CHAPTER 5

Conclusions and Suggestions

5.1 Conclusions

The properties of TiO_2 thin nanofilm are affected by varying a several FCVA deposition conditions; oxygen doping pressure, bias voltage, deposition time and annealing. In order to achieve the highest amount of anatase structure with high porosity by FCVAD, the film deposition on various different substrates which are suitable for specific analysis techniques is required. The TiO_2 deposited silicon is suitable for analyzing the film's structure, eg. Raman spectroscopy, while TiO_2 deposited glass are suitable for non-structure analysis techniques. Moreover the TiO_2 deposited FTO glass is suitable to be assembled as a DSSC to do the power conversion efficiency test.

- The oxygen doping pressure does affect the amount of oxygen composed in the film, moreover the oxygen doping pressure at 10^{-3}torr is the most suitable oxygen doping pressure because it provides a ratio between the amount of O:Ti the closest to 2:1. However, the deposited substrate with the pressure does not show the Raman spectrum of the anatase structure without annealing.
- More negative biased substrate during the deposition causes a higher amount of ion deposit on a substrate; however, the bias voltage does not change the film's thickness significantly. As a result, the more negative bias voltage causes more density of the film.
- After annealing of the 10^{-3}torr O_2-doped, 30 minutes deposition time with -250 V biased with annealing at 400°C for 2 hours, the increases the intensity of anatase peak at 639 cm^{-1} effectively.

- Deposition time affects the film's thickness; however, it does not affect the films structure. Moreover at the 10^{-3} torr, -250 V biased and 600 V arc deposited substrate required at least30 minutes deposition time unless the film is not thick enough to be analyzed its structure.

The annealed TiO_2 deposited DSSC shows higher power conversion efficiency than non-annealed TiO_2 deposited DSSC, which concerns to the earlier experiment that the annealing boosts the anatase structure up significantly which improve the film efficiency. While the more negative biased TiO_2-deposited DSSC shows lower power conversion efficiency because more negative biased causes more density as a result as a lower surface area to be attached by the sensitizing dye for converting the light into the electric current. It can be concluded that the non-biasing is the most suitable for the film deposition. In addition, the 30 minutes deposition time increases the efficiency significantly compared to the 20 minutes deposition time, which happened because the 20 minutes deposition time causes very low thickness TiO_2 layer and less surface area to be attached by the sensitizing dye. However, the highest power conversion efficiency from this studying is around 0.0249 % which is still far from 11% of the international laboratory DSSC because it contains the TiO_2 with its thickness more than 200 times compared to ours which can contain higher amount of the dye to be attached to. Therefore, it can be implied that the applying FCVAD to deposit the TiO_2 to reach the micron scale causes the power conversion efficiency to reach 5 % approximately. However, there are a plenty of deposition conditions of TiO_2 deposited by FCVAD are still required to be studied in order to increase the efficiency.

In this study, the deposition and characterization of the diamond-like carbon in the form of tetrahedral amorphous carbon (ta-C) with nitrogen doped deposited by FCVAD are investigated by three different parts, including effects of; substrate bias voltage and nitrogen doping pressure.

The bias voltage influenced to the structure and hardness of the ta-C films. The films with applied substrate bias voltage at −250 V provided the highest sp^3 content compared to the sp^2. As a result, the deposited film at -250 V biased contains the most amount of diamond structure compared to graphite structure. Moreover, the addition of nitrogen content at low level in ta-C film to form nitrogen doped tetrahedral amorphous carbon (ta-C:N) decreases the hardness while increases the adhesion of the films because the additional nitrogen in the DLC films reduce the sp^3 fraction in the films resulting in hardness reduction; in contrast, the adding nitrogen content in the films decreases the internal stress and strain in films which causes the increasing of adhesion strength.

5.2 Suggestions

Although the annealing with 400^{o}C for 2 hours increases the anatase structure in the film effectively, the annealing with other temperature is still interesting for being studied. Moreover the deposition time should be increased in order to increase the film's thickness into the micron scale to compare its efficiency with the film deposited by other deposition techniques.

Moreover, the more deposition conditions of DLC are still needed to be investigated in order to increase the film's hardness as well as its adhesion. For instances, arc voltage and other reactive gas with various pressures are the interesting parameters of being studied.