Passion of crystalline silicon with solution-processed amorphous silicon

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Back-contact back junction solar cells with an amorphous/crystalline silicon p/n-heterojunction enable the highest efficiencies of all silicon based solar cell technologies [1]. Unfortunately their industrialization is questionable due to the lack of an industrially viable structuring method for the preparation of the interdigitated contacts.

Printing of solution process-able silicon precursors [2] could be a possible process.

This contribution aims at investigating the conversion from Neopentasilane to amorphous silicon (a-Si:H) and at evaluating the potential of solution processed a-Si:H layers for surface passivation of crystalline silicon.

Liquid silicon precursors based on Neopentasilane were prepared and converted to a-Si:H using spin-coating and subsequent annealing.

To further decrease the defect density in the a-Si:H layers and at the a-Si:H/c-Si interface hydrogen plasma post-deposition treatments were applied.

The annealing temperature for the conversion from liquid Neopentasilane to a-Si:H was varied from 250°C to 600°C and the passivation properties of the layers were investigated using carrier lifetime spectroscopy. The thermally treated layers exhibit strong charge induced and unstable passivation if the annealing temperature is kept below 350°C.

For annealing temperatures above 400°C the layers are fully converted to a-Si:H and the passivation is due to chemical passivation of dangling bonds.

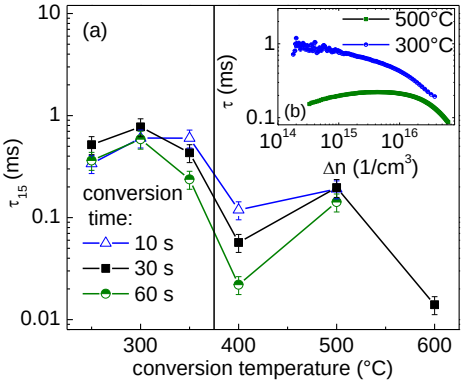

Fig. 1 (a) Minority carrier lifetime of liquid silicon after exposure to different annealing temperatures. (b) Minority carrier lifetime curves of samples treated at 300°C and 500°C. Fig. taken from [3]

A hydrogen plasma and in diffusion of hydrogen to the a-Si:H/c-Si interface can greatly enhance the passivation and enables excellent minority carrier lifetimes of 1.37 milliseconds.

Furthermore the electronic properties of spin-coated a-Si:H are compared to a-Si:H deposited using plasma-enhanced chemical vapor deposition. The liquid processed layers exhibit Urbach energies of 90 to 120 meV, compared to about 60 meV for PECV deposited a-Si:H. Furthermore their valence band is about 200 meV closer to the Fermi level, since the exhibit lower hydrogen contents.

Nevertheless the excellent minority carrier lifetime of about 1.37 milliseconds enables an implied open circuit voltage of about 724 mV and proves the viability of the presented approach.

[1] K. Masuko et al. IEEE J. Photovolt. 4 (2014) 1433-1435

[2] T. Shimoda et al. Nature 440 (2006) 783-786

[3] M. Mews et al. Appl. Phys. Lett. 105 (2014) 122113