CHAPTER 6

CONCLUSION

In this thesis, we have designed and constructed a compact microwave plasma reactor for diamond film deposition. This reactor can be divided into two main parts; (i) vacuum system, and (ii) microwave module. For the vacuum chamber, the main body of chamber is constructed from stainless steel cylinder with outer diameter of 219 mm and height of 254 mm. The vacuum chamber has six ports connected to the bottom plate, the front plate, the left plate, the right plate (ISO 63), the rear plate (ISO 63), and the top plate. The microwave power module including waveguide, waveguide plunger, and cylindrical resonator are designed and constructed based on the electromagnetic wave theory. We have used the optical emission spectroscopy (OES) technique with the Boltzmann plot method to determine the electron excitation temperature (T_{exc}) in our MW-PECVD reactor. We found that the T_{exc} of Ar plasma was varied from 0.82 to 1.06 eV over the pressure range of 0.15 to 7 Torr at microwave power of 300 watts.

The deposition parameters which are deposition time, surface pretreatment method, CH_4 concentration, and deposition pressure have been varied to study the effect on film morphology and structure. SEM photographs showed that the diameter of individual diamond nuclei is increased as deposition time increased. Moreover, two different methods of surface pretreatment which are ultrasonic agitation and hand scratching are studied. The results of SEM photographs showed that diamond film which is prepared by hand scratching yield preferable higher nucleation density than film prepared by ultrasonic agitation, we consider from the continuous film on Si substrate. The main result may be a high number of

grooves on the substrate surface. In addition, the Raman spectroscopy of the CVD diamond film is also studied. For films grown at same condition, the Raman spectrum taken with 810 nm laser shows a broad band around 1300 cm^{-1} and it does not appear a characteristic of diamond peak. However, when investigating this film with 514.5 nm laser, the characteristic of diamond peak located around 1333 cm^{-1} including broad band around 1550 cm^{-1} can be observed. These observations agree with the result of Leeds et al. [49].

The CH_4 concentrations in H_2 admixture are varied in the range of 0.5-5 % by fixed the deposition pressure at 30 Torr. With increasing CH_4 concentration, film surface morphology changes from scatter well-faceted to non-faceted continuous film. Moreover, we observed that the RMS roughness and grain size decrease with increasing CH_4 concentration. However, the decrease of RMS roughness is not clear for the growth condition at CH_4 concentration at 5%, which the decrease of grain size should decrease the RMS roughness. Moreover, the film crystallinity reduces when the CH_4 concentration increase, which is observed by intensity of characteristic diamond peak decreases with in the FWHM increase. The deposition pressure are also varied in the range of 10-50 Torr by fixed CH_4 concentration of 1%. The SEM photographs and Raman spectrums of films at deposition pressure of 30, 40 and 50 Torr reveal well faceted continuous films with the FWHM of diamond characteristic peak in the range of 10.2-11.8 cm^{-1}. However at deposition pressure of 10 Torr, no clear faceted film is observed. Also the diamond characteristic peak in Raman spectroscopy is not observed. At deposition pressure of 30 Torr, the film morphology reveals well crystalline film similar to that of film deposited at pressure of 40 Torr. The average grain sizes are found to be 353 and 343 nm at deposition pressure of 30 and 40 Torr, respectively. The film at deposition pressure of 50 Torr has average grain size 400 nm. This is due to the lower secondary nucleation on the film. However, we do not observed trend of roughness with deposition pressure. In the range of this study, we found that at CH_4 concentration of 1%, deposition pressure of 30 Torr, microwave power of 450 watt, and substrate temperature in the range of 430-470 $^{\circ}C$ would yield good

film results which is indicated by well faceted continuous film with lower FWHM of diamond characteristic peak.