

In-situ Low Pressure Thermal Oxidation for Polysilicon Passivated Contacts

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Doped polysilicon passivated contacts on tunnel oxide (Poly-Ox) is regarded as among the most promising upcoming technologies to significantly increase silicon solar cell energy efficiency while being capable of wide scale industrial adoption.

The film stack boasts the ability to simultaneously provide excellent surface passivation and ohmic contact. It typically consists of a thin layer of tunneling oxide approximately 1 nm thick, and a doped polysilicon layer.

There are numerous methods of depositing this film stack, where the interfacial oxide can be grown thermally in an oxygen ambient [1, 2], or a wet chemical process [3, 4, 1], while the polysilicon layer can be deposited via PECVD or LPCVD. The process of introducing dopants can be done in-situ doped with diborane or phosphine added into the deposition gas mix [5-7, 1], or ex-situ where a separate diffusion process is performed after polysilicon deposition.

Recent advancement by the authors of this work has demonstrated among the best combination of J_0 and contact resistivity achieved simultaneously using a novel approach of in-situ low pressure thermal oxidation in combination with LPCVD polysilicon deposition and ex-situ phosphorus diffusion [2], as presented in Figure 1.

This work presents the continual investigation on numerous aspects of the interfacial oxide, its function as a passivating layer, dopant diffusion barrier, and possible explanations to the transport mechanism through the oxide layer.

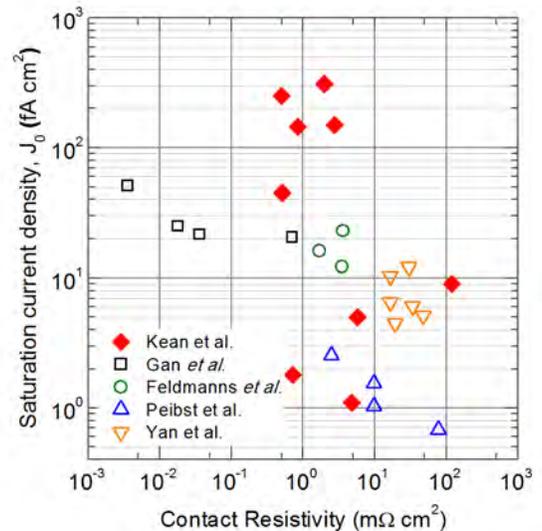


Figure 1. Compilation of J_0 and contact resistivity of various Poly-Ox results as published in literature as compared to the work presented by the authors[8-11, 2].

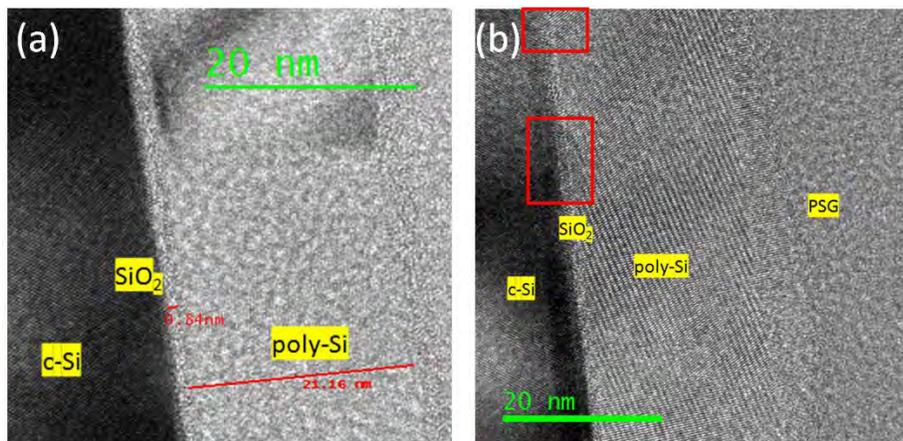


Figure 2. High resolution TEM images showing (a) the layer thicknesses and (b) observation of interruptions along the interfacial oxide pointing towards likelihood of pinholes.

Figure 2(a) presents the TEM image of the polysilicon stack where the c-Si/SiO₂/poly-Si layers are clearly observed. Due to the interfacial oxide being extremely thin (<1.5nm), it was impossible to measure accurately via optical means, and a TEM image is the only reliable method of gauging its physical thickness. This exercise indicates that the thickness of the interfacial oxide achieved in this work ranges from 0.85 nm to 1.5 nm for an oxidation temperature of 700 °C and 800 °C respectively, with other parameters such as pressure and oxidation time being held constant. More importantly, Figure 2(b) shows that numerous "inconsistencies" are visually observable at the interfacial oxide, where the crystal orientation of c-Si and the poly-Si layers are seen to extend towards the boundary of the SiO₂, indicating the sporadic absence of the oxide interfacial layer along the depth of the TEM cross section. This can possibly be interpreted as a "pinhole" or regions where the interfacial oxide is too thin to provide sufficient electrical separation between the c-Si and poly-Si layers.

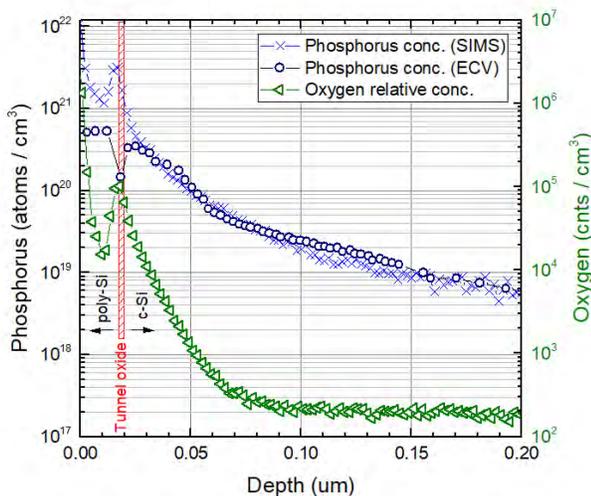


Figure 3. ECV measurements of active concentration and SIMS measurement of absolute phosphorus concentration and relative oxygen concentration in a Poly-Ox sample.

Figure 3 presents the comparison between ECV and SIMS measurement of the diffused Poly-Ox layers for a sample with 750 °C low pressure oxidation, 800 °C phosphorus diffusion and 900 °C annealing. Since the ECV measures only electrically active dopant concentration, it provides a more accurate representation of the electrical properties such as the sheet resistance of the film stack. The comparison to SIMS measurement of phosphorus dopants and the relative oxygen content provides some interesting observations. This comparison provides opportunity to examine the effect of inactive dopants on the recombination properties, and carrier mobilities which in turn affects the sheet resistance of the passivating contact film stack. Further detailed discussions and findings shall be further presented during the presentation.

References

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