CHAPTER V

CONCLUSION

5.1 Conclusions

This research was focused on the properties improvement of alumina surface coated with synthesize DLC films using MW-PECVD technique. The influences of CH_4 concentrations, deposition pressure, and deposition time were studied in order to obtain the optimum conditions which can lead to an increase in hardness of the films and examined the effects of the conditions to the surface morphology, surface roughness, quality, and hardness on the DLC films.

For the films deposited under a low CH_4 concentration of 0.5%, the ballas-like shape particle could be seen in the film. With CH_4 concentration increasing, a fine grained surface similar to cauliflower-like morphology was observed. The surface roughness decreased from 33.0 to 29.7 nm as well as the grain size decreased from 107.1 to 53.6 nm when increasing CH_4 concentration from 1 to 5%, respectively. It is believe that an increase in CH_4 concentration can lead to a more secondary nucleation effect, resulting to an increase in the nucleation density, as well as the reduction of the grain size. The Raman spectra is found to have two main peaks; quite a broad diamond peak around 1332 cm^{-1} and broad hump peak around 1550 cm^{-1}, corresponding to graphite-like sp^2 structure or amorphous carbon phase. However the diamond peak was quite broad, which broadens effect can be caused by the large mismatch in thermal expansion coefficient between alumina and diamond. The FWHM of 1332 cm^{-1} increased from 61.2 to 74.8 cm^{-1} with increasing CH_4 concentration from 1 to 5%, respectively. It indicated that the films had a lower sp^3-bonded carbon and higher sp^2-bonded carbon with increasing CH_4 concentration, which means that the films have low diamond phase purity. This result was in good agreement with the variation of hardness. The hardness of alumina found to increase from 7.3±2.0 GPa in uncoated to 39.4±10.0 – 52.2±2.1 GPa after coated with DLC under various CH_4 concentrations. As a result, the maximum value hardness was 52.2±2.1 GPa at CH_4 concentration of 1%.

The DLC films were deposited at different deposition pressure, SEM images indicates a cauliflower-like morphology and continuous DLC films coating over the alumina substrate. With increasing deposition pressure from 10 to 50 torr, the grain size increased gradually from 53.6 to 125 nm and the dense continuous films were obtained. The smaller grain sizes were formed at low deposition pressure, which were considered as the result of enhanced secondary nucleation. The surface roughness of the films increased significantly from 23.1 to 45.0 nm, while the FWHM of the Raman spectra of 1332 cm^{-1} decreased from 79.4 to 56.9 cm^{-1}, with increasing deposition pressure from 10 to 30 torr respectively. The hardness of these films was in the range of 13.9±1.3 to 52.2±2.1 GPa. The maximum hardness of the film was deposited at deposition pressure of 30 torr.

For the DLC films grown at different deposition time, it could be found that the nucleation density was a function of deposition time. With increasing deposition time, the particle diameter of individual diamond nuclei was increased. When deposition time reached at 30 hr, a dense continuous DLC films coating all over the alumina substrate could be obtained. A minimum surface roughness for the films after 5 hr was obtained at about 8.2 nm. With increasing deposition time from 10 to 30 hr, not only the grain sizes increased but also the surface roughness increased from 22.9 to 33.0 nm. In contrast, the FWHM of diamond peak decreased from 64.2 to 56.9 nm, with increasing deposition time from 20 to 30 hr. It indicated that higher purity of the diamond phase in the films deposited at higher deposition time was significant, corresponds with the hardness of the films. These films presented the hardness values in the range of 37.3±1.0 to 52.2±2.1 GPa. With deposition time increasing, the hardness of these films increased.

For these experiments, it could be concluded that DLC films have been successfully deposited on alumina substrate using MW-PECVD technique. The main process parameters extremely affected the characteristics of DLC films and optimum conditions at CH_4 concentration of 1%, deposition pressure of 30 torr, and deposition time of 30 hr, which were able to achieve superior quality of the films. The maximum film hardness was 52.2±2.1 GPa, indicating the films deposited under the optimum conditions could be very hard. It demonstrated that the improvement on the hardness of the coated alumina was significant.

5.2 Recommendations

In CVD process, the optimization of deposition conditions space is very large and complex. The properties of diamond growth films are upon to deposition conditions such as methane gas concentration, deposition pressure, substrate temperature, and also the substrate materials. CVD process enables to synthesize diamond films on several materials with different shapes and sizes that can be used to differentiate technological and industrial applications. This research demonstrated that DLC films have been successfully deposited on alumina substrate that can increase in hardness of the coated alumina. It is therefore very interesting to explore the possibility of coating of DLC films on other substrate materials. Furthermore, the additional heating of the substrate beneath the substrate holder can produce more efficient plasma, resulting in an increase in growth rate. However, there may be alternative methods for future work.