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Effects of Annealing on Crystallographic Properties of amorphous carbon films grown by plasma-enhanced chemical vapor deposition

Nagoya Univ.[1], ○Lingyun Jia[1], Da Xu[1], Masayuki Nakamura[1], Hirotsugu Sugiura[1], Hiroki Kondo[1], Kenji Ishikawa[1], Makoto Sekine[1], Masaru Hori[1]

E-mail: jia.lingyun@d.mbox.nagoya-u.ac.jp

Amorphous carbon (a-C) film is expected as a new material for the next generation of solar cells, owing to its widely-variable optical bandgap values ranging from 0.0 to 5.5 eV and low material cost.[1] However, photovoltaic effect of pure a-C junction still have not be confirmed, due to a large amount of defect density in a-C films. Understanding of the deposition mechanism of a-C films is also insufficient. In this study, with the purpose of modifying crystallographic properties, alternate processes of short time deposition and annealing was carried out.

In this study, a-C films were synthesized by a radical-injection plasma-enhanced chemical vapor deposition (RI-PECVD) system. H_2 gas was introduced to the upper surface wave plasma source (SWP, 2.45 GHz, 400 W). Generated H radicals of high density flow through a shower head into the lower capacitively coupled plasma (CCP, 100 MHz, 100 W) chamber. CH_4 gas introduced to the CCP chamber and carbon radicals were generated. The substrate holder also serves as an electrode, which is subject to an RF bias of 13.56 MHz and 50 W. Gas pressure was kept at 5 Pa during the process. During the deposition process, deposition and annealing were operated alternately for 40 circles. Deposition time in every circle was kept at 15 s. During annealing time, only CH_4 and H_2 were kept flowing without plasma in the chamber.

Fig. 1 shows optical gaps and thickness of a-C films as a function of annealing time. While thickness slightly decreases with increasing annealing time, optical band gaps decreases. On the other hand, D-band peaks in Raman spectra, which indicates imperfection or fluctuation of graphitic six-membered ring structures, decreased by annealing for more than 15 s. These results indicate the change of crystalline structures of a-C films by annealing between the deposition processes.

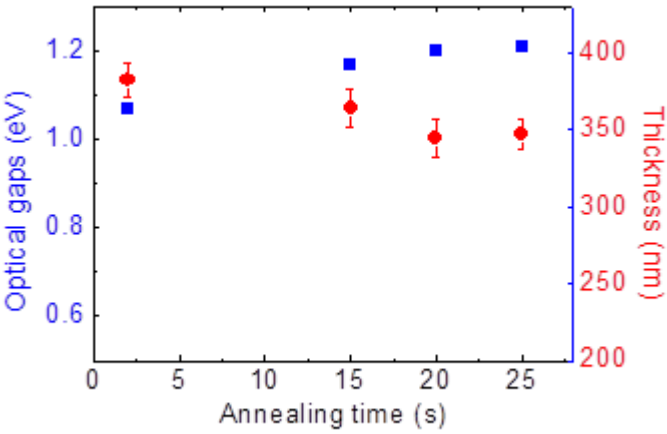

Fig. 1　Optical gap and thickness of a-C films as a function of annealing time.

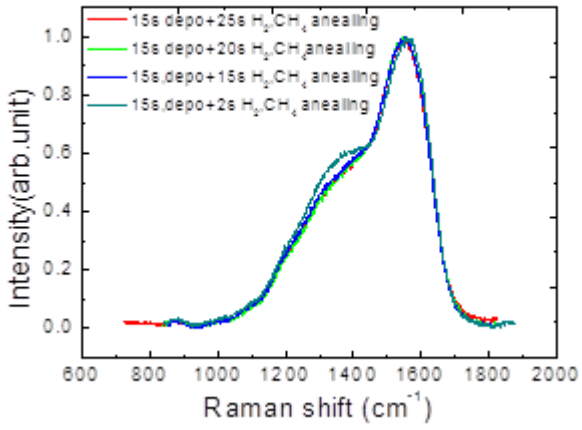

Fig. 2　Raman spectra of a-C films synthesized by different annealing time.

References

[1] H. Zhu, J. Wei, K. Wang and D. Wu: Solar Energy Materials & Solar Cells 93, 1461 - 1470 (2009)