

MICROWAVE THERMOGRAPHY FOR CANCER DETECTION*

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The paper presents some new methods for early breast cancer detection using microwaves. On describe the following methods and techniques: microwave impedance tomography, termography and microwave radiometry, combined methods - microwave and ultra-acoustic image and confocal microwave imaging. We make an analysis of advantages and disadvantages of every method and also physical principles of microwave thermography.

Key words: thermography, microwave, cancer detection.

INTRODUCTION

Nowadays the most common ways for detecting breast cancer are manual palpation, mamography, ultrasounds examination, examination through optical and infrared thermography. Each method has advantages and disadvantages but researches are looking for using non invasive methods and disclaimed of penetrant radiation from usual methods: mamography, method with radiation risk and uncomfortable for patient. Globally there are a lot of campaigns against mamography because of the reasons mentioned. One of the methods complementary to mamography is represented by early breast cancer detection using microwaves. Images with microwaves obtained for breast cancer detection are distribution maps of electrical properties in tissues. One of microwave image application is represented by hyperthermia, which indicate a change in electrical properties of interest tissue depending on tissue warmth. The advantage of using microwaves are both avoiding ionisation radiation and breast compression, using a fast method, specific and cheaper than MRI and has a fast image processing. Nowadays there are studies regarding new methods for breast investigation using microwaves: impedance tomography with microwaves, confocal image with microwaves, radiometry or

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microwave thermography, combined methods with microwaves and ultrasounds. There are more methods for early breast cancer detection using microwaves. The following methods and techniques are presented: microwave impedance tomography, thermography and microwave radiometry, combined methods - microwave and ultra-acoustic image and confocal microwave imaging.

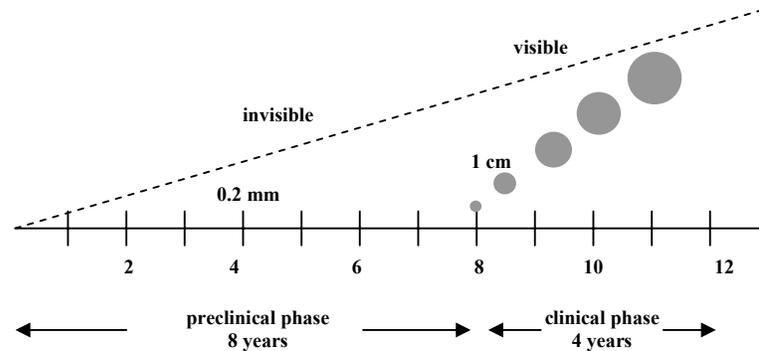


Fig.1. Doubling time of tumor.

In Fig. 1 one presents the tumors evolution in clinical and preclinical stage [1]. An analysis of advantages and disadvantages of every method is made.

Confocal microwave imaging: this method is based on illuminating the breast from a number of antennas and analysis of received signal to detect and locate the small tumors [2]. This method compares for detection the contrast at microwaves frequency between malignant and normal breast tissue.

Microwave impedance tomography: a fixed array of antennas connected to a system for data acquisition (each antenna can receive or transmit the signal) [3]. Knowing that a malignant tissue has a higher conductivity than the surrounding tissue, this method is based upon tissue specific transmission of electrical low level currents due to tissue specific conductivities and permittivities [4].

Thermography - microwave radiometry is a method for measuring the electromagnetic radiation [5], [6].

We present a laboratory system which is using electromagnetic radiation emitted by worm bodies, in conformity with Planck law. The advantage of using microwaves is a greater deep for detecting tumors. A microwave radiometer which works on GHz frequency band is described and technical problems of radiation detection on microwave domain in condition of ambient thermal noise are discussed.

Researches regarding microwave use for early breast cancer detection guide to priority use of the following methods: active methods, passive methods and mixed or combined methods.

Active methods: external emission of one electromagnetic radiation which can cross the tissue and following the detection of the waves which cross through the tissue and observing tissue modifications.

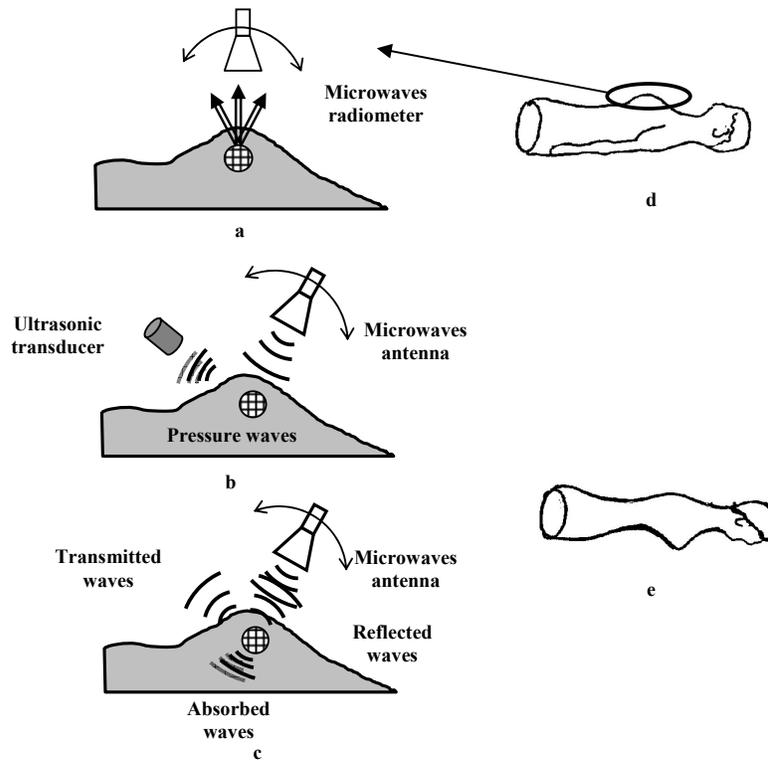


Fig. 2. Microwave exploring methods for breast [7].

a - microwave thermography, b- combined methods with microwaves and ultrasounds, c - radar method, d- patient orientation for planar system, e - patient orientation for cylindrical system.

Passive methods: refer especially to measurement through radiometric ways of breast temperature and compare the differences between thermal "images" for the two breasts obtained on microwave frequencies. The identification of malignant tissue is made through spotlight of one high temperature given the normal tissue and the appearance of one asymmetry between the two images.

Combined methods: refer to ultrasounds and microwave use, the detection referring to ultrasounds reflection of malignant structures found in expansion because of microwave heating.

PHYSICAL PRINCIPLES OF MICROWAVE THERMOGRAPHY

These principles refer to thermography or microwave thermography and uses a microwave receiver of high precision and low noise to detect electromagnetic radiation from microwave spectrum. The system allows the detection of depth malignant structures because of the fact that microwaves has a greater wave length as compared with the infrared radiation and less absorbed by the tissue on which it covers from the tumour to the surface.

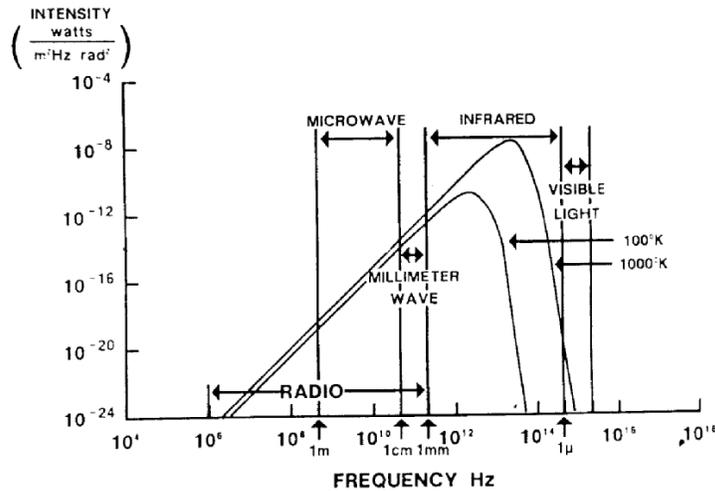


Fig. 3. Black body radiation.

The advantage of microwave thermography is the fact that the method is non-invasive and non-ionogenic, of low energy, framing in norms regarding the exposure of the body at electromagnetic energy. The main problem of this method is the very low level of the energy of the signal produced by tumors (10^{-13} - 10^{-16} W).

The thermography uses electromagnetic radiation (thermal radiation and microwaves radiation). The human body is exposed at the same laws regarding electromagnetic emission as the surrounding bodies. In Fig. 3 we present a black body radiation in accordance with Planck radiation law [8]. The radiation distribution depends on the temperature and also on the frequency (wave length). Fig. 3 presents the dependence of intensity of electromagnetic radiation with respect to frequency. On the microwave domain the intensity of electromagnetic radiation is with almost 10^6 less than infrared radiation. Except for this, the system has to ensure the spotlight of a high contrast between the temperature of ill tissue and the healthy tissue and this when in which the body temperature is very close to the ambient temperature (20°C).

To detect a difference of 1°C it should be detected a signal of 10^{-6} W , which raised technical problems. A solution is to use refrigerators with carbon dioxide or nitrogen dioxide to reduce the temperature of microwave detector. The radiometric method presents some major advantages:

- is non-invasive because the internal temperature of the breast is non-invasive determined;
- it allows the early breast cancer detection because the temperature modifications preceding the modifications of anatomical structures of tissues;
- it can be detected the growing tumors because they are "warmer";
- it allows the monitoring of some treatments through hyperthermia;
- medical personnel is not exposed to electromagnetic risks.

EXPERIMENTAL METHODS

To detect microwave radiation we use a microwave receiver (LNC) in 10-12 GHz band. The own noise is less than 0.2 dB.

Each stage of the installation is generating noise which contribute on the whole noise fitting. Thus, the installation shall contain on the output both the own noise and thermal noise received of antenna. Choose the frequencies of operation depends on more factors: the intensity of electromagnetic radiation which is proportionate frequent in the area of microwaves, which resolution scales up by the growth frequencies.

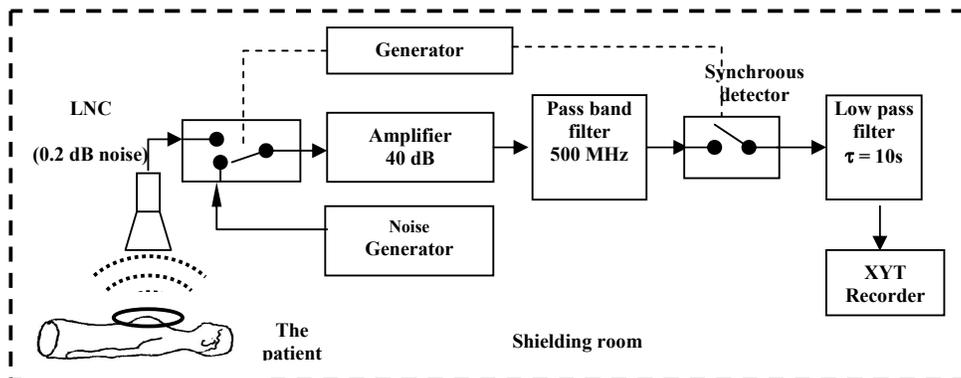


Fig. 4. Experimental device.

Block scheme of radiometer is presented in the Fig. 4. To measure the differences of temperature between the two breasts, the radiometer antenna is maintained periodically in symmetrical positions against the median axis bodies on the right breast and the left breast to a duration of 60–100 s.

The result of some typical measured is presented in Fig. 5. The difference of temperature is of maximum 2.5°C for two symmetrical positions.

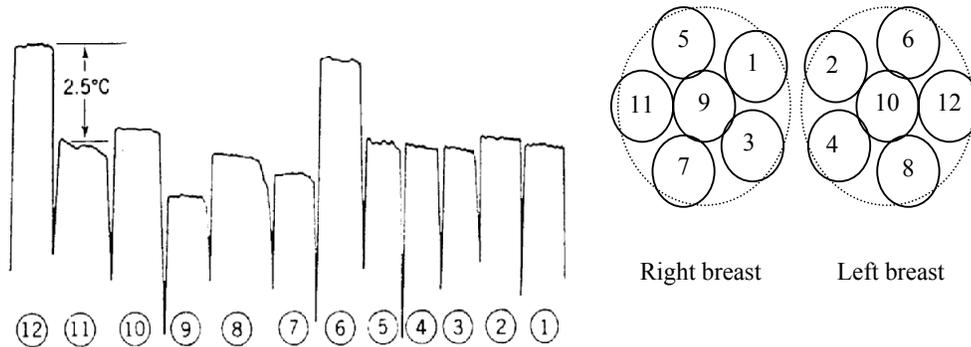


Fig. 5. Typically microwaves breast thermography.

CONCLUSIONS

Microwaves could be used with great success in cancer investigation. The new methods for investigation present great advantages as compared with the present medical technique:

- the new investigation systems for breast cancer present a low risk for the health of the patient;
- the method could be used for detecting breast cancer in men (we can't do a mamography for them);
- the structural modifications of tissues could be detected before those being detected with classical methods, ultrasounds and ionisating radiations;
- the method is sensitive to all tumors and offers a specific contrast for malignancy;
- breast cancer detection is made in a curable stage;
- is a non-invasive method and easy to make;
- no risk for patient of any age;
- is cheap, faster and vastly used;
- involves a minimum discomfort for patient, being easily accepted by women;
- is easy to interpretate and objective.

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