Chapter 4
Theoretical Analysis of a Microwave Antenna for Optically Detected Magnetic Resonance (ODMR) in NV Centre of Diamond

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ABSTRACT

The nitrogen vacancy (NV) centre is one of the most popular stable point defect centres in diamond. It acts as a single photon source even at room temperature. In order to analyse the optically detected magnetic resonance (ODMR) with the help of NV colour centre in diamond, an external magnetic field is needed as well as a microwave (MW) antenna. In this chapter, the authors present a simulated model of a microwave antenna and propose further modifications in order to increase the intensity of the microwave field.

INTRODUCTION

Colour centres are basically one or several point defects centres. The origin of these defect centres are vacant lattice sites or impurity atoms, which can be perfectly identified by individual absorption and emission spectra. Colour centres in diamond are responsible for the typical colouration of diamond. At the starting of this kind of research, natural diamonds were used intensively, but now a days industrially

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grown diamonds are used for this purpose. Diamond nanoparticles have promising fluorescence characteristics with many potential applications in the domain of biolabeling. The electronic characteristics of such impurities are the field of interest for physicists. The nitrogen Vacancy defect (Gruber et al., 1997) is one of such kind of impurities and along with some exceptional electronic characteristics it shows quantum as well as magnetic behaviour even at room temperature. The proposed work is based on constraint decision making system that contains several types of decision making. In the last decade, several types of decision making works are done such as different architecture design and its methodologies of wireless network and its components (Das et al., 2021; Das et al., 2020; Das et al., 2021), metaheuristic and soft computing based work (Binh & Dey, 2018; Binh et al., 2020), machine learning based work (Das et al., 2021), smart application design based work (Das, 2021; Das & Giacalone, 2022), etc. A constraint of a system is responsible for slowing down of its performance or preventing it from the desired goal. In order to keep the flow of a project going identification, exploitation and elevation of constraints are very important.

This report focuses on both physical as well as simulation groundwork with the goal of optical sensing of local magnetic field as well as microwave. Finite difference time domain software is used to determine and vary the intensity of the microwave field over a specific region on which the diamond sample would be kept on. A paramagnetic iron is also used to increase the strength of magnetic field.

THEORETICAL BACKGROUNDS

Nitrogen Vacancy Centre

The Nitrogen Vacancy (NV) centre in diamond is one of the numerous point defects (Schirhagl et al., 2014) in diamond. Photoluminescence is the one of the most discussed as well as useful properties of NV centres. The NV centre`s electron spin, localized at atomic scale, can be manipulated at room temperature by external factors such as magnetic or electrical fields, microwave radiation, or light, resulting in sharp resonance in the intensity of photoluminescence. An individual NV centre can be used as a basic unit for a quantum computer, a qubit, used for quantum cryptography.

Crystal and Electronic Structure

As nitrogen is the most abundant impurity in diamond, the NV centre (Schirhagl et al., 2014) was already discovered in the 1970s. Due to diamond`s outstanding properties, which includes mechanical hardness, optical transparency, and high Debye