Multicrystalline silicon solar cells exceeding 22%
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In the last years the development of seed-assisted silicon crystallization has allowed for a remarkable improvement of the quality of multicrystalline silicon (high-performance multicrystalline silicon). At the same time new passivated contact technologies became available. They would allow to contact the whole rear surface of multicrystalline silicon solar cells which is particularly interesting since the lateral conductivity of multicrystalline silicon might be limited.

Therefore, we would like to investigate if the TOPCon technology developed at Fraunhofer ISE is suited for application to multicrystalline silicon. We have fabricated cells exhibiting a black silicon front texture, a homogeneous boron emitter and a full-area TOPCon rear contact (see Fig. 1).

Fig. 1 Sketch of solar cell on multicrystalline silicon with diffused front boron emitter and full-area rear passivated contact (TOPCon) based on a thin intermediate oxide and a heavily doped silicon layer.

n-type high-performance multicrystalline silicon was grown at Fraunhofer ISE and analyzed with photoluminescence imaging. It exhibits high lifetimes with a narrow distribution even after the full cell process including boron diffusion.

Fig. 2 Prediction of efficiency potential of our HP mc-Si material using ELBA (Efficiency Limiting Bulk recombination Analysis) taking into account the cell structure shown in Fig. 1. The high efficiency potential of the good grains is remarkable. Even the areas with higher crystal defect density show very good performance resulting in excellent area-weighted average values. Our analysis shows that the material should allow conversion efficiencies of more than 22%.

In fact we were able to achieve an efficiency of 22.3% experimentally (confirmed by Fraunhofer ISE Callab). This result represents the new world record for multicrystalline silicon and shows impressively that the fabrication of TOPCon structures on multicrystalline silicon is feasible i.e. growing a highly functional thin tunnel oxide on material with different crystal orientation.