Microwave Technology Based Medical Imaging and Diagnostics

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Abstract— Future trends in medical applications of microwave technique and technology can be seen in development of new diagnostic and imaging methods based on high frequency EM field. A significant importance for the future can be identified for the following methods: Microwave tomography, Microwave radiometry, Measurement of complex permittivity, Imaging in the Terahertz waves band and Microwave diagnostic radars.

1. INTRODUCTION

Recent trends in microwave medical applications are to study the possibilities to develop new diagnostics based on EM field resp. on microwace technique. A significant importance for the future can be identified for the next methods:

- Magnetic resonance,
- Microwave tomography,
- Microwave radiometry,
- Measurement of complex permittivity,
- Imaging with terahertz waves,
- Microwave diagnostic radar.

We will not talk here about magnetic resonance, as it is just well known and broadly used application of EM field in medical diagnostics. We will focus here on other above mentioned methods (excluding microwave diagnostics radars).

2. MICROWAVE APPLICATORS FOR MEDICAL IMAGING AND DIGNOSTICS

Since 1981 we develop microwave thermotherapeutical applicators working in frequency band from 27 MHz up to 2450 MHz. These applicators were used for the treatment of more then 1000 patients with superficial or sub-cutaneous tumors (up to the depth cca 4–6 cm). Now, following new trends in this field, we continue our research in the important directions of deep local and regional applicators. We have found, that quite similar applicators are optimal to be used for medical imaging and diagnostics.

3. MICROWAVE TOMOGRAPHY

Microwave tomography [1] is in general application of basic CT principals but by utilization of microwave band. Scattering of EM waves in non-homogeneous human body is however much more complicated than simple attenuation of ionising radiation. Therefore development of microwave tomography is conditioned by new theoretical approach, optimization of evaluation algorythms and more efficient computer technique.

An experimental setup is schematically shown on Figure 1. Studied object will be placed in water phantom. It will be irradiated by transmitting antenna while scattered EM field will be monitored by receiving antenna and evaluated by a network analyser. Receieving antenna will be scanning around studied object and/or it will be possible to move/rotate the studied object.

Microwave tomography represents applications of CT known principals to microwave frequency band, where in general situation is more complicated because of much more complicated propagation of EM waves. Therefore mathematical model should be created and optimized evaluation algorithms are needed and last but not least — powerful computers are necessary for the calculations.

4. MICROWAVE RADIOMETRY

Microwave radiometry is based on measurement of a very weak EM signal, which radiate any object (e.g., people), whose temperature is superior to absolute zero [1]. It is based on utilization of so-called Planck radiation law. Interest in microwave radiometry is given by possibility of its utilization at diagnostics of cancer and also of inflammatory disorder (e.g., appendicitis, arthritis,

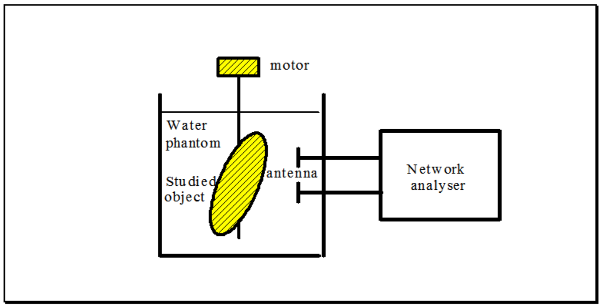

Figure 1: Schematics of experimental setup of microwave tomograph for biomedical imaging.

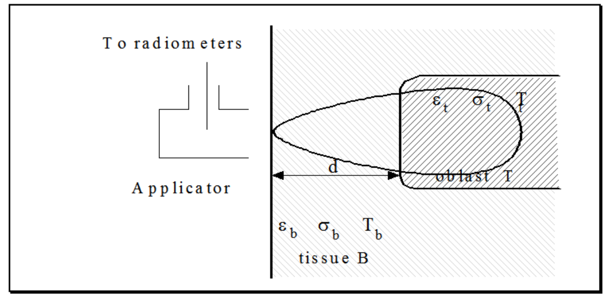

Figure 2: Principals of imaging by a microwave radiometer.

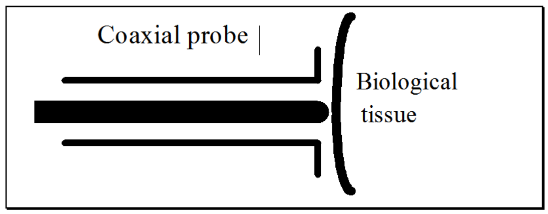

Figure 3: Coaxial probe for measurement of ???.

atp.) because tumors and inflammatory processes causes temperature rise. Microwave radiometer as a tool for biomedical imaging applications has the possibility to "monitore" a thermal noise produced by objects with the temperature over absolute zero. Figure 2 gives a basic idea about experimental setup. Advantage of microwave radiometer is ability to "see" the temperature increase under the surface of human body. Therefore wee need to scan studied area of the tissue with a sensor and to evaluate the results of temperature measurements.

Let us suppose, that applicator (antenna of the radiometer) is situated on the layer B of the monitored biological tissue. Thicknes of this layer is d and it temperature T_b. Its dielectric parameters will be ε_b and σ_b.

5. MESUREMENTS OF COMPLEX PERMITTIVITY

Measurements of complex permittivity "in vivo" could be a suitable for biomedical imaging applications [1]. Usually an open end of coaxial line is used as a very suitable sensor for this measurement. Scanning the studied object by a such probe can bring us a map of the permittivity — we can then evaluate symmetry resp. unsymmetry of the measurement results and from this information we can make hypothesis about possible medical problems.

Characteristic impedance is Z_o, C_o and C_f are fringing.

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