**THESIS INFORMATION**

**Thesis title:** *“Fabrication and study on the properties of functional layers in a-Si:H thin film solar cell”*

**Specialization:** Solid state physics

**Code:** 62 44 07 01

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1. **THESIS SUMMARY**

* Thin film solar cell based on the hydrogenated amorphous silicon (a-Si: H) with N-I-P or P-I-N structures has attracted much attention from researchers and technology corporations because of various advantages: ability to be made on many different substrates (glass, steel, plastic), low fabrication temperature, simpler fabrication process than that of crystalline silicon counterparts, possible manufacture on large areas ..., therefore it has high potential in industrial production at low cost. It is one of the brightest candidates to replace silicon crystalline solar cell.
* The structure of N-I-P studied in the thesis with the order of manufacturing layers is **Glass/FTO/AZO/N-nc-Si:H/a-Si:H/a-SiO: H/P-SnO/Cu.** In which the N-nc-Si: H, a-Si: H and a-SiO: H thin films were prepared by plasma enhanced chemical vapor deposition method (PECVD), while the Al-doped ZnO ( AZO), P-SnO and metal electrode (Cu) layers were fabricated by DC magnetron sputtering (PVD) method, specifically:
* By the dilution technique of hydrogen into silane in PECVD method from precursors SiH4, H2, PH3; N-nc-Si:H nanostructured layer could be achieved with large conductivity and wide band gap as an electron collecting layer (*Eg = 2,23 eV*, *σd =7,84 Ω-1cm-1)*
* The intrinsic a-Si:H absorbing layer has amorphous structure with low defect density
* and low electric conductivity (*σd = 1,4.10-10 Ω-1cm-1*). The a-SiO:H layer, there exist both SiO and a-Si phases, it has low dislocation density and wide optical band gap (*Eg* = *2,27 eV, σd* = *4,88.10-10 Ω-1.cm-1, Ndd = 8,7.1015cm-3),* which fulfills the requirements of a buffering layer at P-I junction.
* The AZO layer has high light tranmittance, strongly enhanced electric conduction under hydrogen plasma treatment(Eg = *3,52 eV, µ = 18 cm2/Vs, ρ = 1,98.10-3 Ω cm)* and high durability in hydrogen plasma, which works as protection layer for FTO and optical electrode.
* The intrinsic and Ag-doped SnO thin films of high hole conductivity and suitable band gap were fabricated as hole collecting layers(*Eg = 2,63 eV, NH = 5,8.1018cm-3, µ = 4,10 cm2/Vs, ρ= 0,262 Ωcm, σ = 3,8 (Ωcm)-1).*

In the process of manufacturing these single layers of materials, especially at low temperatures (2000C), all functional layers have achieved satisfactorily optical, electrical, structural ... properties for thin-film solar cell.

* The influence of fabrication parameters of those functional layers on characteristic quantities of solar cells, such as: short circuit current density (JSC), open circuit voltage (VOC), efficiency (η ) was investigated and optimized (VOC = 438 mV, JSC = 11,17 mA/cm2, FF = 46,6 %, η = 2,27 %) according to the cell struture **Glass FTO/AZO (15 nm)/N-nc-Si:H (30 nm)/I-a-Si:H (200 nm)/a-SiO:H (15nm)/ P-type SnO:Ag (50 nm)/Cu (300 nm).**
* In addition, semi-transparent solar cell structure capable of applying to "smart" windows is a potential practical application of thin-film solar cells.

1. **NEW CONTRIBUTIONS OF THESIS**

* All functional layers are fabricated at low temperatures (2000C) but they still maintain the necessary properties for opto-electric device applications without destroying their structures and at the lowest cost.
* Fabrication of nanostructured a-SiO:H film with low temperature PECVD method and controllable optical band gap (by oxygen content) plays an important role in different multi-layer devices. Specifically, in this research, it was employed as an energy buffering cladding layer to increase open-circuit voltage, short-circuit current and thin-film solar cell performance.
* The Ag-doped SnO film made by sputtering method at low temperature has a sharp increase in hole concentration but the mobility is not significantly reduced by the amount of doping Ag, which meets the requirement of collecting holes in amorphous thin film solar cells of N-I-P structure. P-type SnO films promise to be a new research orientation in "transparent" semiconductor devices as they gradually replace classic "non-transparent" P-type bulk crystalline semiconductors in P-N junction semiconducting devices. This will significantly reduce cost of devices.
* Successfully fabricate solar cells with thin semi-transparent amorphous silicon films from the above functional material layers, which satisfies three requirements: i) light transmission (about 34%), ii) energy conversion (0.91%) and iii) reflective interference creating decorating colors in blue, violet (about 30%), and future potential application for "smart" window.

1. **PRACTICAL AND POTENTIAL APPLICATIONS OR FUTHER ISSUES TO BE SOLVED**

* Develop a multi-chamber, multi-function vacuum system to manufacture multi-layer components, to minimize the impact of contamination in the junctions between layers. On that basis, we utilize a-Si: H, p-type SnO layers in thin-film diode manufacturing of P-N junction, thin film photodiode of N-I-P junction.... for further applying to gas sensing and optical detecting sensors.
* Thoroughly study the semi-transparent solar cell series, so that the cell has high transmittance, but the performance is still high enough and the reflecting colors are richer to apply to the new generation of "smart" windows.

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