Hybrid (front-side diffused, rear-side heterojunction) solar cells combine the high short-circuit potential of conventional diffused solar cells with the reduced contact recombination of heterojunction solar cells, while at the same time being able to avoid the (costly) transparent conductive oxide TCO layer used in conventional heterojunction solar cells. The use of heterojunction point- or stripe-contacts may allow to combine a conventionally screen printed front contact (using a high temperature contact firing at 700°C) with a rear-side heterojunction contact [see Figure 1(a)]. Alternatively, low temperature metallization methods have to be screened.

In this study, the single-side textured, phosphorous diffused and silicon nitride passivated, screen printed front-contact of our hybrid solar cell pre-cursors (before forming rear-side heterojunction point- or stripe-contacts) is optimized by investigating (i) etch back techniques (ii) separation between a drive-in and a post-oxidation processes, thereby monitoring the resulting diffusion profile by electrochemical capacitance voltage profiling (ECV). The local heterojunction (point or stripe) rear-contact of our hybrid solar cell pre-cursors (before front-side screen printing) is optimized by optimizing (i) the local contact opening process, using femtosecond (fs) laser ablation, (ii) the wet-chemical laser-induced damage removal process and (iii) the contact-area fraction and the pitch of the subsequent (heterojunction) re-passivation processes. In both cases the corresponding effective lifetime of the contact system is monitored by photo conductance decay (Sinton lifetime, QSSPC) as well as by photoluminescence imaging (PL), thereby being able to extract the saturation current density ($j_0$) of the passivated area and of the contact area, using our in-house developed simulation program “Griddler-AI”. Furthermore, the contact resistance is measured by means of transfer length measurements (TLM).

As a result, a close to zero damage rear-side contact opening can be realized. Furthermore, the rear-side contact geometry (pitch and contact-area fraction) can be specifically adapted to the measured front contact system under investigation. Using an optimized chemical etch back / oxidation process, the lifetime of the pre-cursors for the front-contact optimization improves from 500 to ~700 µs, and the implied open-circuit voltage increases from 660 to 680 mV.

Our initial results predict that the solar cell efficiency potential of the pre-cursors can be improved by 0.7% absolute, i.e. from 22.6% to roughly 23.3%. However, a complete process integration (thereby evaluating the degradation of the local heterojunction contacts during screen printing or screening corresponding low temperature front-contact metallisation processes such like inline plating or ink-jet printing) has not yet been investigated at the time of submitting this abstract.

Figure 1 Sketch of a hybrid cell (a), a front-contact pre-cursor (b) and two rear-contact pre-cursors (c). Furthermore, a PL image before and after rear-side re-passivation is shown (d), currently AlO$_x$/SiN$_x$ stack is used as re-passivation films instead of $i/p^+$ a-Si:H.