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Implementation of Patient Motion Compensation for L-Band In Vivo Electron Paramagnetic Resonance (EPR) Tooth Dosimetry

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1. Introduction

Electron Paramagnetic Resonance (EPR) is a non-invasive technique for the quantitative measurement of unpaired electrons. The technique has been applied for radiation dosimetry by measuring irradiated human tooth. In case of a large-scale radiation accident, the in vivo EPR tooth dosimetry has an advantage of direct estimation of the exposed dose without pre-processing of tooth, and therefore, it has been used as a screening method for efficient medical treatment. [1] However, when conducting in vivo EPR measurement, patient movement interferes the EPR spectrum acquisition. In previous paper of in vivo EPR spectroscopy, automatic tuning circuit (ATC) has been used to measure small animals. [2] In this study, we implemented the ATC system, especially to be optimized at in vivo tooth dosimetry, and for this purpose, a tunable resonator was designed and fabricated.

2. Materials and Methods

A homebuilt L-band in vivo EPR spectroscopy is used for EPR spectroscopy. [3] The RF is used of 0.1 W with resonator that can be used as a replacement for the previous resonator and is more optimized for in vivo measurement. A surface-coil type resonator is designed to measure the intact tooth from the outside. In order to control the impedance of the tunable resonator, passive tunable integrated circuit (PTIC) is implemented. Because, this electronic device has a variable capacitance according to applied voltage and is appropriate in L-band RF. [4] The designed tunable resonator has two applied-voltage connection ports that can adjust the resonance frequency. Through the connection ports, real-time remote control is possible during EPR measurement.

During the operation of in vivo EPR spectroscopy, the patient motion by breathing causes the resonance-frequency shift. The ATC, which generates a feedback signal, is implemented to correct the shifted resonance-frequency and fix it at 1.15 GHz. The designed ATC is connected with tunable resonator and RF bridge circuit, and we use amplitude modulation (AM) in the resonator control signal to make feedback signal based on phase sensitive detection. The open-loop feedback system can be controlled by a toggle switch. For the testing of ATC, in vivo tooth phantom was used, which mimic the patient motion.

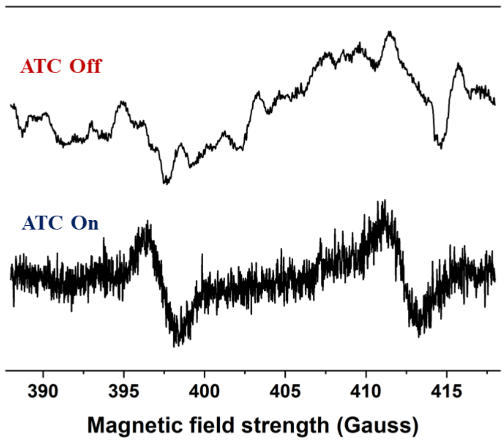

Figure 1. EPR spectrum of in vivo measurement

3. Results and Discussions

Based on the measurement of network analyzer, the resonance frequency of the fabricated tunable resonator is observed near the 1.15 GHz, which is previously used. When three materials (air, dry tooth, in vivo tooth phantom) were positioned in front of the surface coil, the quality factors are 204, 200, and 88, respectively. Although these results are relatively lower than that from the previous resonator, it is enough to estimate the radiation dose from the tooth. Scattering matrix parameter S_{11} indicated that resonance frequency changed depending on the target to be measured and it can be modified to the applied frequency of 1.15 GHz.

Figure.1 shows the EPR spectrum measured in the in vivo measurement condition with the tunable resonator installed to the homebuilt EPR spectrometer. The first EPR spectrum is measured with feedback signal off. The EPR spectrum is distorted by respiration of the volunteer, and numerical analysis is impossible. However, in the second spectrum, which is measured with feedback activated, the EPR signal of the standard sample was clearly indicated, regardless of the patient motion. It can be said that the fabricated tunable resonator can conduct the dose estimation from intact tooth with more stable and faster EPR measurement.

Acknowledgements

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