Radiology Techniques
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Theoretical Radiation Physics

Third stage- Radiology Techniques Department

Lecture 7

By

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Radiation Physics precise specialization

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the components of the single crystal transducer

1-the crystal element:

The crystal element is the most important part of the transducer and it consists of a piezoelectric material located near the front of the surface of the transduce.

and since some crystalline materials possess piezoelectric properties naturally, and others possess piezoelectric properties artificially, through the treatment of these materials thermally and electrically, and these materials lose their piezoelectric properties when Heated at high temperatures,

Since the vibration of the two surfaces of the crystal transmits ultrasound waves in two directions from the two surfaces of the crystal, so the thickness of the crystal plays an important role in controlling the frequency of vibrations. Since the vibration of the two surfaces of the crystal transmits ultrasound waves in two directions from the two surfaces of the crystal,

so the thickness of the crystal plays an important role in controlling the frequency of vibrations. Where the thickness of the crystal is chosen so that the vibrations of the two surfaces, one of them, reinforcement the other, And where the strengthening process occurs when the thickness of the crystal is equal to half the wavelength(1/2) λ ,That is the wave travels back and forth equal to the length of one wave, and the reinforcement process occurs at the two surfaces of the crystal due to the constructive interference between the successive waves reaching the two surfaces of the crystal, and where the resulting reinforcement process is called resonance, Therefore, the state of resonance occurs when the thickness of the crystal is equal to half the wavelength, The thickness required to obtain a specific ultrasound frequency can be known as follows.

$$V = \lambda * f$$

Where $t = (1/2)\,\lambda$, $\lambda = 2t$

$$V = 2t * f$$

$$t = v/2f$$

Ex (1): if the velocity of the ultrasound wave that result from the piezoelectric crystal material is (4000m/sec), calculate the crystal thickness in which the desired frequency of ultrasound wave is (5MHz).

Sol:

$$t=v/2f$$
$$t=4000/(2*5*10^{6})$$
$$=400x10\text{-}6m$$
$$=0.4mm$$

Ex(2):if the velocity of the ultrasound wave that result from the piezoelectric crystal material is (4000m/sec),calculate the crystal thickness in which the desired frequency of ultrasound wave is (20MHz).

$$t=v/2f$$
$$t=4000/\ (2*20*10^{6})$$
$$=100x10\text{-}6m$$
$$=\ 0.1mm.$$

Conclusions:

1-The thinner crystal gives a higher frequency.
2-The frequency of the ultrasound waves emitted by the piezoelectric crystal is inversely proportional to the thickness of the crystal.

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2-The electrical connections:

The front surface and the back surface of the crystal are coated with a thin layer of electrically conductive material to facilitate the process of electrical connection with electrodes in order to provide the crystal with a pulse potential difference.
The back electrode acts as a direct conductor between the voltage source and the back surface of the crystal, while the front electrode acts as a ground conductor to protect the patient from electric shock, And where the electrodes work to transmit electrical impulses to the crystal ,so that the two surfaces of the crystal vibrate and ultrasound waves are generated, and also these electrodes work as a pickup for the electrical signal generated on the two surfaces of the crystal as a result of the collision of the reflected wave with the crystal upon its return, which made it vibrate generating an electric charge on the two surfaces of the crystal, And where the front side of the transducer, which is in direct contact with the patient, is covered with an electrically insulating material.

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3-The backing material:

This material is located behind the crystal and is made of a material that absorbs ultrasound waves, and the purpose of this material is to absorb the energy of ultrasound waves transmitted into the transducer.

4-The acoustic insulator:

This isolator prevents the vibrations originating from the crystal to reaching to the transducer cover, as well as isolating the crystal from ultrasound coming from external sources, and it is made of a material that is a poor conductor of ultrasound such as rubber.

5- The transducer housing:

It is a cover used to protect the internal components of the transducer.