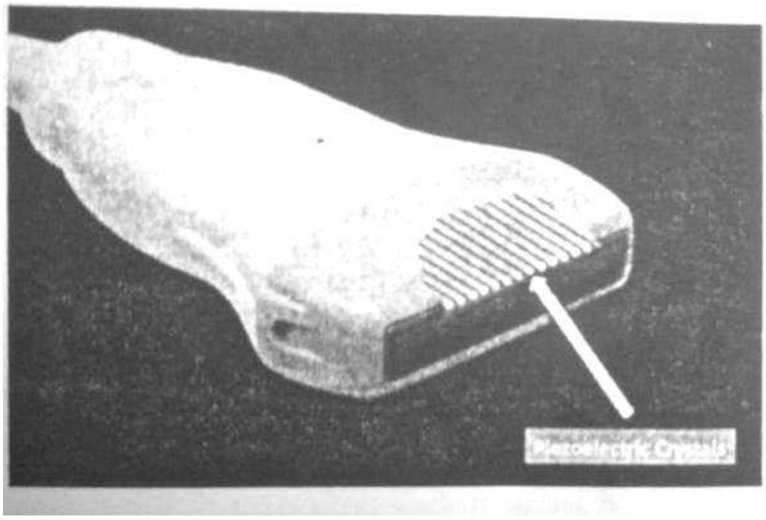
It allows close to 100% transmission of the ultrasound from the element into the tissues by minimizing reflection due to traversing different mediums (Acoustic impedance describes how much resistance an ultrasound beam encounters as it passes through a tissue

It may consist of one or multiple layers. Each layer is one-quarter wavelength thick

5. Housing

It gives electrical insulation and protection of the element

It includes a plastic case, metal shield and acoustic insulator



Working of ultrasound transducer

When an alternate current is applied to these crystals, they contract and expand at the same frequency at which the current changes polarity and generate an utrasound beam. The ultrasound beam traverses into the body at the same frequency.

On the other hand when the ultrasound beam returns to the transducer, these crystals change in and this minor change in shape generate a tiny electric current that is amplified by the ultrasound machine to generate an ultrasound image on the monitor

The piezoelectric crystals within the transducer therefore transform electric energy into mechanical energy (ultrasound) and vice-versa

One crystal is not sufficient to produce an ultrasound beam for clinical imaging and modern transducers have large number of crystals arranged into parallel rows (Figure 5.10) Each crystal can however be stimulated individually.