Abstract

Biological separations and various medical applications have achieved the use of magnetic particles, especially superparamagnetic particle microbeads such as magnetite (Fe_3O_4) layer covering the shell of the particle. Magnetite nanoparticles can be used to generate heat to destroy exotic cells in biomedical applications. In addition, its single magnetic domain creates varying magnetic noise in the surrounding area. Although the average field of randomly diffusing magnetic noise is zero, the magnetic noise projected vertically in both constructive and destructive directions is not completely zero in a plane layer. One of the most promising sensors to detect this magnetic noise is the nitrogen-vacancy (NV) center in diamonds, which is one of the most effective quantum sensors for magnetometry on a nanoscale scale.

In this research, we demonstrated the relaxometry imaging of a superparamagnetic core-shell particle, based on the longitudinal spin relaxation time T_1 measured at a proximal ensemble NV center in a diamond. The core-shell particle is covered by magnetite superparamagnetic materials over 200 - 300 nm thickness. The magnetic noise in GHz frequency is generated into the environment sample even without the external magnetic field. The NV spin populations reflected the unstable electron-phonon coupling, caused by the fluctuation noise in the environment, before relaxing to the thermal equilibrium of the mixed spin states. The relaxation imaging is achieved by a home-built confocal microscope which measures the fluorescence decay pixel by pixel. The different decay fluorescence is normalized revealing the contrast and mapping the relaxometry image of the magnetic noise around the core-shell particle. In the presence of the externally applied field, the magnetic field induced the magnetization of the particle along the axis of the NV. The local magnetic vector is analyzed to expose the stray field of a magnetic particle, resulting in the measurement of the magnetic B-H curve.

Finally, the discussion in this prospective research is to pave the way to develop new insight into stochastic sensing with NV centers in diamonds and broaden the horizon in biomedical, especially in NMR imaging in the future.

Keywords— relaxation time, relaxometry image, superparamagnetic, magnetic noise, magnetic fluctuation, NV center, magnetometry.