CHAPTER I

INTRODUCTION

1.1 Research motivation

Diamond has 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 and other properties [1, 2]. Combined with these properties, diamond is far more effective and efficient than other materials used for hard coating, cutting and grinding tools and as electronic devices [3-6]. However, the high cost of material production has limited the commercial use of diamond thin films to only few very specialized applications. A large number of deposition techniques have been employed for successful deposition of diamond from vapor phase. Deposition techniques are mainly divided into two major categories, namely chemical vapor deposition (CVD) and physical vapor deposition (PVD). In CVD techniques, the source of carbon is an activated gas phase. PVD techniques rely on excitation of the target that is usually solid to produce the necessary material for film formation. In addition to the basic difference in the way that material transfer from the vapor phase to the solid phase is achieved [7, 8]. In CVD of diamond, the driving cost factors include low reagent utilization, low deposition rate, high energy consumption, large thermal management loads at the substrate and capital equipment costs [9]. A variety of CVD techniques have been proposed for diamond growth such as microwave plasma CVD (MW-CVD) [10-12], hot filament CVD (HF-CVD) [13-14], radio frequency plasma CVD (RF-CVD) [15-16], DC plasma [17-19], etc. Diamond formed by sp^3 hybridized carbon atoms is a unique structure in nature. Its unique properties make it suitable for a variety of commercial application. Not only be prominently as a gemstone, but also a very useful industrial material. The diamond coated cutting tools, abrasive wheels are a few products used routinely in industry [8].

Currently, ceramic materials are important in many industries, especially grinding technology with ball-mill, in which incorporate the uses of alumina grinding ball. However, wear could occur in the grinding ball after the long use. Thus, this proposed work is focused on the properties improvement of alumina surface coated with synthesize diamond-like carbon (DLC) thin films using microwave plasma enhanced chemical vapor deposition (MW-PECVD) technique. This technique can increase hardness and wear resistance, resulting to an increase in life time span of the alumina usage.

There are many researches of diamond film deposited on alumina substrate that has been applied in several applications. For example Linjun Wang *et al.* [20] studied the growth of polycrystalline diamond films on alumina substrates by microwave plasma CVD using gaseous mixture of methane and hydrogen. They controlled the process pressure in the range of 1.5-5 kPa (11.4-38 torr) and the substrate temperature in the range of 700-900 °C by adjusting the microwave power level. They found that decreasing the gas pressure in nucleation process was an efficient method to enhance diamond nucleation density on alumina substrates. The optimum substrate temperature for a good-quality diamond films on alumina substrate was in the range of 800-860 °C. Based on Mo *et al.* [21], their research studied a nucleation mechanism for diamond film deposited on alumina by microwave plasma CVD using methane and hydrogen gaseous mixture. They showed that by using suitable pretreatment such as polishing the substrate with diamond particles and pre-depositing a nondiamond carbon layer under high methane gas concentration, could enhance the nucleation of the diamond. Ternyak *et al.* [13] reported about evolution and properties of adherent diamond films grown on alumina by hot-filament chemical vapor deposition (HF-CVD) technique. The substrates were ultrasonically abraded with mixed poly-disperse slurry that allows well adherents diamond films and high nucleation density. They described that the reason for well adherents between alumina substrate and diamond film was high carbon diffusivity onto alumina grain boundaries, which prevented the delamination of diamond film.

The main aim of this research is to investigate the influences of methane concentration, deposition pressure and deposition time. The properties of DLC thin films were characterized using Scanning Electron Microscopy (SEM), Raman spectroscopy, Atomic Force Microscopy (AFM) and nanoindentation testing. The expectation of the diamond films properties will increase in hardness.

1.2 Research objective

The objective of this research is to investigate the effects of the CVD diamond growth conditions on DLC thin films deposited on alumina substrates using MW-PECVD technique in order to obtain the optimum conditions, which can lead to an increase in hardness of the films and examine the influences of the conditions to the surface morphology, structure of carbon, surface roughness and hardness on CVD diamond films.

1.3 Research scopes

1.3.1 Synthesis of DLC thin films on alumina substrates by MW-PECVD technique under various conditions, for instance:

1.3.1.1 CH_4:H_2 %: 0.5, 1, 2, 3 and 5 %

1.3.1.2 Deposition pressure: 10, 20, 30 and 50 torr

1.3.1.3 Deposition time: 5, 10, 20 and 30 hr

1.3.2 Characterization of DLC thin films with the following techniques :

1.3.2.1 Scanning Electron Microscopic (SEM) technique is used to investigate surface morphologies on grown DLC thin films deposited on alumina substrates.

1.3.2.2 Raman spectroscopy technique is used to analyze the bonding structure of the films.

1.3.2.3 Atomic force microscopy technique is used to investigate the surface roughness of the films.

1.3.2.4 Nanoindentation test is used to examine the hardness of the films.

1.4 Benefits

The expected benefit from this research is to increase in hardness of DLC thin films deposited on alumina substrates using MW-PECVD technique.

1.5 Thesis organizations

This thesis can be divided into five chapters. Chapter I provide the general introduction to lead the objective and scope of this research. Chapter II knowledge and open literature dealing with diamond growth for CVD technique were presented. The experimental procedure as well as the instrument and techniques used for characterizing the resulting DLC films were also described in Chapter III.

In Chapter IV, the results on diamond-like carbon thin film deposition using MW-PECVD technique were presented. The influences of the ratio of methane to hydrogen gas, deposition pressure and deposition time were investigated. The characterization of the films using Scanning Electron Microscopy (SEM), Raman spectroscopy, Atomic Force Microscopy (AFM) and nanoindentation testing were described.

Finally, conclusion of this work and recommendations for future research work were provided in Chapter V.