Optical Properties of Hydrogenated Amorphous Silicon with Nanocrystalline Germanium via CPM

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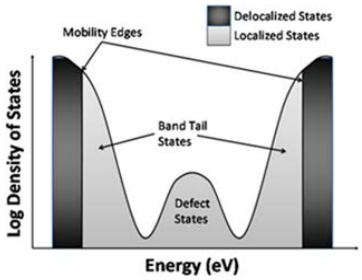
Introduction

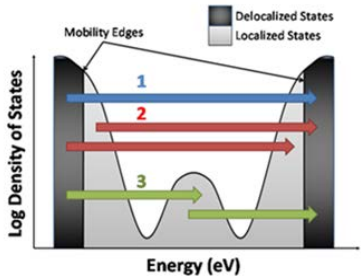
- Due to the low cost of production and ease of deposition on a variety of substrates, amorphous silicon(a-Si) rises great interests of large area electronics applications.
- The disorder in the atomic structure of a-Si leads to the presence of localized states in both valence band and conduction band and the exponential decay of the band tails.
- To reduce the disorder and adjust the energy gap, hydrogen and germanium are introduced to a-Si, forming nc-Ge/a-Si:H.
- The films used in the projects are nc-Ge/a-Si:H with varying Ge content.
- Tauc and Cody energy gap and Urbach slope are measured via CPM.

CPM&absorption spectrum of a-Si:H

- CPM is short for constant photocurrent method, measuring absorption coefficient α by keeping the photocurrent constant as photo energy varied.
- However,α spectrum produced by CPM is only relative values, which needs a traditional transmission measurements in the applicable regions to calibrate it
- the Ritter-Weiser formula below will calibrate the relative absorption spectrum.
- There are three possible transitions in a:Si:H shown in the right . In this project, transition 1 and 2 are the major concerns, which will produce Tauc and Cody gaps and Urbach slope.
- For good device quality films, Urbach slope should be 50meV~70 meV and Tauc and Cody gaps should be 1.6eV~1.8 eV.
- To measure its mobility gap and disorder , Tauc and Cody energy gap and Urbach slope are determined in the absorption spectrum for 1.1eV to 2.1 eV via CPM.

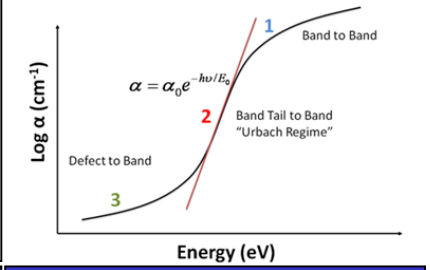
Three transimissions



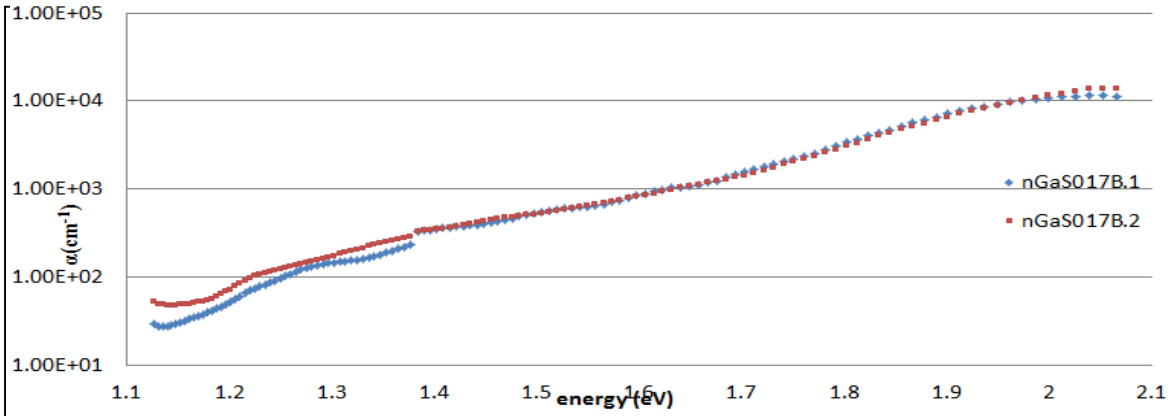


Figures above are the sketches of a-Si:H band gap density of states (left) and the indication of three types of transitions. (right)

Figure on the right is a sketch of absorption spectrum of a-Si:H with indication of the Urbach region.



Results and analysis



film	x	d(μm)	E^T_g (eV)	E^c_g(eV)	E_0(meV)
nGaS017B.1	2.94%	1.8	1.55	1.47	125
nGaS017B.2	7.29%	2.2	1.61	1.55	128

Table.1: Summary of two films' parameters-crystal fraction x, thickness of the film d, Tauc energy gap E^T_g , Cody energy gap E^c_g and Urbach slope E_0.

a.The graph on the left are α spectrum of the two films with different germanium content but there is no obvious difference between the two spectrum above 1.4 eV.

b.Tauc and Cody energy gaps are less favorable and contradicts the fact the larger Ge content leads to smaller mobility gap.

c.Urbach slopes of two films are almost the same and indicates that the band tails are broad and a great amount of disorder

conclusion

- The increase of Ge content fails to change obviously the mobility gap and Urbach slope.
- It is worthy to check the film without Ge content and slightly higher Ge content for further confirmations.
- Above 2.0eV, the flat regions may affect the measurements of moblity gap.

reference

- R.A Street, *Hydrogenated Amorphous Silicon* (Cambrdge University Press, 1991)
- L. Wienkes, Optical Absorption in Thin Film Mixed-Phase AmorphousSilicon(unpublished）