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A Study on Amorphous Silicon Lifetime, Hydrogen Effusion and Passivation Quality

Huiting Wu[1], Hieu Nguyen[1], Di Kang[1], Nikita Gagrani[2], Wenjie Yang[1], Daniel Macdonald[1]
1Research school of electrical, energy and materials engineering, The Australian National University
2Department of electronic materials engineering, The Australian National University
E-mail: huiting.wu@anu.edu.au

Background & Introduction

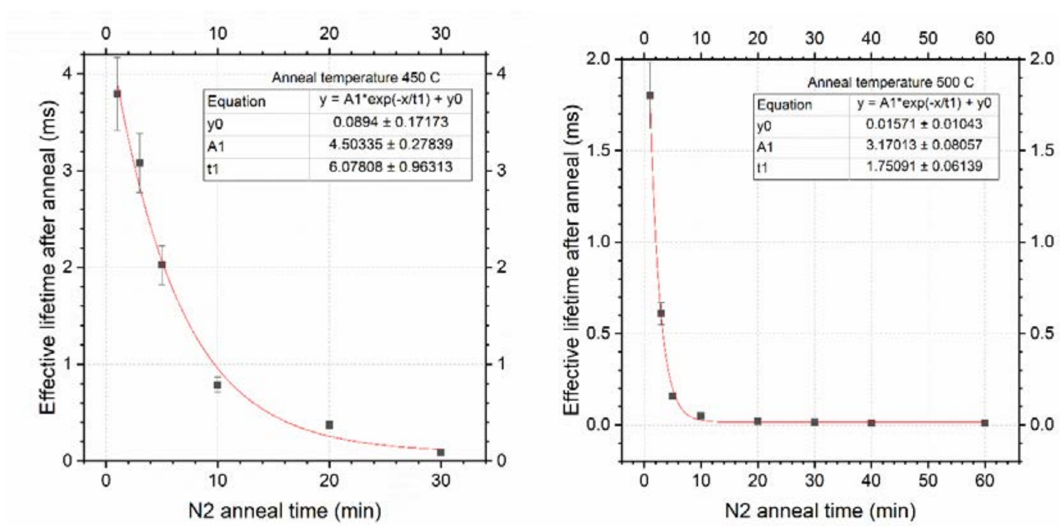
Intrinsic hydrogenated amorphous silicon film has demonstrated outstanding passivation performance [1], however, it is also shown to have high sensitivity to thermal processes due to the effusion of hydrogen out of a-Si films [1]–[4]. In this study, we measure quantitatively the hydrogen loss during annealing, the effective lifetime of the samples as well as the bulk lifetime of the a-Si films. We aim to discover the link between the passivation quality to the a-Si/c-Si interface passivation as well as the bulk lifetime of the a-Si film.

Experimental methods

The wafers selected for the experiments were 2 Ω cm phosphorous doped float zone crystalline silicon wafers. The a-Si was deposited onto the wafers using PECVD (Plasma Enhanced Chemical Vapour Deposition). Two groups of quarter samples, which come with samples of similar effective lifetime, were collected. One group was annealed from 1min to 40 mins in the manual furnace with N2 flow at 450 °C while another group was anneal at 500 °C. After the annealing, the effective lifetime of the samples were measured again. The a-Si film lifetimes were measured by the TRPL (time-resolved photoluminescence) system, and the hydrogen concentration of a-Si film were measure with FTIR (Fourier-transformation infrared spectroscopy) for the transmission spectra. The crystallinity of a-Si film, which could change as a result of the high temperature annealing, were measured with UV Raman with laser wavelength of 325nm.

Results and discussions

As shown in figure 1, for each annealing temperature, the time constants for the changes in effective lifetime, the a-Si lifetime and the hydrogen loss are of comparable values. It shows that the changes in both the effective lifetime and a-Si bulk lifetime largely result from changes in hydrogen concentration. The effective lifetime, however, consistently exhibits faster drop compared to the other two parameters. On one hand, we can see that on top of the a-Si/c-Si interface, the passivation quality of the samples are also affected by the bulk lifetime of the a-Si film. On the other hand, this also suggests potentially the loss of hydrogen at the a-Si/c-Si interface could be more dramatic compared to the a-Si bulk or could cause more dramatic increase in the surface recombination. Other changes that occur during the annealing process could also play a part.



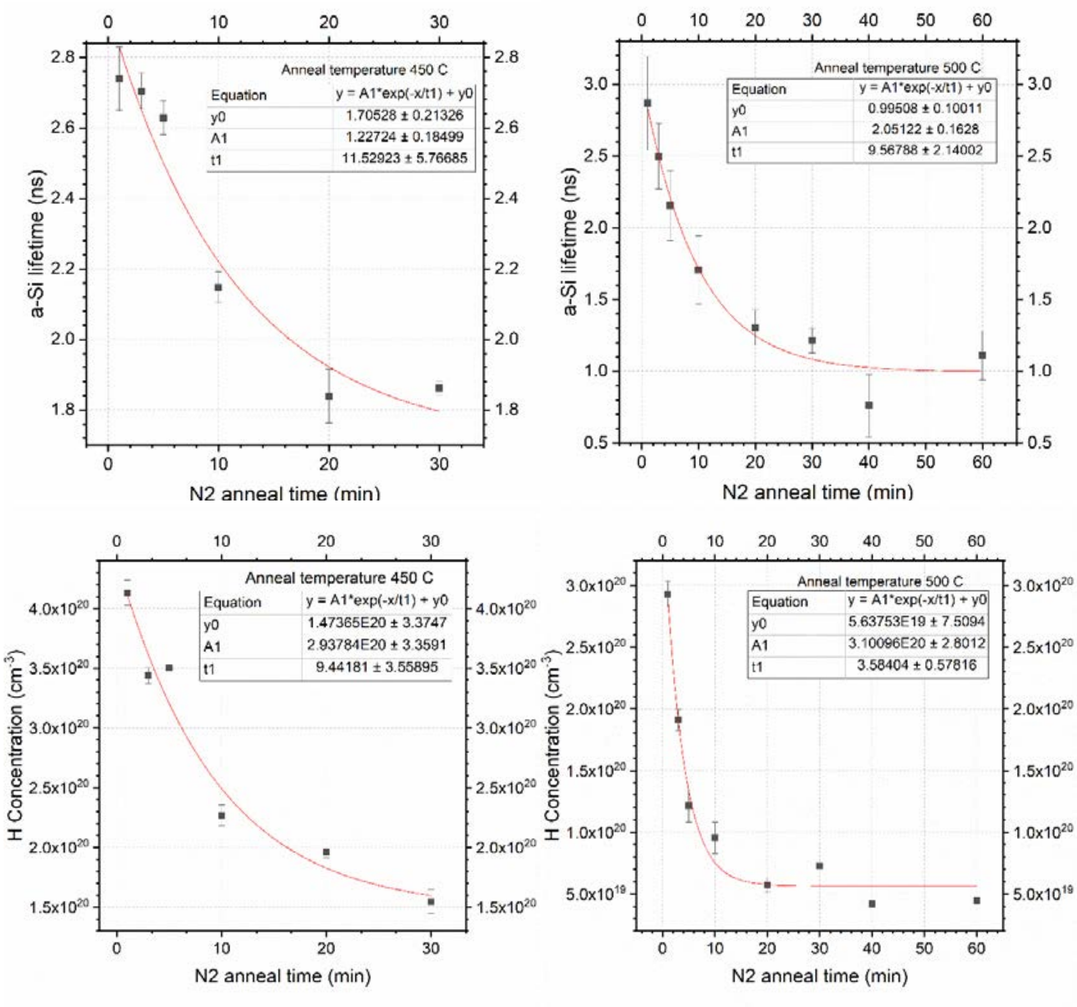


Figure 1 Comparison of the effective lifetime, a-Si lifetime as well as the hydrogen concentration of the samples when annealed at temperature 450 °C (left column) and 500 °C (right column).

From UV Raman measurements, we can see that on top of the broad a-Si peak at 480cm^{-1}, the sharp poly crystalline Si peak, which situates at 518cm^{-1}, occurs after a long aneal for both 450°C and 500°C. It is as expected to see the higher annealing temperature results in more significant transformation from a-Si to poly crystalline silicon. The results show that the phase change during the annealing process cannot be neglicted, and that the a-Si lifetime measurements for long anneal durations could be inaccurately high for this reason.

Reference

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