4th International Symposium on
Energy Challenges & Mechanics
- working on small scales

11-13 August 2015
Aberdeen, Scotland, UK

Precise control over oxygen impurities in nano-crystalline silicon thin film processed with a low hydrogen dilution gas system at near room temperature

Jin Nyoung Jang[1,2] and MunPyo Hong[1*]

[1]*Department of Display and Semiconductor Physics, Korea University, Sejong, Korea*
[2]*Center for Advanced Photonic Materials, Korea University, Sejong, Korea*

Accepted for publication on 3rd June 2015

An atmosphere highly diluted with hydrogen is essential to increase the crystal fraction during formation of hydrogenated nano-crystalline (nc) or micro-crystalline (μc) silicon thin films via chemical vapor deposition (CVD). This hydrogen-rich process, however, hinders the ability for the material to find adequate use in micro-electronic devices due to contamination that results in oxygen-related problems such as donor-like doping, defect creation, or passivation. The use of neutral beam assisted chemical vapor deposition (NBaCVD[1~7]), with a low hydrogen ratio (R= H_2/SiH_4) of 4, successfully deposits a highly-crystallized nc-silicon (HC nc-Si) thin film (TF) at near room temperature (< 80 °C) and effectively reduces oxygen contamination by as much as 100 times when compared to conventional plasma enhanced CVD. During the formation of HC nc-Si TF via NBaCVD, energetic hydrogen atoms directly react with oxygen atoms near the surface of the nc-Si TF and remove the oxygen impurities.[8,9] This is a completely different mechanism from the hydrogen-enhanced oxygen diffusion model. Also neutral beam, mainly hydrogen, induces supply efficient energy to form uniform nano grain distribution and continuously nucleation that enable incubation free interface. This NBaCVD processed nc-Si thin films are applicable to the performances of thin-film transistors fabricated by that of thin-film transistors based on highly hydrogen diluted and high temperature processed silicon materials in terms of operational stability and filed-effect mobility. The filed-effect mobility of the NBaCVD processed nc-Si thin film is as high as 17 $cm^2V^{-1}s^{-1}$ and has high stability is as low as 0.5 V threshold voltage shift under gate bias stress, current stress, and light illumination stress. This technology meets the recent requirements of a high deposition rate and low temperature necessary for flexible electronics.

Keywords: oxygen control; nano crystal silicon; low hydrogen ratio; neutral beam; CVD

1. Jang, J.N., et al., *Effects of neutral particle beam on nano-crystalline silicon thin films, with application to thin film transistor backplane for flexible active matrix organic light emitting diodes*, Thin Solid Films, 2011, **519**: p. 6667-6672.
2. Song, B., et al., *Reactive particle beam based deposition process of nano-crystalline silicon thin film at low temperature for the flexible AM-OLED backplane*, Thin Solid Films, 2010, **518**: p. 6299-6303.
3. Lee, D. et al., *Influence of argon neutral beam energy on the structural properties of amorphous carbon thin films grown by neutral particle beam assisted sputtering*, Thin Solid Films, 2011, **519**: p. 6703-6707.
4. Yoo, S.J., et al., *Hyperthermal neutral beam sources for material processing (invited)*, Review of Scientific Instruments, 2008. **79**(2): p. 20C301

5. Choi, S.G., et al., *Effect of plasma source power on the nanocrystallization of silicon thin films by reactive particle beam assisted chemical vapor deposition*, Ceramics International, 2012, **38**: p. S641-644.
6. Choi, S.G., et al., *Effect of reflector bias voltage on the nanocrystallization of silicon thin films by reactive particle beam assisted chemical vapor deposition*, Journal of the Ceramic Society of Japan, 2011, **119**: p. 922-925
7. Wang, S., et al., *Properties of amorphous silicon thin films synthesized by reactive particle beam assisted chemical vapor deposition*, Thin Solid Films, 2010, **518**: p. 7372-7376.
8. Jang, J.N., D.H. Lee, and M. Hong, *Precise control over oxygen impurities in nano-crystalline silicon thin film processed with a low hydrogen dilution gas system at near room temperature*, Current Applied Physics, 2014. **14**: p. 901-904.
9. So, H. et al., *New approaches for micro-controlling of oxygen dopant contents in silicon-based thin films with application to multi-band gap solar cells*, Current Applied Physics, 2012. **12**: p. 64-70.