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Title of abstract: Carrier recombination in black silicon fabricated by high repetition rate fs-laser

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Abstract (max length: 3000 characters including spaces – only plain text - no formulae – no figures)
The femtosecond (fs)-laser is a well-known method for fabricating ultra-doped or hyperdoped silicon. It has been repeatedly demonstrated to result in high-absorptance Si surfaces (thus called black silicon or bSi), however, the electrical properties of bSi such as the charge carrier recombination are equally important for the application in electronic devices but are far less addressed. Recently, we studied the charge carrier recombination of the fs-laser processed bSi with high absorptance with tailored laser parameters [1]. While most of the past studies on the fs-bSi have used a substantially low repetition rate down to 1 kHz [2-3], we used a much higher repetition rate of 417 kHz for reduced processing time (i.e., the processing speed was 417 times faster to deliver the same amount of laser pulses per unit time). However, one of the known issues with the high repetition rate fs-laser is the heat accumulation effect that can change the formation mechanism of surface nanostructures and under which the laser damage can be accumulated [4]. As a result, the carrier recombination caused by the cumulative damage might be increased. Hence, our question here is whether such high repetition rate limits the carrier lifetime as compared to the nanostructures fabricated with conventionally used repetition rates.

To address the above question, we fabricated an array of fs-bSi samples with variable repetition rates from 417 kHz to ~1 kHz and with varying scan speeds from 100 to 1 mm/s. After surface passivation with atomic layer deposited Al₂O₃, the effective minority carrier lifetime was measured by using a photoconductance decay method. The results show that the lifetime is similar (40–50 μs) regardless of the repetition rate, i.e., the lifetime is not limited by the high repetition rate, which is against our intuition. However, the absorptance is seen to decrease significantly as a function of repetition rate and scan speed. Therefore, our results suggest that high repetition rate fs-laser is advantageous in preparing high absorptance bSi as it provides high fabrication efficiency without causing extra carrier recombination, which is especially desired for large scale production. To further increase the minority carrier lifetime, identifying and eliminating the lifetime limiting factors are currently underway.
References:

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