CHAPTER 1

INTRODUCTION

1.1 Research Motivation

Recently, synthetic diamond has gained very high attention among engineering materials. This dues to its extreme physical and chemical properties, for example, extreme hardness, high wear resistance, high corrosion resistance, high thermal conductivity, variable electrical resistivity, and high optical transparency etc [1]. Two prominent growth deposition technologies, which are high-pressure high-temperature (HPHT) and chemical vapor deposition (CVD), are among the methods utilized in diamond synthesis. However, the high cost of production and technical limitation of HPHT method are the prohibiting factors and CVD method is chosen as a better choice. Various CVD techniques have been proposed for diamond growth such as combustion flame, DC arc jet, hot filament CVD (HF-CVD), radio frequency CVD (RF-CVD), and microwave plasma CVD (MW-CVD) [2, 3] etc.

At present, microwave plasma enhanced CVD (MW-PECVD) technique is the most widely used technique for diamond growth, as reported in many publications [4, 5, 6]. Growth of diamond by this technique has many advantages over the other techniques (i.e. HF-CVD, and RF-CVD) such as (i) the MW-PECVD reactor does not has electrode inside of the vacuum part, therefore the contamination due to electrode erosion does not occur within vacuum chamber, (ii) the microwave discharge operates at high frequency (generally at 2.45GHz), hence it can produce high energy electron and high plasma density, (iii) plasma is confined in the center of the deposition chamber, which prevents to deposit on/etch the wall of reactor.

Recently, Tachibana et al. [7] have presented the high power (60-kW) microwave reactor of ASTeX Inc, which can accommodate substrate up to 300 mm in diameter. Such reactor has been expected to be a future commercial reactor for producing diamond wafers.

1.2 Research Objective

The main objective of this thesis can be expressed into two main fold. Firstly, we aimed to design and construct a MW-PECVD reactor for diamond film deposition. The reactor consists of vacuum chamber, waveguide, cavity resonator, waveguide plunger and microwave energy source. Secondly, we aimed to synthesize diamond films with our MW-PECVD reactor as well as characterize them by scanning electron microscopy, atomic force microscopy and Raman spectroscopy. Previous work reported that there are many diamond growth parameters such as substrate material, substrate temperature, microwave power, deposition pressure, substrate biasing, and precursor concentration that can effect film morphology and structure. However, due to limitation of our reactor, only deposition time, substrate pretreatment method, gases composition, and deposition pressure are varied in order to examine the influence to the film morphology, roughness, and structure of carbon on CVD diamond films.

1.3 Thesis Organization

After an introduction in this first chapter, this thesis is divided into 6 chapters. Chapter 2 describes the necessary background including structure and properties of diamond, CVD processes, MW-PECVD techniques and CVD diamond growth conditions.

Our design and construction works are described in chapter 3, which will describe the details of vacuum chamber, rectangular waveguide, cavity resonator, mode excitation design as well as the gas-flow setup.

Chapter 4 describes the sample preparation process, the detail of system set up, and film characterization techniques.

The first part of chapter 5 presents the effects of deposition times and seeding methods to the film morphologies. The effect of methane concentrations and deposition pressure to the film morphologies and film qualities will also be presented.

Finally, in chapter 6, the conclusions of the thesis will be presented.