# CHAPTER 5 CONCLUSION

## 5.1 Summary

The characterizations on the thickness dependence of bi-layer film stack of DLC/a-Si deposited on Ge wafer substrate coupon using PFCA were carried out by TEM, AFM, XPS, SE and visible Raman. The results showed that the films stack were amorphous and DLC films surface roughness was independent DLC thickness. When the a-Si thickness exceed 6 nm (as controlled by in-situ ellipsometer) the film stacks exhibit bi-layers film which is good agree with XPS depth profile. The Raman results showed that the evolution of $sp^3$ structure as a function of the DLC thickness contains two stages: when thickness is 2 nm, the film contains less $sp^3$ sites and when thickness is 4 nm and over, the $sp^3$ site abrupt change and then slightly increase with further increase of DLC thicknesses. DLC thickness was related with intensity G. The Si-C transition layer was observed for a-Si/DLC thickness ratio of 6/9 nm. This thickness ratio can be estimated using BEMA. However, BEMA transition layer was not observed when a-Si thickness was less than 6 nm. Moreover, a-Si and DLC thickness can be determined using SE. Finally, we can cross-correlate DLC thickness using various analysis techniques.

The surface energy of the substrate could play an important role on the growth of DLC thin film. The thickness of DLC thin film deposited on the substrate can be addressed by the wetting ability of the substrate surface at the early stage of the film formation. The wetting ability is inversely proportional to the surface energy. In this work, the lowest surface energy of $Ta_2O_5$ substrate yielded the thickest a-Si layer since it can build up more globular droplet of a-Si molecules at the initial step of the film growth. However, the highest surface energy of $SiO_2$ substrate induced almost a flat droplet of a-Si molecules, consequently leading to form the thinnest a-Si layer. Unlike the a-Si layer, the DLC films deposited on the three substrates have the same thicknesses approximately of 9.9 nm, because all of them were deposited on a-Si layer-coated substrates having the same surface energy.

## 5.2 Future Work

The thin DLC/a-Si films from the pulse filtered cathodic arc (PFCA) processes were characterized on various properties such as surface morphology, chemical layer, thickness and chemical bonding. For all stack ratio deposition conditions, the bonding properties depend on the DLC thickness, thus the quality of the film can be further improved by adjusting the coating recipe and seed layer material. The following works are recommended as a follow-up to this study:

1. Varying the coating parameters such as pulse frequency, angle of deposition, coil voltage and arc voltage.
2. New seed layer using silicon nitride.
3. Thermal annealing effect to DLC/a-Si deposition films.
4. Growth mechanism of SiC interfacial layer.