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High Temperature rf SQUIDs and their Application in Biomedicine and Non-Destructive Evaluation

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Speaker

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Abstract

High-temperature (HT) radio-frequency (rf) Superconducting Quantum Interference Devices (SQUIDs) are fabricated with step-edge junctions in thin film technology, using the ceramic superconductor YBaCuO. They are conveniently usable for numerous applications because they only need simple liquid nitrogen cooling. In the field of non-destructive evaluation (NDE), SQUIDs yield improved performance in eddy current testing of aircraft, especially for detecting defects at depths of up to 40 mm. An inversion procedure based on pulsed eddy currents provides tomographic conductivity images of the samples. Bridge inspection with a SQUID array integrated with a yoke magnet excitation was shown by scanning along the prestressed steel of bridges. In the field of biomedical SQUID applications, magnetocardio-grams (MCG) of adult and fetal subjects were recorded with a system containing six SQUIDs in a four-channel axial gradiometer configuration. For example, the heart signal of a fetus at the 31th week of gestation is clearly visible in the real-time traces with a signal-to-noise ratio of about 4. Another biosensing application of SQUIDs is the detection of superparamagnetic nanoparticles for monitoring in-vitro immunoreactions. Finally, the usage of the SQUIDs to record nuclear magnetic resonance (NMR) spectra of liquids at low magnetic fields ranging from 0.5 to 50 μT is shown. NMR spectra of water, benzene, fluorobenzene, and 2,2,2-trifluoroethanol were recorded. Linewidths down to 0.034 Hz in the case of benzene were observed. In trifluoroethanol, the broad band detection characteristics of the SQUID enabled the simultaneous observation of fluorine and proton spectra, reflecting their heteronuclear J-coupling. For earth’s field NMR, the technique of frequency-adjusted averaging was developed in order to reduce the line broadening due to fluctuations of the magnetic field of the earth.

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