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Low-Temperature Ozone Native Oxide Based Surface Passivation of Silicon

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Abstract
As crystalline silicon solar cells become thinner the carrier lifetime of the device becomes more dependent on the surface passivation of the device. The current gold standard for passivation is thermally grown oxide which has resulted in silicon solar cells with photovoltaic conversion efficiencies of over 25%. Thermal oxide growth however involves processing at temperatures of ~800-1000 ^{o}C which can exacerbate crystalline silicon bulk properties through defect migration, induce thermal stresses particularly in the context of ultra-thin silicon, and has a significant thermal budget.

We have recently reported the use of native oxide based passivation of crystalline silicon wherein a 1 nm native oxide layer and an overlayer of silicon nitride results in high quality passivation; surface recombination velocities of less than 8 cm/s and effective minority carrier with lifetimes exceeding 1.7 ms have been reported [1]. This novel approach has been incorporated in Back Amorphous-Crystalline Si Heterojunction (BACH) PV cells achieving efficiencies approaching 17% [2]. However, the process of growing native oxide takes up to a month and is not deemed commercially viable. This work reports on the increase of the rate of growth of native oxide using an ozone ambient; specifically, the growth time is reduced from a month to an hour at room temperature. Additionally, a working relationship has been established between the growth time, temperature and oxide thickness. The influence of oxide thickness on passivation is also investigated. Currently lifetimes exceeding 1500 µs have been achieved with room temperature ozone based oxide as measured with µPCD.

[1] Z. R. Chowdhury, K. Cho, and N. P. Kherani, "High-quality surface passivation of silicon using native oxide and silicon nitride layers," *Applied Physics Letters,* vol. 101, 2012.
[2] Z. R. Chowdhury and N. P. Kherani, Back Amorphous-Crystalline Silicon Heterojunction (BACH) Photovoltaic Device with Facile Grown Oxide – PECVD SiNx Passivation, *Progress in Photovoltaic Research and Application* (accepted February 2014).