Abstract

The advent of dielectric optical fiber following the invention of laser has completely redefined the fledging field of photonics in particular the photonic sensing technology in the large area of fundamental research as well as in industry applications. Currently, optical fibers play a major role in designing and realizing wide variety of fiber-optic sensors. The essential motives recognizing the features of optical fiber owe to light weight, immunity to electromagnetic interference, capability of distributed sensing, higher sensitivity, remote and multiplexed operation. Using fiber-optic approach, today almost every known physical parameter is directly or indirectly measureable. Meanwhile, there has been a growing interest in magnetic field sensing during last few years due to its essential encroachment in many industrial, scientific and defence projects. The measurement of low magnetic field using optical methods has remained attractive lending to the inherent capability of interrogating in a hazardous environment encompassing high voltage, significant electrical noise and high temperature. With this intent, a new approach of *fiber-cantilever beam deflection* in designing magnetometer is conceived and experimentally investigated through different configurations leading to improving sensitivity while keeping system complexity at minimum as needed for electrically-prone environment.

The thesis begins with the experimental research on preparing and optimizing the composition of probe magnetic material *cobalt-doped nickel ferrite* ($Ni_{0.97}Co_{0.03}Fe_2O_4$) till achieving high-performance probe composition in terms of low coercive field, high magnetization and low hysteresis. Utilizing the optimized probe composition as coating on single-mode fiber forming *fiber-beam deflection cantilever*, a number of organized experiments are then performed to detect a low-order magnetic field in the laboratory environment. The chronological development of configurations showing improved performances is recorded. Starting with a basic *fiber-optic double-slit interferometric scheme* where influence of the field on interfering cantilever-fiber beam is modeled through measuring the fringe-width of the dynamic interference pattern as a function of magnetic field, a *fiber-to-fiber transmission arrangement* for modulation of guided light is then devised to detect even lower order field. A magnetic field as low as 2.0 mT is unambiguously measured using etched fiber-cantilever modification. A theoretical analysis modeling the bending of fiber-cantilever and fiber-to-fiber transmission loss is worked out to estimate magnetizations (M) of the probe sample at various magnetic fields and is validated with SQUID data obtained from a high-end quantum device.

Next, the attention is focused to improving sensitivity of cantilever configurations by cascading effect. Starting from *twin-cantilever scheme*, we extend the model for n number of cascaded cantilevers and betterment in sensitivity is realized theoretically and experimentally demonstrated. In the next phase, a *fiber-optic extrinsic Fabry-Perot magnetometer* is devised and response of the magnetometer has been investigated experimentally followed by a theoretical model corroborating the experimental results. Developed configuration is then modified by incorporating an in-house fabricated fiber-mirror to enhance the sensitivity at this converged scheme and improved response towards low field sensing (~mT or even lower) is achieved.

Finally, a new material of multiferroic class, *bismuth ferrite*, is explored as magnetic field sensitive material by modifying its property through specific transition metal (*chromium* and c*obalt*) doping and incorporating it as probe material in fiber-optic cantilever-beam deflection arrangement. This yields a new possibility of using multiferroic as magnetic field sensing probe.

Keywords: *Single-mode optical fiber, Magnetic material, Cantilever beam deflection, Magnetic field sensing, Fiber optic sensors, Fiber optic interferometers.*