Room Temperature Magnetoencephalography and Magnetocardiography Measurements using TMR Sensors

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Measurement of bio-magnetic fields such as Magnetoencephalography (MEG) or Magnetocardiography (MCG) have great potential to improve the diagnosis of diseases and to clarify the biological functions of living organisms. However, such measurements requires the use of SQUIDs with high equipment and running costs, especially the price of liquid helium. In this study, we developed tunnel magneto-resistance (TMR) sensors that operate at room temperature to measure weak bio-magnetic fields.

The magnetic tunnel junctions (MTJs) multilayer was Si/ SiO_2/ Ta 5/ $Ni_{80}Fe_{20}$ 70/ Ru 0.9/ $Co_{40}Fe_{40}B_{20}$ 3/ MgO 1.6/ $Co_{40}Fe_{40}B_{20}$ 3/Ru 0.9/ $Co_{75}Fe_{25}$ 5/ $Ir_{78}Mn_{22}$ 10/ Ta 5 (in nm). 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 × 7.1 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 pT_{p-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.

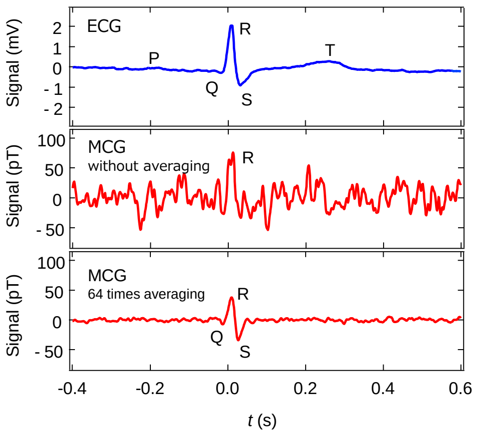

Fig. 1 Electrocardiography (ECG) and magneto-cardiography (MCG) using TMR sensor.

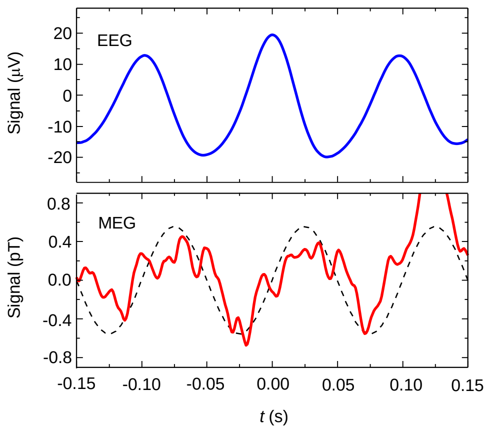

Fig. 2 Electroencephalography (EEG) and magnetoencephalography (MEG) using TMR sensor.

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