

Design and study of monotonous linearity graded varying in p- i- n layer's energy band gap (Eg) on hydrogenated nanoamorphous silicon film (na-Si:H) solar cells

Yu Huachong ^{a*} Cui Rongqiang ^a Yang Hong ^b Zhao Baichuan ^a Wang He ^b
Zhao Liang ^a Peng Hua ^a Zhou Zhibin ^a Meng Fanying ^a

(^a Solar Energy Institute, Shanghai Jiaotong University, Shanghai 200240, China)

(^b Solar Energy Institute, Xi'an Jiaotong University, Xi'an 710049, China)

With increasing awareness of the pollution associated with burning fossil fuel, it is apparent that PV is going to take a much more prominent role in the 21st century. A key requirement for the wide-scale deployment of PV is the lowering of its cost. Although the price has fallen dramatically over the last decade to make PV cost-competitive with fossil fuel for the grid application, further reduction in cost is essential to make PV viable for grid-connected systems. There is a tremendous ongoing international effort to meet this challenge, and many different technologies are being pursued. One of the leading candidates is amorphous silicon (a-Si) alloy technology. The inherent disorder in the material makes it easier to absorb sunlight; only a very thin (less than 500 nm) film is needed, thereby lowering material cost. Innovative manufacturing processes have also been developed to reduce production cost. The challenge has been to increase the light-to-electricity conversion efficiency. a-Si alloy is a very intriguing material. The lack of long-range order and the presence of dangling bonds and other defects give rise to states in the mobility gap that impede carrier transport. Exposure to light also creates metastable states in the gap that degrade material and cell performance.

The interface effect and Staebler-Wronski(S-W) Effect of p- i- n type solar cells based on amorphous have been perplexing puzzle in the photovoltaic science field; The raising this kind of solar cells' light-to-electricity conversion efficiency and reducing their light-induced degradation(S-W Effect) have been studied. The na-Si:H films consists of the crystalline phase and the grain boundary phase (hydrogenated amorphous silicon—a-Si:H), the basic characteristic of nanophase structure were manifested by the photoelectric performance of the films, and the na-Si:H films exhibit a good photosensitivity for photovoltaic applications because of the existence of the grain boundary phase.

This paper reports the design on p-I-n layer's energy band gap by Energy Band Theory and study utilized the relationship between the energy band gap and structural characteristic of the hydrogenated nanoamorphous silicon film (na-Si:H) by varying the processing power, gas pressure, gas composition, and etc., the monotonous linearity graded varying in p- i- n layer's energy band gap (Eg) on hydrogenated nanoamorphous silicon film (na-Si:H) solar cells were designed by relationship between the many paper have reported that Eg vs hydrogen pressure ratios, Eg vs the crystallization, Eg vs the nanocrystalline grain size, photoconductivity and dark conductivity vs hydrogen

pressure ratios, photoconductivity and dark conductivity vs the crystallization, photoconductivity and dark conductivity vs the nanocrystalline grain size etc.. Figure 1 shows the schematic of the energy band gap figure of the monotonous linearity graded varying in p- i- n layer's energy band gap (E_g) on hydrogenated nanoamorphous silicon film (na-Si:H) solar cells.

In order to reduce interface effect of p-I-n solar cells, The design will not only avoiding the introduced of buffer layer bring I-V curve's aberration, but also improved all layer's photoconductivity; Since active layer of nanoamorphous silicon films(I layer) in solar cells, will reduce its light-induced degradation and improved i layer's photoconductivity. Meanwhile, the quantum number in I layer will increase consumedly, that will raise this kind of solar cells' light-to-electricity conversion efficiency(E_{eff}),

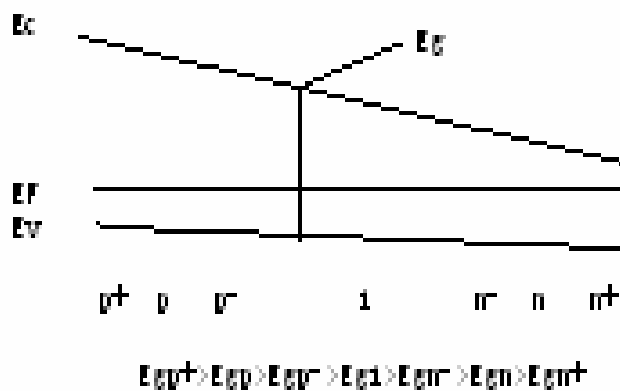


Figure 1 The energy band gap figure of the monotonous linearity graded varying in p- i- n layer's energy band gap (E_g) on hydrogenated nanoamorphous silicon film (na-Si:H) solar cells

open voltage(V_{oc}) and reduce their light-induced degradation(S-W Effect). The design will study the all p-I-n layer as a integer and know from isolated researching in p,i,n, The paper will account for all problem in p-I-n, and given the better way in technology process. A new energy band model of hetero-junction structure for the hydrogenated nanoamorphous silicon films is built by using energy band theory for the first time, This study lays a foundation for developing high efficiency hydrogenated nanoamorphous silicon films solar cells in next step.

Reference

- [1] A.Achiq, R.Rizk, R.Madelon, F.Gourbilleau, P.Voivenel, Growth control and properties of microcrystallized silicon films deposited by hydrogen plasma sputtering, The Solid films 296(1997)15-18.
- [2] Sukti Hazra, Swati Ray, Nanocrystalline silicon as intrinsic layer in thin film solar cells, Solid State Communications 109 (1999) 125-128.
- [3] J. Meier, S. Dubail, J. Cuperus, U. Kroll, R. Platz, P. Torres, J.A.A. Selvan, P. Pernet, N. Beck, N.P.Vaucher, C. Hof, D. Fischer, H. Keppner, A. Shah, J. Non-Cryst. Solids 227 - 230 (1998) 1250.

- [4] A.V. Shah, J. Meier, E. Vallat-Sauvain, N. Wyrsh, U. Kroll, C. Droz, U. Graf, Material and solar cell research in microcrystalline silicon *Solar Energy Materials & Solar Cells* 78 (2003) 469 – 491.
- [5] J. Meier, H. Keppner, S. Dubail, U. Kroll, P. Torres, P. Pernet, Y. Ziegler, J.A.A. Selvan, J. Cuperus, D. Fischer, A. Shah, *Proc. Mater. Res. Soc. Symp.* 507 (1998) 139.
- [6] J. Meier, H. Keppner, S. Dubail, U. Kroll, P. Torres, P. Pernet, Y. Ziegler, J.A.A. Selvan, J. Cuperus, D. Fischer, A. Shah, *Proc. Mater. Res. Soc. Symp.* 507 (1998) 139.
- [7] Tawada, M. Kondo, H. Okamoto et al., *Jpn. J. Appl. Phys.* 21, Suppl. 21-1, (1982) 297
- [8] S. Hamma, P. Roca i Cabarrocas, Low-temperature growth of thick intrinsic and ultrathin phosphorous or boron-doped microcrystalline silicon films: Optimum crystalline fractions for solar cell applications, *Solar Energy Materials & Solar Cells*, 69 (2001) 217-239
- [9] Toshiaki Sasaki, Shinji Fujikake, Katsuya Tabuchi et al., Structural study of p-type $\mu\text{c-Si}$ layer for solar cell application, *J. Non-Cryst. Solids*, 266-269 (2000) 171-175
- [10] S. Guha, J. Yang, P. Nath, and M. Hack, Enhancement of open circuit voltage in high efficiency amorphous silicon alloy solar cells, *Applied Physics Letters* 49 (1986) 218-219

Keywords: Monotonous Linearity, Graded Varying Energy Band Gap, Hydrogenated Nanoamorphous Silicon Films, Nanocrystalline Grain, Photoelectricity Performance, Energy Band Engineering.