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Supplementary Material: Post passivation light trapping back contacts for silicon heterojunction solar cells

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Processing guideline:

In the manuscript (see section "processing PPLTBCs) the process routine to fabricate the post passivation light trapping back contacts (PPLTBC) was presented. In order to give a deeper insight into the processing routine of the complete silicon heterojunction solar cell, additional information is provided here. An overview on the single steps is shown in the flow chart in Fig. 1. The colors of the layers are kept similar to the ones in the main manuscript.

We start from a double side planar p-type monocrystalline silicon wafer (light grey). First, cleaning steps consisting of (i) 10 minutes cleaning in Piranha solution (900 ml H_2O_2 + 450 ml H_2SO_4), (ii) Flushing in a "Quick Dump Rinser" till a resistance of 10 M Ω is reached (iii) 2 min cleaning in Hydrofluoric Acid and (iv) again flushing in a "Quick Dump Rinser" till a resistance of 10 M Ω is reached, are applied.

Subsequent to the cleaning steps, the samples are transferred to a cluster tool equipped with chambers for plasma enhanced chemical vapour depositions (PECVD) for the deposition of the passivation layers. These layers consist of ~6 nm of hydrogenated amorphous silicon oxide (a-SiO_X:H), marked in green in Fig.1. Next, field generating layers, marked in yellow, consisting of hydrogenated microcrystalline silicon oxide (μ c-SiO_X:H) with thicknesses of ~20 nm and

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30 nm are deposited at the front side and the backside, respectively. (Fig 1 step 1)

Next, ~70 nm indium tin oxide (ITO) is locally sputtered at the front side forming the front contact of the solar cells and defining the solar cell area (blue layer). In order to protect the covered layers against deterioration and destruction during the processing of the PPLTBCs, 30 nm aluminium doped zinc oxide (ZnO:Al) is sputtered at the back side (blue layer). The basis of the PPLTBC is a hydrogenated amorphous silicon (a-Si:H) layer with a thickness of around 700 nm (red layer), which is deposited on the ZnO:Al layer (see Fig. 1 step 2). Due to a nanoimprint lithography step, a textured photoresist layer is processed on the a-Si:H (Fig. 1 step 3). Applying the reactive ion etching routine presented in detail in the manuscript, the imprinted texture is transferred from the photoresist to the a-Si:H (Fig. 1 step 4)

To finish the back contact, 50 nm ZnO:Al and 500 nm Ag (dark grey) are deposited locally to define the solar cell area and to act as a mirror for the incident light (Fig. 1 step 5). In a last step, an Ag grid with a height around 2 μ m and a width around 80 μ m is deposited via evaporation at the ITO front contact (not shown). Optional, a MgF₂ layer with a thickness around 85 nm can be deposited on top of the ITO to act as an additional anti-reflection coating and thus improve the light incoupling.

Solar cell characteristics:

The relevant characterization of the solar cells was presented in the manuscript (see "Results"). In order to provide additional insight into the raw data of the

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solar cells in table 1, the corresponding IV-curves are provided in Fig. 2. One solar cell per applied PPLTBC and a planar reference solar cell are compared here. It can be seen that the open-circuit voltage of all three solar cells is similar. Moreover, it can be seen that the solar cell with a PPLTBC based on randomly distributed craters generates the highest short-circuit current density.



Figure 1: Representative flow diagram of the processing routine used to realize silicon heterojunction solar cells during the work.



Figure 2: IV-curves of representative silicon heterojunction solar cells with single anti-reflection coating consisting of indium tin oxide (ITO) and (i) planar back contact, (ii) binary grating based PPLTBC and (iii) a PPLTBC based on randomly distributed craters (see table 1).