Measurement of Magnetoencephalography and Magnetocardiography using Tunnel Magneto-Resistance Sensor

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The electrical activity of the tissue of the human body creates magnetic field. Measurement of biomagnetic fields such as magnetoencephalography (MEG) and magnetocardiography (MCG) is useful for elucidation of biological functions and diagnosis of diseases from its non-invasiveness and high spatial resolution. However, such measurements requires the use of SQUIDs with high equipment and running costs, especially the price of liquid helium. We have been studying to measure these biomagnetic fields using tunnel magneto-resistance (TMR) sensor which is a room temperature operating device. In this study, we performed MCG and MEG measurement using low noise, high sensitivity TMR sensor and circuit system.

The Magnetic Tunnel Junction (MTJ) multilayer film constituting the TMR sensor was deposited on a thermally oxidized Si substrate. MTJs were micro-fabricated by photolithography and Ar ion milling. To reduce the $1/f$ noise, MTJs were connected in 870 series and 2 parallel[1)]; the size of the integrated TMR sensors was $7.1 \times 7.1\ \mathrm{mm}^2$.

Fig. 1 shows the MCG signals using TMR sensor. The R peak of MCG was observed without averaging. This is the first demonstration of real-time MCG measurement using the TMR sensors. In addition, the Q and S peaks were clearly observed with 64 times averaging. Fig. 2 shows the MEG signal acquired by the TMR sensor. The signal was averaged 10,000 times with alpha wave as a trigger. Although there was a phase shift, the same 10 Hz signal as the brain wave was obtained in the MEG. The amplitude of the magnetic field was approximately 2 pTp-p, which is consistent with the reported value[2)]; the correlation coefficient of the MEG with the EEG was as high as 0.7 or more.

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Reference

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2) D. Cohen, Science 175 (1972) 664

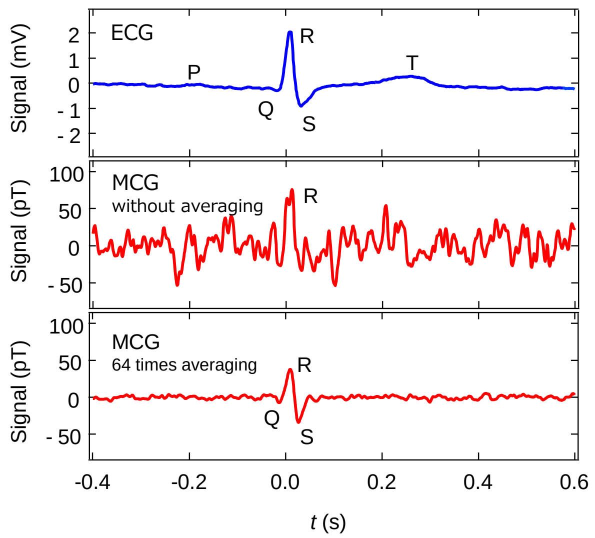

Fig. 1 Electrocardiography (ECG) and magneto-cardiography (MCG) using TMR sensor.

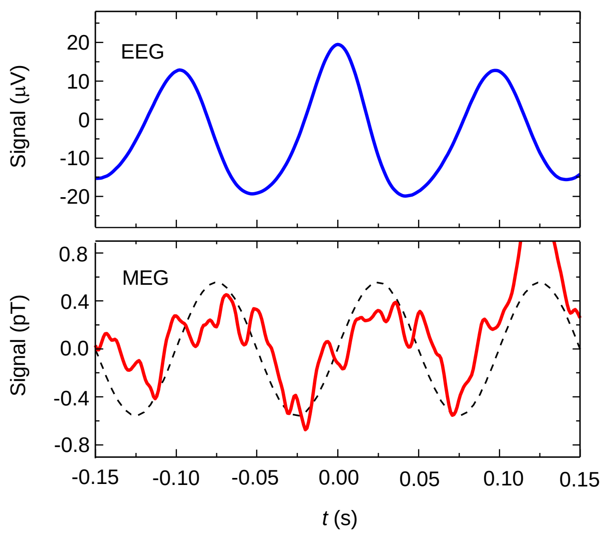

Fig. 2 Electroencephalography (EEG) and magneto-encephalography (MEG) using TMR sensor.