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Nanoscale Study of the Hole-selective Passivating Contacts with High Thermal Budget Using C AFM Tomography

One of the ways to solve the rear-contact related limitations of dominant p-type c-Si homojunction solar technology is the implementation of the passivating contact. This type of contact typically consists of a layer stack, where one layer effectively passivates the surface of the Si wafer and another layer acts as a selective contact for one type of the charge-carriers. One of the possible architectures of a selective contact is based on a thin interfacial layer of silicon oxide (SiOx) passivating the Si wafer and capped with highly doped poly-Si layer. Integrated at the rear side of p-type solar cells, this type of passivating contact resulted in promising efficiencies above 22% [1]. To further increase the applicability of these contacts, it is necessary to deepen the understanding of the charge-carrier transport mechanism through the layer stack and its changes during annealing, as industrial implementation often requires high-thermal-budget steps.
We investigate hole selective passivating contacts that consist of an interfacial layer of SiOx and a layer of boron-doped silicon carbide (SiCx). The fabrication process of these contacts involves an annealing step at temperatures above 750℃ which crystallizes the initially amorphous layer and diffuses dopants across the interfacial oxide into the wafer to facilitate charge transport, but it can also disrupt the SiOx layer necessary for wafer-surface passivation. To investigate the transport mechanism of the charge carriers through the selective contact and its changes during the annealing process, we utilize various characterization methods, such as transmission electron microscopy, micro Raman spectroscopy and Conductive Atomic Force Microscopy. Combining the latter with a sequential removal of material, using the technique known as C-AFM tomography [2], we assemble a tomographic reconstruction of the crystallized layer that reveals the presence of preferential vertical transport channels.
C-AFM tomography revealed the presence of charge-carrier transport channels in the partially crystallized selective SiCx(p) layer. Moreover, the density of these channels proved not to be related to the interfacial SiOx layer properties or its existence, but only to the degree of crystallinity of the doped selective layer as was shown by performing measurements on the samples without any SiOx layer. The first direct visualization of the transport channels through the selective contact proves the importance of the crystallinity of the doped selective layer in the local transport of charge-carriers as well as usefulness of the new microscopical techniques on the up-to-date solar structures and materials.
[1] G. Nogay et al., 'Crystalline Silicon Solar Cells With Coannealed Electron- and Hole-Selective SiCxPassivating Contacts', IEEE Journal of Photovoltaics, vol. 8, no. 6, pp. 1478–1485, Nov. 2018, doi: 10.1109/JPHOTOV.2018.2866189.
[2] U. Celano et al., 'Mesoscopic physical removal of material using sliding nano-diamond contacts', Scientific Reports, vol. 8, no. 1, p. 2994, Feb. 2018, doi: 10.1038/s41598-018-21171-w.

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