

Unveiling the mechanism of attaining high fill factor in silicon solar cells

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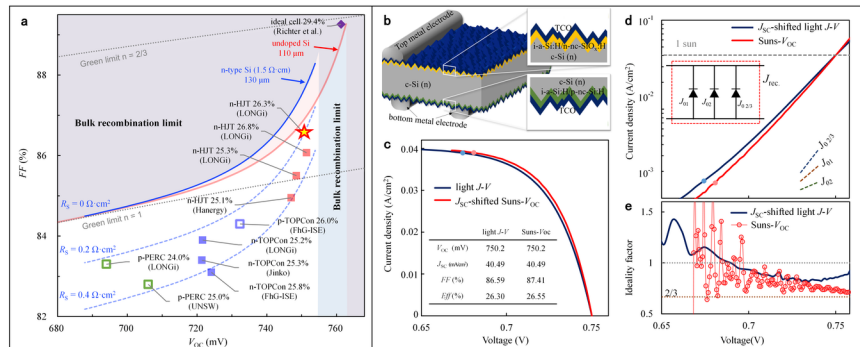
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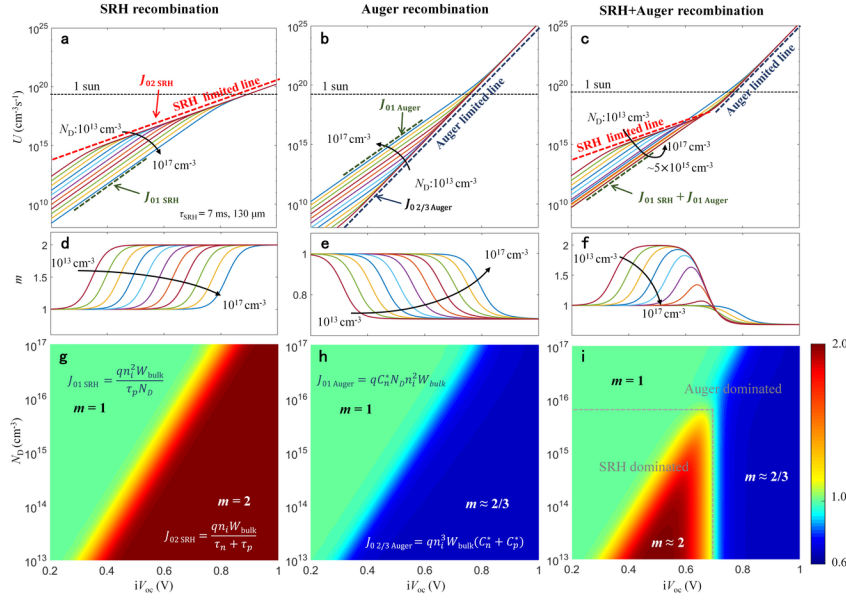
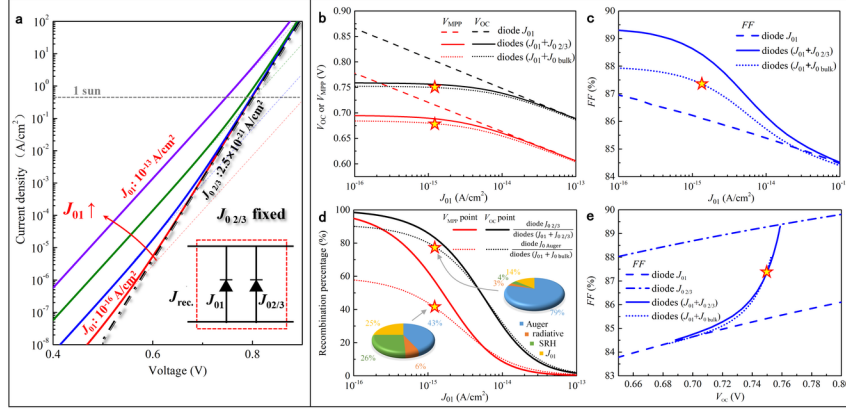
Abstract

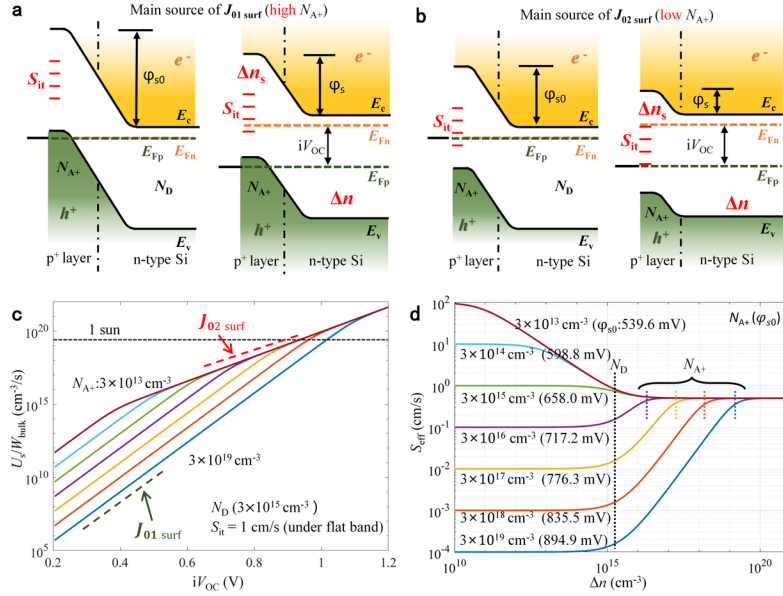
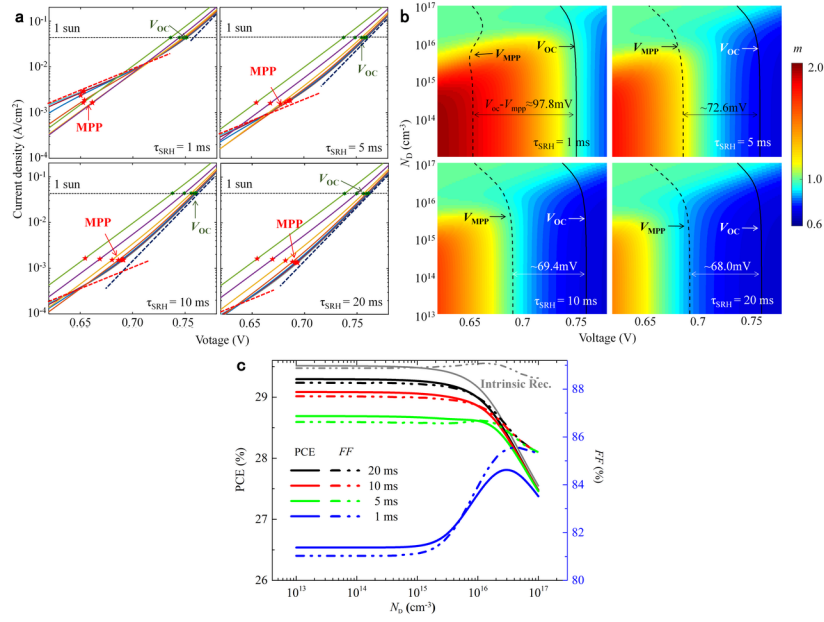
A world record conversion efficiency of 26.81% has been achieved recently by LONGi team on industry-grade silicon wafer (274 cm², M6 size). An unparalleled high fill factor (FF) of up to 86.59% boosted the cell performance. The theoretical FF limit has been predicted to be 89.26%, while the practical FF is far below this limit for a prolonged interval due to the constraints of recombination (*i.e.*, SRH recombination) and series resistance. The ideality factor (m) in the equivalent circuit of silicon solar cells is consistently ranging from 1 to 2 and rarely falls below 1, resulting in a relatively lower FF than 85%. Here, this work complements a systematic simulation study to demonstrate how to approach the FF limit in silicon solar cell fabrication. Firstly, a diode component with an ideality factor equal to 2/3 corresponding to Auger recombination is incorporated in the equivalent circuit for LONGi' ultra-high FF solar cell; Secondly, an advanced equivalent circuit is put forward for comprehensive analysis of bulk recombination and surface recombination on the performance, in which specific ideality factors are directly correlated with various recombination mechanisms exhibiting explicit reverse saturation current density (J_0); Finally, we evaluate precisely the route for approaching theoretical FF in practical solar cell fabrication based on electrical design parameters using the developed model.

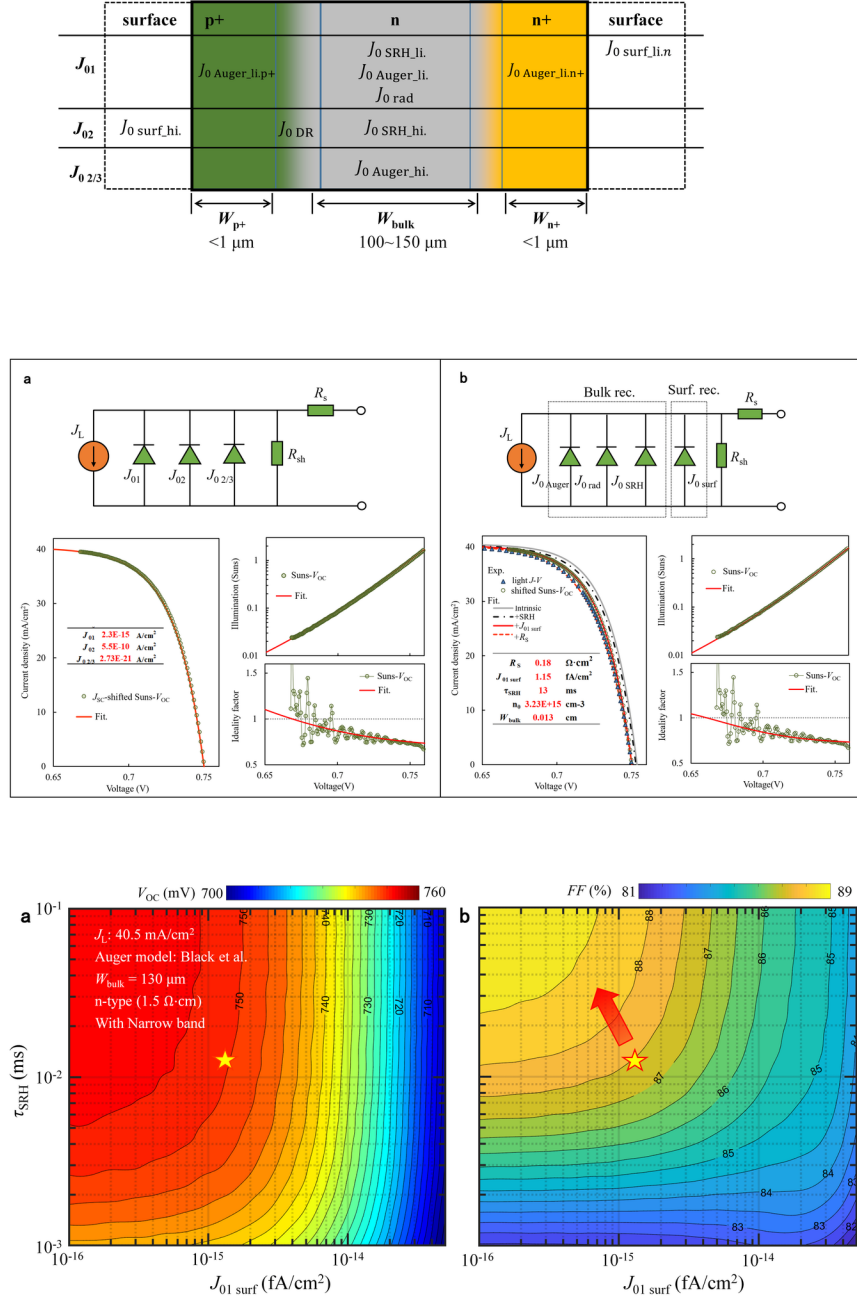
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