Abstract

In recent years, the nitrogen-vacancy (NV) centers in diamonds have been studied by a large number of researchers for their quantum properties. The spin states in the negatively charged NV can be excited by a laser to generate fluorescence and their magnetic resonances split by the external magnetic fields are detected via the optically detected magnetic resonance (ODMR). Therefore, the NV center can be used as a probe to measure stray magnetic fields from magnetic materials and to elucidate magnetic structures. Compared to other magnetometers, the NV center magnetometer is becoming increasingly used due to its high sensitivity and nanoscale spatial resolution.

In this research, the $^{14}N^{+}$ implanted diamond was fabricated via a focused ion beam (FIB) and attached to a quartz tuning fork as a scanning NV center probe with a diameter down to about 500 nanometers. Furthermore, to increase the performance of the fabricated probe, the inductively coupled plasma (ICP) etching was considered to be applied to the probe. We did the ICP etching on the probe for a few tens of nanometers, then measured the Rabi oscillation and spin coherence properties before and after the ICP etching process to evaluate the performance of the probe.

The fabricated scanning NV probe combined with an atomic force microscopy (AFM) was used to detect the stray fields from the magnetic samples, such as Bismuth Lutetium iron garnet (BLG) and Yttrium iron garnet (YIG). The magnetic structures (magnetic domains) from these magnetic samples can be monitored by the magneto-optic Kerr effect (MOKE) microscope and imaged by the fabricated NV-AFM system. Moreover, the bubble-shaped magnetic domains (bubble domains) from the magnetic samples were formed by applying external fields. This kind of domain from low-field magnetic samples could not be imaged by the fabricated probe clearly unless increasing the performance of the probe, for example, via the ICP etching process with around 25 nm.

In a word, this research focuses on the development of a high-performance scanning NV center probe in order that we can detect and image the stray field from the magnetic samples.

Keywords: NV center, scanning probes, focused ion beam, ICP etching, spin properties, magnetic samples, stray fields, magnetic domains