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Reduction of thermal budget in the solar industry

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Introduction Industrial production of silicon solar cells relies on the formation of a pn-junction typically realized by thermal diffusion of phosphorus or boron. Such thermal diffusion processes are performed at $\sim$ 800-900 °C for 15-30 minutes, depending on the target sheet resistance. We present initial results on enhanced thermal diffusion on black Si made by maskless RIE. Sheet resistance and carrier density have been measured with a micro-four-point probe.

Experimental Results Micro-four-point probe and electro-chemical capacitance-voltage (ECV) measurements were performed on the nanostructured front and planar rear side of 200 μm thick CZ Si wafers with a resistivity of 1.6 Ω-cm. P- and n-type wafers with phosphorus- and boron doped emitters, respectively, were used. Macro-four-point probe measurements of sheet resistance show 51.5 Ω on the nanostructured front and 82.3 Ω on the planar rear.

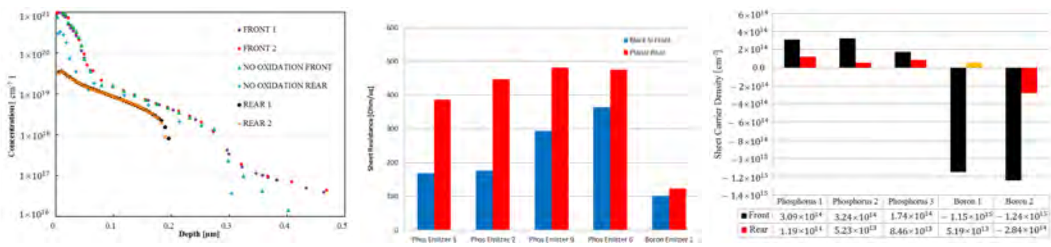

Figure 1: ECV (left), sheet resistance (middle) and carrier density (right) on nanostructured and planar Si

The doping profile (from ECV), sheet carrier density and sheet resistance seen in Figure 1 show that the nanostructured front is more highly doped than the planar rear. The sheet resistance in all cases is significantly lower on the nanostructured front compared to the planar rear. For sheet resistances suitable for solar cell fabrication (100-200 Ω/sq. selective emitters) the difference between the nanostructured front and planar rear is more than 100%.

From an industrial perspective the result indicates a potential decrease of the thermal budget of large-scale, industrial thermal diffusion processes, used for all emitter formations in the solar industry: If RIE-texturing is applied to industrial Si solar cells, emitters (with sheet resistances of 60-120 Ω/sq.) may be formed at lower thermal budget due to the lower sheet resistance on nanostructured Si for a given diffusion process. The thermal budget may be decreased by reduced time, temperature or a combination of the two.

Our hypothesis is that the RIE-textured nanostructures increase the surface area and induce surface defects. These two effects in combination enhance the diffusive flux of dopants into Si and thus enable emitter formation at a lower thermal budget in general.

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